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Male-Female Disparity in Child Survival in Districts of India

Aalok Ranjan Chaurasia

Abstract

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

Introduction

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

In this paper we analyse male-female disparity in the probability of survival up to 15 years of age in districts of India. We also analyse how male-female disparity in the probability of survival up to 15 years of age varies across different population sub-groups within the same district. Children below 15 years of age can be grouped into children aged 0-1 year of age; children 1-4 years of age; children 5-9 years of age; and children 10-14 years of age. The rationale for this age grouping of children is grounded in the fact that both probability of survival and male-female disparity in the probability of survival varies across the four age groups as the primary causes of death in the four age groups are essentially different. The probability of survival in the first 15 years of life, therefore, is the cumulation of the probability of survival in the four age groups. This means that male-female disparity in survival up to 15 years of age should be analysed in the context of the male-female disparity in survival in 0-1 year; 1-4 years; 5-9 years; and 10-14 years of age.

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

Analytical Framework

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

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

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

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

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

which means that

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

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

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

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

$${}_{15}p_0 = {}_1p_0 * {}_4p_1 * {}_5p_5 * {}_5p_{10} \quad (4)$$

so that equation (3) becomes

$$\nabla = LM * \left[ln\left(\frac{{}_1p_0^m}{{}_1p_0^f}\right) + ln\left(\frac{{}_4p_1^m}{{}_4p_1^f}\right) + ln\left(\frac{{}_5p_5^m}{{}_5p_5^f}\right) + ln\left(\frac{{}_5p_{10}^m}{{}_5p_{10}^f}\right)\right] \quad (5)$$

or

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

where

$$\partial_1 = LM * ln\left(\frac{{}_1p_0^m}{{}_1p_0^f}\right) \quad (7)$$

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

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

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

Similarly,

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

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

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

Since

$$\nabla^j = \partial_1^j + \partial_2^j + \partial_3^j + \partial_4^j \quad (12)$$

It follows that

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

Notice that by construction

$$\sum_{i=1}^{c} \bar{a}_i = 0 \quad (14)$$

and

$$\sum_{i=1}^{c} r_i^j = 0 \quad (15)$$

So that equation (13) reduces to

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

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

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

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

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

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

Data

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

Results

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

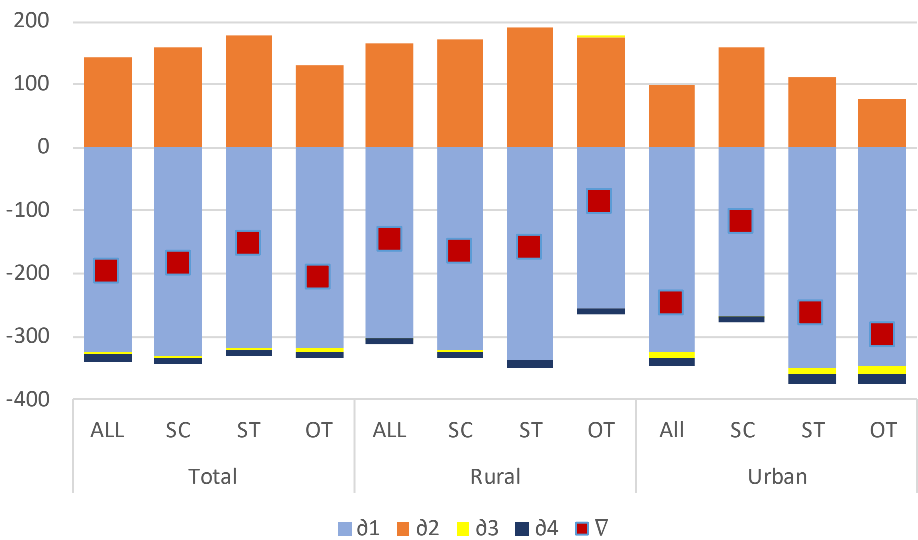

Figure 1: Empirical 'normal' male-female disparity in probability of survival up to 15 years of age (per 100 thousand births) in India and in different population sub-groups
Source: Author

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

Population	Male-female disparity in survival probability 0-15 years	Contribution of male-female disparity in the probability of survival in the age group				Number of districts
		0-1 year	1-5 years	5-10 years	10-15 years	
	∇	∂_1	∂_2	∂_3	∂_4	
Total	-195	-323	144	-5	-11	640
Scheduled Castes	-184	-331	161	-3	-11	579
Scheduled Tribes	-154	-319	178	-2	-11	556
Other Castes	-205	-317	130	-6	-11	639
Rural	-145	-301	167	-1	-10	631
Scheduled Castes	-164	-322	171	-2	-11	565
Scheduled Tribes	-157	-337	191	-1	-11	540
Other Castes	-86	-257	176	2	-8	630
Urban	-248	-324	98	-10	-12	636
Scheduled Castes	-119	-268	158	0	-9	567
Scheduled Tribes	-262	-349	112	-11	-14	502
Other Castes	-298	-348	77	-13	-14	632

Source: Author

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

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

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

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

Source: Author

District level variation in male-female disparity in survival up to 15 years of age from the empirical 'normal' is quite marked (Table 2). There are 81 districts in the country where survival advantage in females is high compared to males. In these districts, the probability of a female newborn to survive to the 15th birthday is substantially higher than that of a male newborn. By contrast, in 122 districts, male survival advantage is high compared to females which implies that, in these districts, the probability of a female newborn to survive to the 15th birthday is lower than that of a male newborn. On the other hand, there are 139 districts where female survival advantage is marginal. Similarly, there are 109 districts where male survival advantage is marginal so that in 248 (39 per cent) districts of the country, the male-female disparity in survival up to 15 years of age may be termed as marginal. In 183 (29 per cent) districts, female survival advantage is substantial (either moderate or high) while in 209 (33 per cent) districts male survival advantage is substantial (moderate or high).

The proportion of districts having either substantial female advantage or substantial male advantage in survival up to 15 years of age varies by different population sub-groups. In the rural population, 196 (31 per cent) districts have female substantial survival advantage while 201 (32 per cent) districts have substantial male survival advantage so that in 234 (37 per cent) districts, either female or male survival advantage is only marginal. The corresponding proportions in the urban population are 27 per cent, 32 per cent and 41 per cent, respectively. Similarly, the proportion of districts having substantial female survival advantage is the highest in the Scheduled Tribes population while the proportion of districts having substantial male survival advantage is the highest in the Scheduled Castes population whereas the proportion of districts having marginal male-female disparity in survival up to 15 years of age is the highest in the Other Castes population. Among the six mutually exclusive population sub-groups, the proportion of districts having substantial female survival advantage is the highest in Urban Scheduled Tribes population while the proportion of districts having substantial male survival advantage is the highest in the urban Scheduled Castes population. On the other hand, the proportion of districts where male-female disparity in survival up to 15 years of age is marginal is the highest in the urban Other Castes population. Table 2 suggests that male-female disparity in survival up to 15 years of age varies across the districts of the country is determined by the within district variation in male-female disparity across six mutually exclusive population sub-groups in each districts. It may, however, be noted that the social class composition of the population is not the same in all districts which also has an impact on the male-female disparity in the probability of survival up to 15 years of age in the district.

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

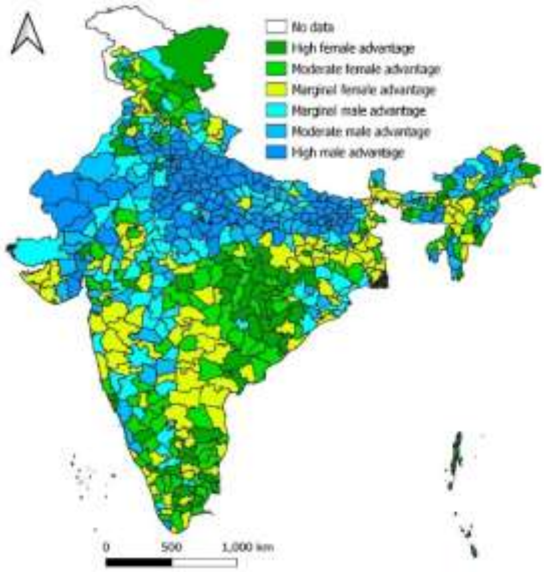

Figure 2: Inter-district variation in male-female disparity in child survival - total population.

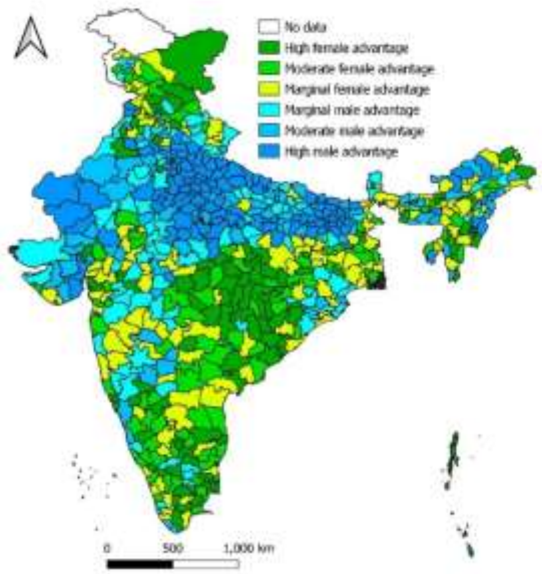

Figure 3: Inter-district variation in male-female disparity in child survival - rural population.

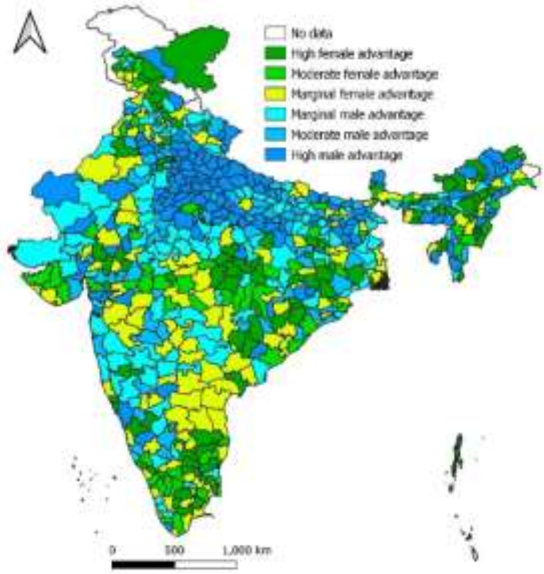

Figure 4: Inter-district variation in male-female disparity in child survival - urban population.

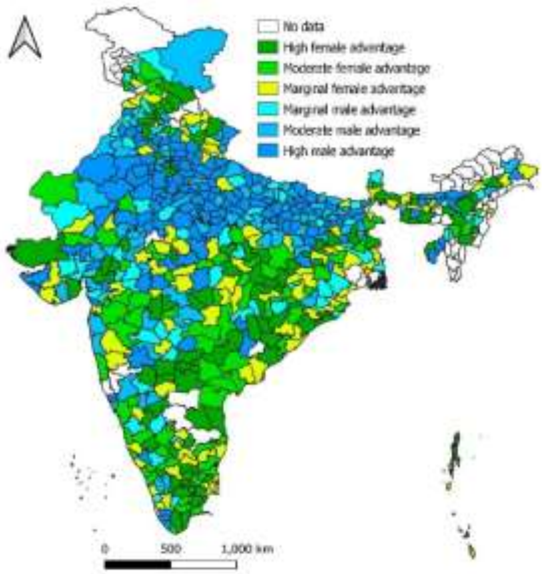

Figure 5: Inter-district variation in male-female disparity in child survival - Scheduled Castes, total.

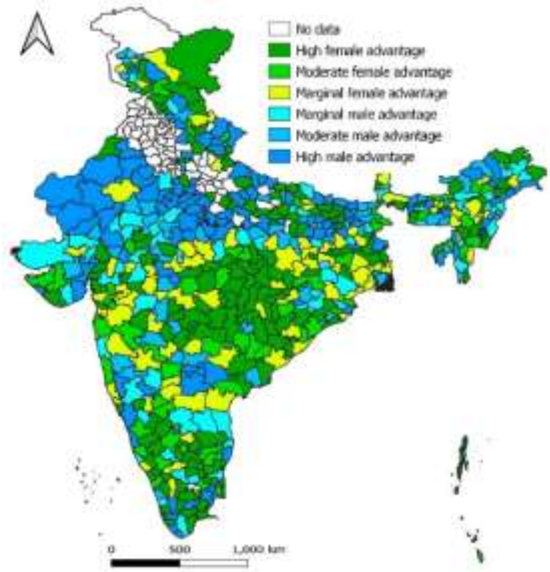

Figure 6: Inter-district variation in male-female disparity in child survival - Scheduled Tribes total.

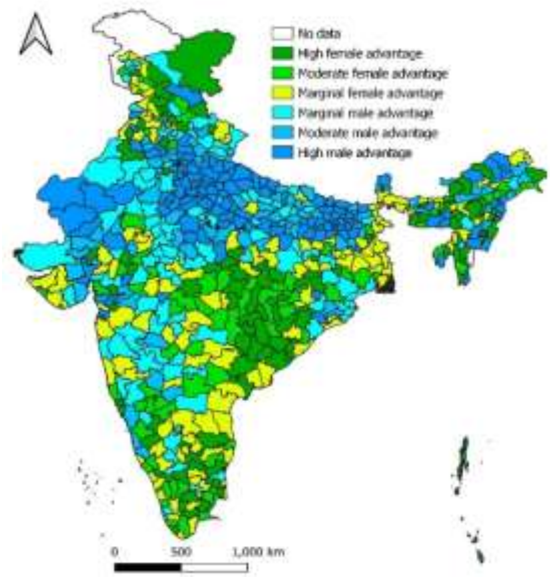

Figure 7: Inter-district variation in male-female disparity in child survival - Other Castes total.

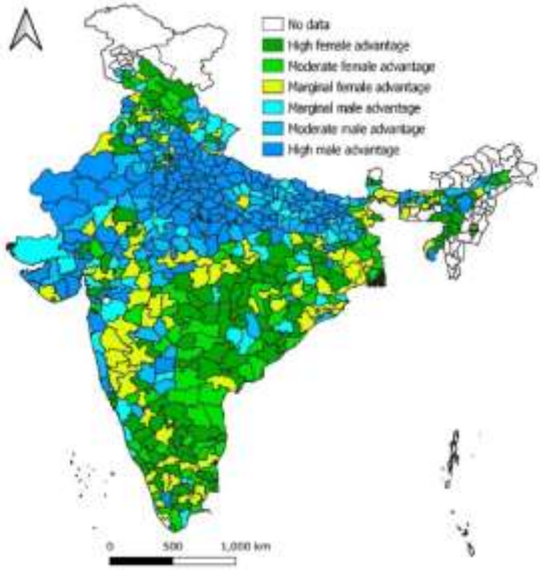

Figure 8: Inter-district variation in male-female disparity in child survival - Scheduled Castes, rural.

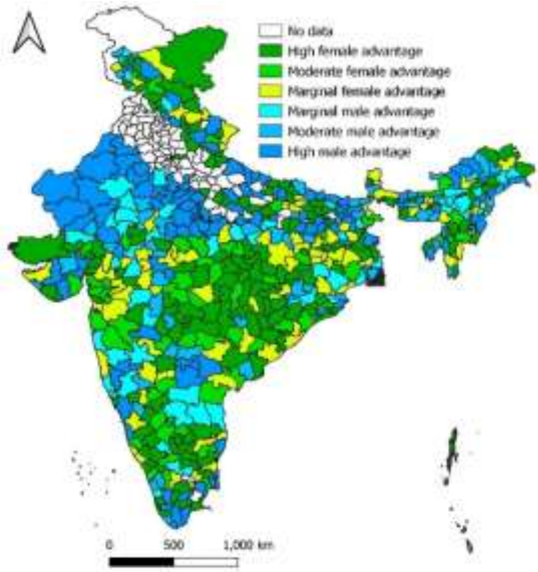

Figure 9: Inter-district variation in male-female disparity in child survival - Scheduled Tribes, rural.

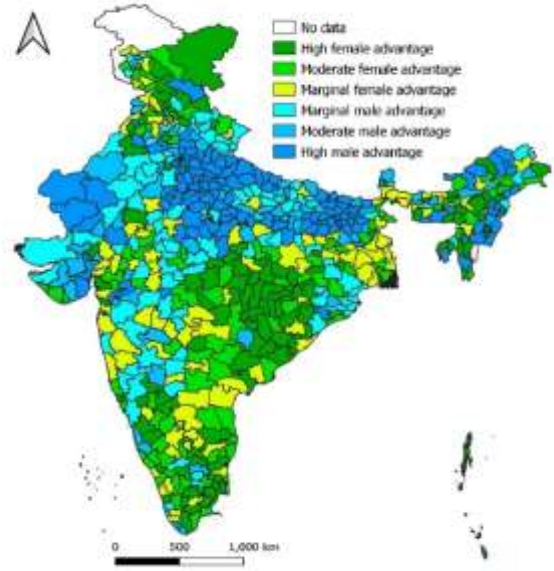

Figure 10: Inter-district variation in male-female disparity in child survival - Other Castes, rural.

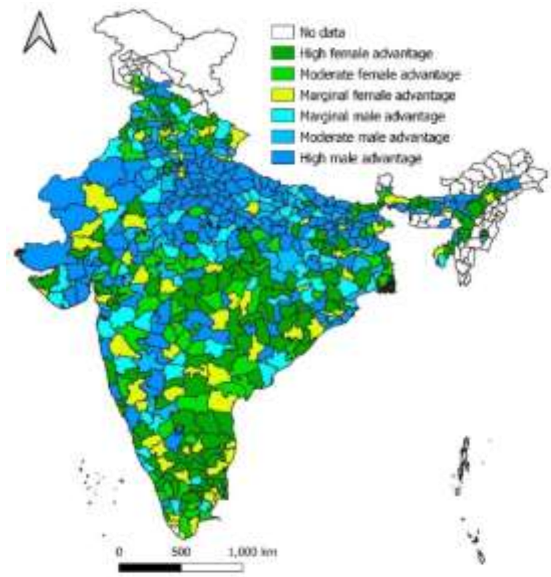

Figure 11: Inter-district variation in male-female disparity in child survival - Scheduled Castes urban

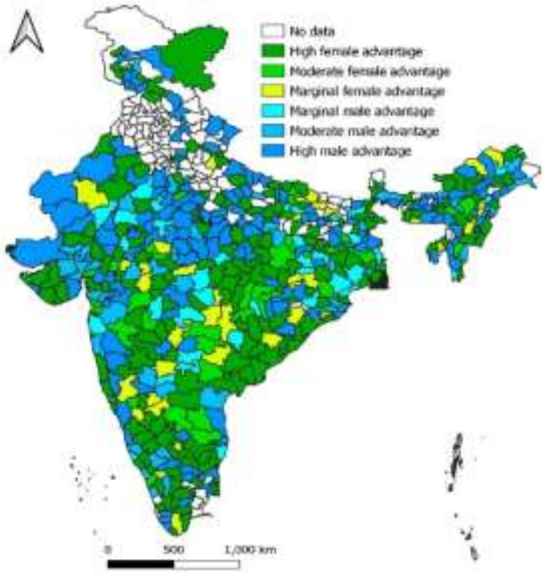

Figure 12: Inter-district variation in male-female disparity in child survival - Scheduled Tribes, urban.

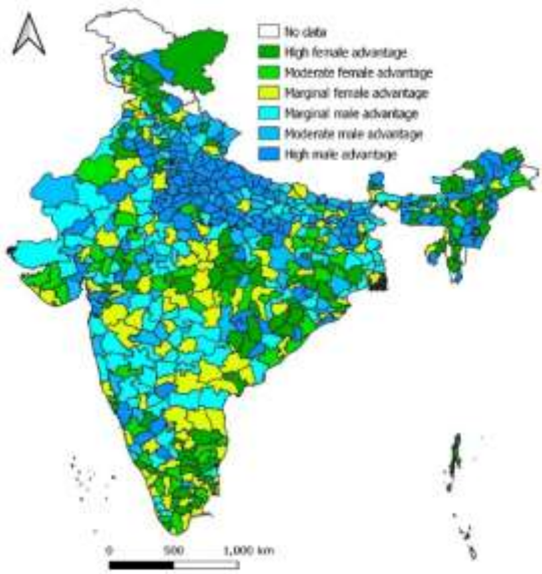

Figure 13: Inter-district variation in male-female disparity in child survival - Other Castes, urban.

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

Country/State/ Union Territory	Male-female disparity in survival in 0-14 years of age						Number of districts
	Female advantage			Male advantage			
	High	Moderate	Marginal	Marginal	Moderate	High	
AN Islands	3	0	0	0	0	0	3
Andhra Pradesh	4	5	13	1	0	0	23
Arunachal Pradesh	3	0	4	1	4	4	16
Assam	5	6	8	4	3	1	27
Bihar	0	0	1	3	7	27	38
Chandigarh	0	1	0	0	0	0	1
Chhattisgarh	8	7	2	1	0	0	18
Dadra & Nagar Haveli	0	0	1	0	0	0	1
Daman & Diu	0	1	1	0	0	0	2
Delhi	0	0	0	3	2	4	9
Goa	2	0	0	0	0	0	2
Gujarat	1	5	7	4	7	2	26
Haryana	2	1	1	3	7	7	21
Himachal Pradesh	6	5	0	1	0	0	12
Jammu & Kashmir	2	6	7	5	2	0	22
Jharkhand	3	4	9	5	2	1	24
Karnataka	2	10	6	7	5	0	30
Kerala	1	4	6	3	0	0	14
Lakshadweep	0	0	0	0	0	1	1
Madhya Pradesh	6	9	8	11	8	8	50
Maharashtra	1	8	14	10	2	0	35
Manipur	4	1	2	1	0	1	9
Meghalaya	1	1	1	1	0	3	7
Mizoram	1	2	1	1	2	1	8
Nagaland	0	0	2	5	2	2	11
Odisha	7	5	6	9	3	0	30
Puducherry	4	0	0	0	0	0	4
Punjab	2	1	7	5	2	3	20
Rajasthan	1	1	2	11	7	11	33
Sikkim	1	0	1	1	1	0	4
Tamil Nadu	11	13	7	1	0	0	32
Tripura	0	2	1	0	0	1	4
Uttar Pradesh	0	0	2	7	17	45	71
Uttarakhand	0	1	4	4	4	0	13
West Bengal	0	3	15	1	0	0	19
India	81	102	139	109	87	122	640

Source: Author

The male-female disparity in survival up to 15 years of age also varies by the six mutually exclusive population sub-groups within each district. There are only There are only 42 (6.6 per cent) districts in the country where females have a survival advantage – high, moderate, or marginal – relative to males in all the six mutually exclusive population sub-groups (Figure 14). Similarly, there only are 61 (9.5 per cent) districts where male have a survival advantage – high, moderate, or marginal - in all the six mutually exclusive population sub-groups. In most of the districts of the country, female, or male survival advantage in one or more mutually exclusive population sub-groups is associated with female or male survival disadvantage or male or female survival advantage in other population sub-groups.

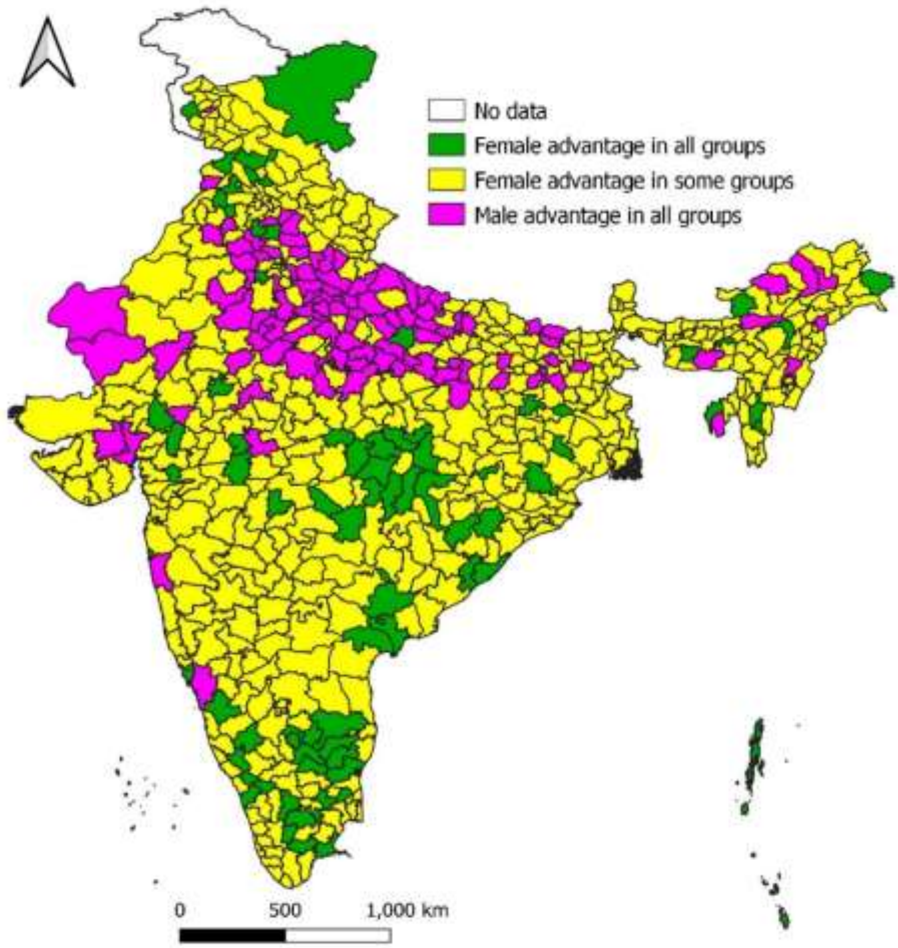

Figure 14: Inter-district variation in within-district male-female disparity in survival up to 15 years of age.

The male-female disparity in survival up to 15 years of age is the cumulation of the male-female disparity in survival in the age groups 0-1 year; 1-4 years; 5-9 years; and 10-14 years. We have carried out a classification modeling exercise using the classification and regression technique (CRT) to classify districts in terms of male-female disparity in survival up to 15 years of age in the context of the contribution of male-female disparity in survival in age groups 0-1 year; 1-4 years; 5-9 years; and 10-14 years to the male-female disparity in survival up to 15 years of age. Districts were first classified into six categories for the purpose of classification modelling exercise based on male-female disparity in survival in the first 15 years of life: 1) districts having high female survival advantage; 2) districts having moderate female survival advantage; 3) districts having marginal female survival advantage; 4) districts having marginal male survival advantage; 5) districts having moderate male survival advantage; and 6) districts having high male survival advantage. On the other hand, independent variables used for the classification modelling exercise are: 1) contribution of male-female disparity in survival in the first year of life to the male-female disparity in survival up to 15th birthday; 2) contribution of male-female disparity in survival in 1-4 years of life to the male-female disparity in survival up to 15th birthday; 3) contribution of male-female disparity in survival in 5-9 years of life to the male-female disparity in survival up to 15th birthday; and 4) contribution of male-female disparity in survival in 10-14 years of life to the male-female disparity in survival up to 15th birthday. The dependent variable in the classification modelling exercise is a categorical one while all the four independent variables are scale variables.

Results of the classification modelling exercise are presented in table 4 and the associated classification tree is depicted in Figure 15. The classification modelling exercise suggests that 640 districts of the country can be grouped into 6 mutually exclusive groups or clusters of districts on the basis of the contribution of male-female disparity in survival in the age groups 5-9 years and 10-14 years and the male-female disparity in survival up to 15 years of age in the clusters identified is different. The first cluster comprises of 80 districts and in all districts in this cluster have high female survival advantage. In all districts of this cluster, the contribution of male-female disparity in survival in the age group 5-9 years is ≤0.005 per 1000 live births while the contribution of male-female disparity in survival in the age groups 10-14 years is ≤-0.300 per 1000 live births. The second cluster comprises of 109 districts and 102 districts of this cluster have moderate female survival advantage while 1 district has high female survival advantage while 6 districts have marginal female survival advantage. The contribution of male-female disparity in survival in the age group 5-9 years is ≤0.005 per 1000 live births in all these districts while the contribution of male-female disparity in survival in the age group 10-14 years ranges between -0.300 and -0.135 per 1000 live births. The third cluster comprises of 134 districts and 131 districts of this cluster have marginal female survival advantage while 3 districts have marginal male survival advantage. The contribution of male-female disparity in survival in the age group 5-9 years, in districts of this cluster, is ≤0.005 per 1000 live births while the contribution of male-female disparity in survival in the age group 10-14 years is >-0.135

per 1000 live births. The fourth cluster has 105 districts and 103 districts of this cluster have marginal male survival advantage while two districts have marginal female survival advantage. The distinguishing feature of the districts of this cluster is that the contribution of male-female disparity in survival in the age group 5-9 years ranges between 0.005 to 0.315 per 1000 live births. The fifth cluster has 89 districts and all but three districts have moderate male survival advantage while three have marginal male survival advantage. The distinguishing feature of districts of this cluster is that the contribution of male-female disparity in survival in the age group 5-9 years ranges from 0.315 to 0.665 per 1000 live births in districts of this cluster. Finally, the sixth and the last cluster has 123 districts and all but one of these districts have high male survival advantage while one district has moderate male survival advantage. The distinguishing feature of the districts of this cluster is that the contribution of the male-female disparity in survival in the age group 5-9 years is more than 0.665 per 1000 live births in districts of this cluster. The accuracy of the classification modelling exercise in classifying a district into one of the six categories of male-female disparity in survival up to 15 years of age is found to be 97.5 per cent. There are only 16 districts where model classification differed from the actual classification. The most important classification or independent variable is found to be the contribution of the male-female disparity in survival in the age group 10-14 years , closely followed by the male-female disparity in survival in the age group 5-9 years. The importance of the contribution of the male-female disparity in survival in the age group 1-4 years to the male-female disparity in survival up to 15 years of age has been found to be the lowest among the four independent variables used in the classification modelling exercise. The analysis also reveals that male-female disparity in survival in the first year of life and male-female disparity in survival in 1-4 years of life contribute little in determining the male-female disparity in survival up to 15 years of age across the districts of the country. The classification modelling exercise suggests that the male-female disparity in survival up to 15 years of age is determined largely by the male female disparity in survival in 5-9 years and 10-14 years and not by male-female disparity in survival in either 0-1 year of age or in 1-4 years of age.

The classification modelling exercise highlights the importance of male-female disparity in survival in the age groups 5-9 years and 10-14 years in deciding the male-female disparity in survival in the age group 0-14 years across the districts of the country. Male-female disparity in survival in the age groups 0-1 year and 1-4 years also matters in determining the male-female disparity in survival in the age group 0-14 years but the contribution of the male-female disparity in survival in 0-1 year and in 1-4 years of age in deciding the male-female disparity in survival up to 15 years of age is not as important as the contribution of male-female disparity in survival in the age groups 5-9 years and 10-14 years. This observation bears significance in the policy and programme context as the strategy and the interventions required for addressing male-female disparity in survival in the age group 5-9 years and in the age group 10-14 years are different from the strategy and interventions required for addressing male-female disparity in survival in age groups 0-1 year and 1-4 years.

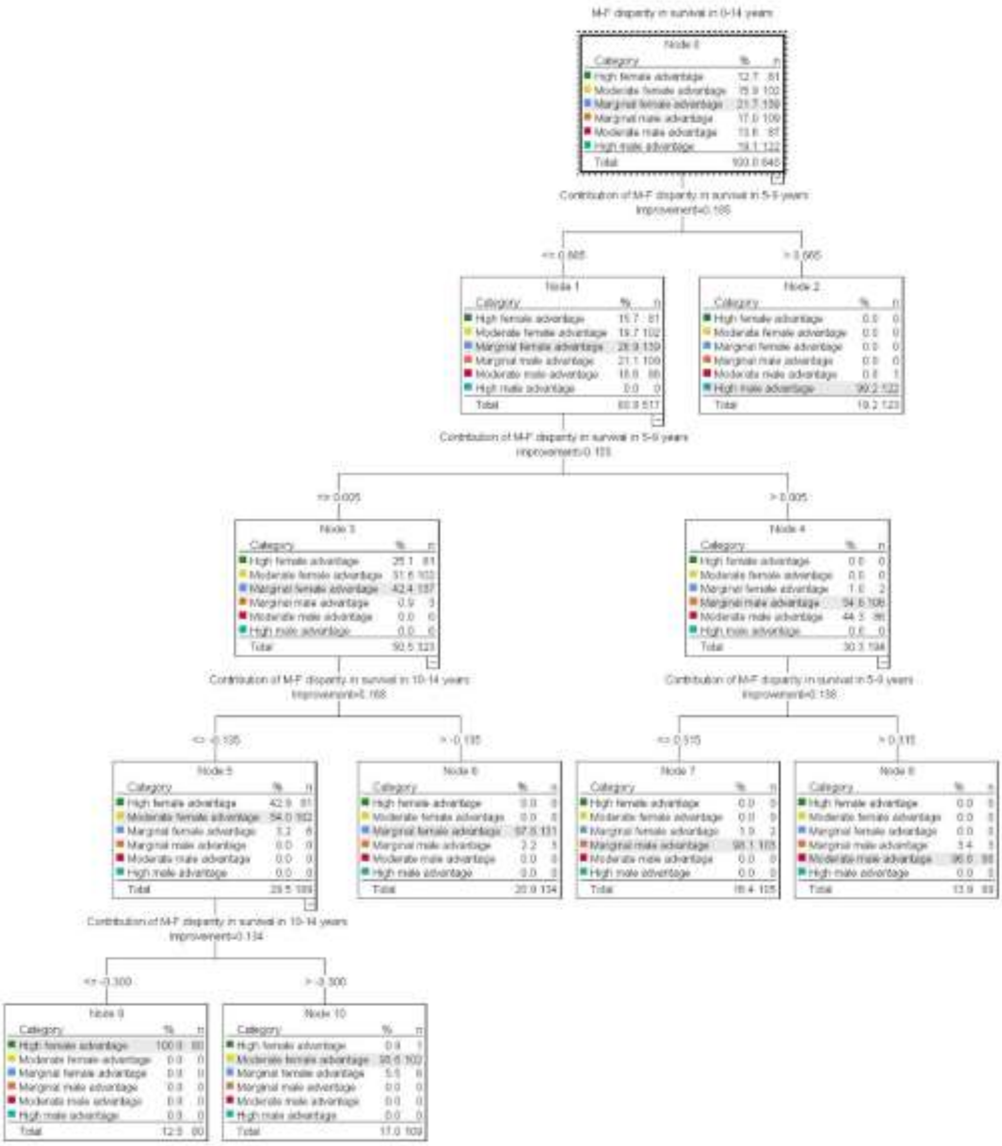

Figure 15: Classification of districts by male-female (M-F) disparity in survival (per 1000 live births) in 0-14 years of age by the contribution of M-F disparity in survival (per 1000 live births) in age groups 0-1 year, 1-4 years, 5-9 years, and 10-14 years.

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

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

Source: Author

Discussions and Conclusions

This paper follows a non-parametric approach to establish empirical 'normal' male female disparity in the probability of survival in the first 15 years of life across the districts of India. Based on district level estimates of the risk of death in the first 15 years of life derived from the summary birth history data from the 2011 population census, our analysis suggests that the empirical 'normal' male-female disparity in child survival up to 15 years of age in the country is marginal female survival advantage for the total population and for different population sub-groups. Deviations from this empirical 'normal' across the districts are substantial and in more than 60 per cent districts of the country, the male-female disparity in the probability of survival up to 15 years of age is quite marked. The analysis also reveals that districts having marked male survival advantage or marked female survival disadvantage are mostly located in the northern part of the country. There are states and Union Territories where there is not a single district with female survival advantage up to 15 years of age. Similarly, there are states and Union Territories where there is not a single district with male survival advantage. The analysis also reveals that there is substantial male-female disparity in the probability of survival within district across different mutually exclusive population sub-groups characterised by residence and social class. There are very few districts where there if female survival advantage in all mutually exclusive population groups in the district. Similarly, there are very few districts where there is male survival advantage in all mutually exclusive population sub-groups. In most of the districts of the country, female survival advantage or male survival disadvantage in 0-15 years of age in some population sub-groups is found to be associated with female survival disadvantage or male survival advantage in other population sub-groups. Moreover, the classification modelling exercise suggests that male-female disparity in survival in age groups 5-9 years and 10-14 years largely determines the male-female disparity in survival up to 15 years of age.

The findings of the present analysis have important policy and programme implications. It is obvious that a district-based approach is needed to address the male-female disparity in child survival. There is substantial within-district inequality in male-female disparity in child survival across mutually exclusive population sub-groups. This inequality needs to be taken into consideration while planning and programming for improving child survival at the district level by identifying factors that influence male-female disparity in survival differently in different population sub-groups within the same district. Finally, planning and programming for improving child survival and reducing male-female disparity in child survival should give particular attention to male-female disparity in survival in children older than 5 years of age as male-female disparity in survival in children above five years of age determine, substantially, male-female disparity in survival up to 15 years of age.

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Environmental Impact of Population, Affluence and Technology in India: 60 Years Perspective

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Abstract

This paper analyses the environmental impact of population growth, increase in affluence and technology development in terms of the increase in primary energy use and CO_2 emission in India during the period 1990 through 2050. The analysis has been carried out for two time periods - 1990-2020 and 2020-2050. The period 1990-2020 reflects the historical perspective of the environmental impact of population growth, increase in affluence and technology development while the period 2020-2050 depicts the likely environmental impact of the projected population growth, predicted increase in the affluence and future technology development in the country. The analysis reveals that the dominant contributor to the increase in primary energy use and CO_2 emission has been and is likely to be the increase in the affluence. The analysis also suggests that although, the direct contribution of the population growth to the increase in the primary energy use and CO_2 emission may not be large, yet its second order effects in conjunction with the increase in affluence has been and is likely to be quite substantive. The analysis also indicates that technology advancement had and is likely to have only a limited impact on environmental concerns in India.

Introduction

The estimates prepared by the Enerdata, an independent research agency that specialises in the analysis and forecasting of energy and climate issues, suggest that the CO_2 emission in India increased by more than four times from around 523 million tons in 1990 to almost 2200 million tons in 2020 (Enerdata, 2021). During the same period, the energy use in the country is estimated to have increased from around 306 to around 908 million tons of oil equivalent. In 1990, India accounted for an estimated 2.6 per cent of total CO_2 emission in the world. This proportion increased to 7.1 per cent in 2020. CO_2 is one of the greenhouse gases and is universally used as an indicator of the impact of human activity on the environment. The emission of the greenhouse gases such as CO_2 from human activities disturb the radiative energy balance of the atmosphere system of the planet Earth. They exacerbate the natural greenhouse effect, leading to temperature changes and other disruption in the climate of the Earth which may endanger the very life on the planet. CO_2 makes up the largest share of greenhouse gases and, therefore, is a key factor in the ability of any country to mitigate the climate change. Climate change is also a global concern for sustainable development. It threatens ecosystems and biodiversity, affects water resources, human settlements and the frequency and scale of extreme weather events, with significant consequences for the production of food grains, human well-being, socio-economic activities, and economic output.

From the analytical perspective, total CO_2 emission in a country may be conceptualised as the product of per capita CO_2 emission and the population of the country. The increase in population leads to the increase in CO_2 emission even if there is no change in per capita CO_2 emission. Similarly, an increase in per capita CO_2 emission may lead to an increase in total CO_2 emission even if there is either no increase or even a decrease in population. The change in per capita CO_2 emission, in turn may be conceptualised and in terms of per capita energy use and the carbon content of the fuel used to produce energy. If the carbon content of the fuel used for producing energy is high, then CO_2 emission from the same amount of energy used will be more than when the carbon content of the fuel used for producing energy is low. Finally, the energy used is determined by the energy intensity of the gross domestic product or energy used per unit gross domestic product and per capita gross domestic product (Baumert et al, 2005).

On the other hand, the change in the size and age composition of the population also influences CO_2 emission. It is well known that demographic transition results not only in an increase in the size of the population but also in the change in population age composition leading to the ageing of the population. There are studies that have attempted to analyse the impact of the change in the population age structure on CO_2 emission (Dalton et al, 2008; Liddle, 2011; Liddle and Lung, 2010; Menz and Kuhling, 2011; Menz and Welsch, 2012; Okada, 2012). Although the age composition of the population can have direct or indirect effect on CO_2 emission (Kim et al, 2020), yet, to the best of our knowledge, there is no study that have analysed how changes in the age composition of the population in India, as the result of demographic transition, have contributed to the change in CO_2 emission in the country. The change in population age composition may have direct impact on CO_2 emission through the change in energy use. At the same time, it may also have an indirect impact on CO_2 emission by hindering output growth and slowing down economic activities (Aksoy et al, 2019; Shirbekk, 2004).

According to the estimates prepared by the United Nations Population Division, India's population is estimated to have increased from around 873 million to more than 1380 million during the 30 years between 1990 and 2020 (United Nations, 2019). This increase in the population of the country has been associated with the change in the age composition of the population. The young dependency ratio, defined as the ratio of the population aged 0-14 years to the population aged 15-64 years, decreased from 652 to 389 persons aged 0-14 years for every 1000 persons aged 15-64 years while the potential support ratio defined as the ratio of the population aged 15-

64 years to the population aged 65 years and above, decreased from 15 persons aged 15-64 years per person aged 65 years and older to 10 persons aged 15-64 years per person aged 65 years and above between 1990 and 2020. At the same time, the ageing index, defined as the ratio of the population aged 65 years and above to the population aged 0-14 years increased from 0.100 to 0.251.

On the other hand, the per capita gross domestic product in the country is estimated to have increased from 1813 (US$ at constant exchange rate, price and purchasing power parities of the year 2017) in 1990 to 6714 in 2019 but decreased to 6118 in 2020 because of the slowing of economic activities in the country as the result of the COVID-19 pandemic. At the same time, it is estimated that the energy intensity of the gross domestic product in the country decreased from around 193 Kg of oil equivalent per US$ at constant exchange rate, price and purchasing power parities of the year 2017 in 1990 to around 102 in 2019 but increased to 106 in 2020 whereas the emission intensity or the carbon intensity of the gross domestic product decreased from 0.330 Kg of CO_2 emission per unit gross domestic product in 2019 to around 0.251 in 2019 but increased to almost 0.256 in 2020. The change in the population stock of the country along with changes in per capita gross domestic product and the energy intensity and emission intensity of gross domestic product suggests that the increase in CO_2 emission in the country during the period 1990 through 2020 should be examined in the context of the change in the population stock and the change in the per capita gross domestic product of the country.

In this paper, we analyse the increase in CO_2 emission in India in the context of the change in population stock and per capita gross domestic product to examine the environmental impact of the population, affluence, and technology in the country during the 30 years between 1990 and 2020 by adopting a factor decomposition approach. We also explore the likely environmental impact of future population growth and the increase in per capita gross domestic product in the country in the next 30 years in terms of the increase in CO_2 emission. The paper provides an empirical perspective that may be relevant to policy and planning for environmental sustainability in India in the next 30 years.

The paper is organised as follows. The next section of the paper describes the analytical framework used in the present analysis. We first examine the trend in CO_2 emission in the country during the 30 years between 1990 and 2020 following the conjecture that the trend may not be the same during the 30 years under reference. Based on the trend analysis, we apply the factor decomposition technique to measure the contribution of several factors that contribute to CO_2 emission. The third section of the paper describes the data sources used for the analysis. The fourth section of the paper presents findings of the analysis which have been presented in two parts – the historical perspective that describes the changes during the period 1990 through 2020 and the future perspective that describes likely changes during the period 2020 through 2050. The last section of the paper summarises the findings of the analysis and their policy implications in the context of sustainable development.

Analytical Framework

The analytical frame adopted for the present analysis comprises of two parts. The first part of the analysis analyses the trend in CO_2 emission in the country during the 30 years between 1990 and 2020. The underlying assumption of the trend analysis is that the trend might have changed during the 30 years under reference. To account for the changing trend in CO2 emission, we apply the joinpoint regression analysis. The joinpoint regression analysis first identifies the time point(s) or change point(s) when the trend in CO_2 emission has changed. Once the time point(s) when the trend has changed is(are) identified, the regression analysis between two change point(s) is carried out assuming linear trend between two change point(s). The joinpoint regression analysis is different from the conventional piece wise regression analysis in the sense that the time point(s) when the trend has changed is(are) fixed a priori in the piece wise regression analysis but identified from the data themselves in the joinpoint regression analysis. Actual calculations have been carried out using the Jointpoint Trend Analysis Software developed by the National Cancer Institute of National Institute of Health of United States of America (National Cancer Institute, 2020). The software requires setting, in advance, the minimum and maximum number of joinpoints. Details of joinpoint regression model and method adopted for identifying changes in the trend are given elsewhere (Kim et al, 2000) and repeated here.

The second part of the analysis focuses on the contribution of change in a set of demographic economic and technological factors to the change in CO_2 emission, *I*, during a given time-period. The change in *I* may be conceptualized as the product of per capita CO_2 emission and the size of the population, *P*. In other words,

$$I = \frac{I}{P} * P \tag{1}$$

Per capita CO_2 emission may, in turn, may now be broken down in terms of the carbon intensity of energy use which reflects the fuel mix used to produce energy, energy intensity of gross domestic product and per capita gross domestic product as follows

$$\frac{I}{P} = \frac{I}{E} * \frac{E}{G} * \frac{G}{P} \tag{2}$$

where ($i=I/E$) is the carbon intensity of energy consumption or emission per unit consumption of energy; ($e=E/G$) is the energy intensity of the gross domestic product, or the energy consumed per unit gross domestic product and G/P is the per capita gross domestic product.

The per capita gross domestic product can be obtained in terms of the labour productivity ($p=G/L$) and the ratio of the working age population to the total population as follows

$$\frac{G}{P} = \frac{G}{L} * \frac{L}{W} * \frac{W}{P} \tag{3}$$

where L is the labour force and W is the working age population. Equation (2) may now be expanded as

$$\frac{I}{P}=\frac{I}{E}*\frac{E}{G}*\frac{G}{L}*\frac{L}{W}*\frac{W}{P} \tag{4}$$

The ratio of the working age population to the total population is a measure of the age composition of the population which is popularly used to reflect the demographic dividend. It can be expanded further by taking into consideration, the ratio of the proportion of the old population to the total population so that equation (4) becomes

$$\frac{I}{P}=\frac{I}{E}*\frac{E}{G}*\frac{G}{L}*\frac{L}{W}*\frac{W}{O}*\frac{O}{P} \tag{5}$$

where the ratio ($s=W/O$) is the potential support ratio (United Nations, 2019) and ($o=O/P$) is the proportion of the old population. Equation (1) can now be expanded as

$$I=\frac{I}{E}*\frac{E}{G}*\frac{G}{L}*\frac{L}{W}*\frac{W}{O}*\frac{O}{P}*P, \text{ or}$$

$$I=i*e*p*l*s*o*P \tag{6}$$

Equation (6) suggests that CO_2 emission are influenced by seven factors, two of which, carbon intensity of energy consumption and energy intensity of gross domestic product, are related to the production technology while the third factor, (G/L) is the labour productivity which, in combination with the proportion of labour force to the working age population determines the level of affluence. Finally, potential support ratio and the proportion of the old population to the total population reflects the age composition of the population.

Using equation (6), the change in the CO_2 emission (I) can be decomposed as

$$\nabla I=I_2-I_1=(i_2*e_2*p_2*l_2*s_2*o_2*P_2)-(i_1*e_1*p_1*l_1*s_1*o_1*P_1) \tag{7}$$

It may be noticed that the logarithmic mean of I_2 and I_1 is defined as

$$LM=\frac{I_2-I_1}{ln(I_2/I_1)}=\frac{\nabla I}{ln(I_2/I_1)} \tag{8}$$

So that

$$\nabla I=LM*ln(I_2/I_1) \tag{9}$$

Or

$$\nabla I=LM*\left[\ln\left(\frac{i_2}{i_1}\right)+\ln\left(\frac{e_2}{e_1}\right)+\ln\left(\frac{p_2}{p_1}\right)+\ln\left(\frac{l_2}{l_1}\right)+\ln\left(\frac{s_2}{s_1}\right)+\ln\left(\frac{o_2}{o_1}\right)+\ln\left(\frac{P_2}{P_1}\right)\right] \tag{10}$$

Or

$$\nabla I=\partial_i+\partial_e+\partial_p+\partial_l+\partial_s+\partial_o+\partial_P \tag{11}$$

Equation (11) is a seven-factor decomposition model that may be used to analyse the change in CO_2 emission. It measures the impact of the change in population on the environment in terms of the change in the population stock – size and age composition – as the result of demographic transition which is captured in terms of the increase in population size and the change in the population age composition measured in terms of the proportion of the old population and the potential support ratio. On the other hand, the impact of the change in the affluence on the change in CO_2 emission is measured through the change in labour productivity and the change in the proportion of the working age population in the labour force. The two factors, in combination, determine the per capita output of the economy which reflects the level of affluence. Finally, the impact of the evolution of the technology on the environment in terms of the change in CO_2 emission is captured through the change in the energy intensity of the output of the economy and the change in the carbon or emission intensity of the energy used. The emission intensity of the energy used depends upon the fuel mix used to produce energy. The emission intensity is high when those fuels are used for producing energy which have high carbon content such as coal and petroleum products. On the other hand, the emission intensity of solar energy is zero which means that there is no CO_2 emission in the use of solar energy, irrespective of the size and age composition of the population and irrespective of the size of the economic activity. Equation (11) permits analysing how change in the population stock, change in the affluence and the evolution of the technology impacts the environment in terms of CO_2 emission.

Data

The analysis is based on the data taken from different secondary sources. Estimates and projection of the population of the country and the age composition of the population used in the present analysis have been prepared by the United Nations Population Division (United Nations, 2019). Estimates of the output of the economy or the gross domestic product have been taken from the world development indicators database prepared by the World Bank for the period 1990-2020. while forecasts of the gross domestic product are those that have been prepared by the Organization for Economic Cooperation and Development (OECD, 2021). Estimates of the labour force, on the other hand, are modelled estimates that have been prepared by the International Labour Organisation. Finally, estimates of total energy consumption and CO_2 emission are prepared by Enerdata, an independent energy intelligence and consulting company (Enerdata, 2021). Enerdata collects energy related country specific information from various sources and prepares and provides consistent, internationally comparable estimates of different dimensions of energy production, energy consumption and CO_2 emission in the world and in its different countries.

Table 1 presents the basic data used in the present analysis. The population of India is estimated to have increased from 873 million in 1990 to 1380 million in 2020 whereas the working age population increased from 509 million to 928 million during this period and the old age population increased from 33 million to 91 million. At the same time, the size of the labour force is estimated to have increased from 317 million in 1990 to 495 million in 2019 but decreased to 473 million in 2020. On the other hand, the gross domestic product per capita increased 1813 million to 6714 million between 1990 and 2019 international $ at constant exchange rate, price and purchasing power parities of the year 2017 but decreased to 6118 million in 2020.

Table 1: CO_2 emission in India and factors that determine CO_2 emission, 1990-2030.

Year	CO_2 emission Mt	Energy use Mtoe	Gross domestic product per capita $ 2017 ppp	Labour force Million	Working age population Million	Old age population Million	Population Million
1990	523	306	1813	317	509	33	873
1991	562	318	1795	324	520	34	891
1992	594	330	1856	331	532	36	909
1993	626	338	1906	339	545	37	927
1994	667	351	1994	348	558	38	946
1995	725	371	2105	356	572	39	964
1996	760	383	2221	363	585	40	982
1997	795	398	2268	371	599	42	1001
1998	813	407	2364	380	614	43	1019
1999	874	431	2528	388	628	45	1038
2000	912	441	2579	397	644	46	1057
2001	927	448	2657	407	658	48	1075
2002	956	462	2712	417	672	50	1093
2003	987	474	2877	428	687	51	1112
2004	1040	500	3055	438	702	53	1130
2005	1085	515	3245	449	718	54	1148
2006	1155	533	3453	452	732	56	1165
2007	1256	568	3662	455	747	58	1183
2008	1338	604	3720	457	761	59	1201
2009	1472	663	3956	460	776	61	1218
2010	1570	701	4235	463	791	63	1234
2011	1662	734	4400	464	806	65	1250
2012	1810	766	4583	465	820	67	1266
2013	1859	779	4819	469	835	69	1281
2014	2024	822	5117	473	850	71	1296
2015	2035	835	5464	477	864	74	1310
2016	2062	852	5851	481	878	77	1325
2017	2182	883	6183	485	891	80	1339
2018	2290	919	6519	488	903	84	1353
2019	2319	940	6714	495	916	87	1366
2020	2191	908	6118	472	928	91	1380

Sources: Enerdata; World Bank; International Labour Organization and United Nations Population Division.

Trend in CO_2 Emission

The CO_2 emission is India is estimated to have increased from 523 million tons in 1990 to 2319 million tonnes, in 2019 but decreased to 2191 million tonnes, in 2020. This means that, between 1990 and 2019, the CO_2 emission in the country increased by 1796 million tonnes. This increase in CO_2 has been associated with an increase in the emission intensity of energy use (*i*) from 1.711 in 1990 to almost 2.5 in 2018 but then the emission intensity of energy use decreased to around 2.412 whereas the energy intensity of the gross domestic product (*e*) decreased from around 193 in 1990 to 103 in 2019 but increased to 108 in 2020 (Table 2).

On the other hand, the productivity of the labour force (*p*) increased from around 5000 international $ at 2017 purchasing power parity in 1990 to 18543 international $ at 2017 purchasing power parity in 2020 while the ratio of the labour force to the working age population decreased from around 62 per cent in 1990 to around 54 per cent in 2018 but decreased to less than 51 per cent in 2020 because of the COVID-19 pandemic. Finally, the potential support ratio or the ratio of the working age population (15-64 years) to the old population (65 years and above) decreased from around 15 to around 10 during this period and the proportion of the old population increased from less than 4 per cent to almost 7 per cent during between 1990 and 2020 (Table 2).

It may be seen from table 1 that the increase in CO_2 emission in the country has not been uniform during the 30 years period under reference. The application of the joinpoint regression analysis informs that the trend in CO_2 emission in India changed four times during the 30 years between 1990 and 2020 (Table 3). During the period 1990 through1996, the annual percentage increase (API) in CO_2 emission in the country was 6.531 per cent which, however, decreased substantially to 3.914 per cent during the period 1996 through 2005. However, the API in CO_2 emission shot up to 7.658 per cent during the period 2005 through 2012 and then decreased to 3.960 per cent during the period 2012 through 2018. After 2018, CO_2 emission in the country decreased, instead increased, probably and so obviously because of the disruption of economic activities due to COVID-19 pandemic in the country and the lockdown measures taken to control the pandemic. For the entire period 1990 through 2020, the average annual percentage increase (AAPI) in CO_2 emission in the country was 4.949 per cent (Table 3). However, the rapid increase in CO2 emission during the 7 years period 2005-2012 accounted for more than 43 per cent of the total increase in CO_2 emission during the entire period 1990-2020. By comparison, the increase in CO_2 emission during the period 2012-2018 accounted for less than 30 per cent of the total increase in CO_2 emission during the 30 years between 1990 and 2020 whereas the increase in CO_2 emission during the period 1996 through 2005 accounted for less than 20 per cent of the total increase in CO_2 emission during the 30 years between 1990-2020. If the CO_2 emission in the country would have not increased very rapidly during the period 2005-2012, the total increase in CO_2 emission during the 30 years between 1990 and 2020 would have been substantially lower. It is clear from table 3 that the increase in CO2 emission in the country has not been linear during 1990-2020. The increase in CO2 emission has been substantially slower during 1996-2005 and during 2012-2018 compared to the increase during the period 1990-1996 and during the period 2005-2012.

Table 2: Contributors to CO2 emission in India, 1990-2020.

Year	Emission intensity of energy use	Energy intensity of gross domestic product	Gross domestic product per worker	Proportion of labour force to working age population	Potential support ratio	Proportion of old population
	i	*e*	*p*	*l*	*s*	*o*
1990	1.711	193	5001	0.623	15.3	0.038
1991	1.765	199	4940	0.623	15.1	0.039
1992	1.801	196	5091	0.623	15.0	0.039
1993	1.851	191	5208	0.623	14.9	0.040
1994	1.899	186	5422	0.623	14.8	0.040
1995	1.952	183	5702	0.622	14.7	0.040
1996	1.987	175	6002	0.621	14.5	0.041
1997	1.998	175	6111	0.620	14.3	0.042
1998	1.996	169	6348	0.619	14.2	0.042
1999	2.028	164	6759	0.618	14.1	0.043
2000	2.069	162	6865	0.617	14.0	0.044
2001	2.068	157	7022	0.618	13.7	0.045
2002	2.069	156	7109	0.620	13.6	0.045
2003	2.083	148	7479	0.622	13.4	0.046
2004	2.082	145	7876	0.624	13.3	0.047
2005	2.108	138	8293	0.626	13.2	0.047
2006	2.168	132	8907	0.617	13.0	0.048
2007	2.212	131	9529	0.609	12.9	0.049
2008	2.215	135	9764	0.601	12.8	0.050
2009	2.220	138	10467	0.593	12.7	0.050
2010	2.241	134	11291	0.585	12.6	0.051
2011	2.266	133	11862	0.576	12.5	0.052
2012	2.362	132	12482	0.567	12.3	0.053
2013	2.387	126	13156	0.562	12.2	0.054
2014	2.462	124	14006	0.557	12.0	0.055
2015	2.439	117	14999	0.552	11.7	0.056
2016	2.419	110	16107	0.548	11.4	0.058
2017	2.471	107	17082	0.544	11.1	0.060
2018	2.491	104	18083	0.540	10.8	0.062
2019	2.466	103	18543	0.540	10.5	0.064
2020	2.412	108	17900	0.508	10.2	0.066

Source: Author’s calculations based on table 1.

Table 3: Trend in CO_2 emission in India during 1990-2020. Results of joinpoint regression analysis

Period	Annual per cent increase (APC)	95% confidence interval		't'	'p'
		Lower	Upper		
1990-1996	6.531	5.801	7.267	19.396	< 0.001
1996-2005	3.914	3.462	4.367	18.606	< 0.001
2005-2012	7.658	6.922	8.399	22.708	< 0.001
2012-2018	3.960	3.008	4.920	8.912	< 0.001
2018-2020	-1.265	-5.868	3.563	-0.563	0.581
1990-2020	4.949	4.518	5.383	22.981	< 0.001

Source: Author's calculations

Decomposition of the Increase in CO_2 Emission

Table 4 decomposes the increase in CO_2 emission in the country during the period 1990-2020 into several factors that account for the change in CO_2 emission in conjunction with equation (11). This decomposition exercise suggests that the change in four factors – emission intensity of energy use (*i*), productivity of the labour force (*p*), proportion of the old population (*o*) and the size of the population (*P*) - had accounted for an increase of 3055 million tonnes in CO_2 emission in the country during the period 1990-2020 whereas the change in three factors – energy intensity of gross domestic product (*e*), proportion of workers in the working age population (*l*) and the potential support ratio (*s*) – had accounted for a decrease of 1387 million tonnes, in the CO_2 emission during this period so that the net increase in CO_2 emission in the country was 1668 million tonnes, during the period 1990-2020. The increase in the per capita gross domestic product, alone, accounted for an increase of 1416 million tonnes in CO_2 emission in the country during the period under reference. By comparison, technological advancement, reflected in terms of the change in the emission intensity of energy use (*i*) and energy intensity of gross domestic product (*e*) had resulted in a decrease of only 281 million tonnes in CO_2 emission during this period. On the other hand, increase in the size of the population and the ageing of population as the result of demographic transition accounted for an increase of 1170 million tonnes in CO_2 emission whereas the decrease in the potential support ratio had resulted in a decrease of 469 million tonnes in the CO_2 emission so that population factors accounted for an increase of 701 million tonnes in CO_2 emission in the country between 1990-2020. It is clear from the decomposition analysis that technology development in the country during the period 1990-2020 could hardly compensate for the increase in CO_2 emission resulting from the increase in the affluence or the gross domestic product per capita and the change in the population stock – increase in the size of the population and the change in the age composition of the population as reflected through the decrease in the potential support ratio.

Table 4 also decomposes the increase in CO_2 emission in the country during different time intervals of the period 1990-2020 in which the trend in CO_2 emission has been different as revealed through the joinpoint regression analysis. The very rapid increase in CO_2 emission during the period 2005-2012 appears to have been associated with a substantial increase in the emission intensity of the energy use and a very substantial slowdown in the decrease in the energy intensity of the gross domestic product. The emission intensity of energy use in the country increased, instead decreased, from 2.11 in 2005 to 2.36 in 2012. By comparison, the emission intensity of the energy use increased from 1.99 to 2.11 only during the period 1996-2005 and from 2.36 to 2.49 during the period 2012-2018. On the other hand, the energy intensity of the gross domestic product decreased only marginally from 138 in 2005 to 132 in 2012 compared to a rapid decrease from 175 to 138 during the period 1996-2005 and from 132 to 104 during the period 2012-2018. Moreover, the proportion of the labour force or workers to the working age population also decreased very rapidly from 63 per cent to 57 per cent during the period 2005-2012 whereas this proportion virtually remained unchanged during the period 1996-2005 while the decrease in this proportion slowed down during the period 2012-2018.

Table 4: Decomposition of the increase in CO_2 emission in India in different time periods

Increase in CO_2 emission attributed to the change in	Period					
	1990-1996	1996-2005	2005-2012	2012-2018	2018-2020	1990-2020
Emission intensity of energy use (∂i)	95	54	161	109	-72	400
Energy intensity of gross domestic product (∂e)	-61	-217	-64	-483	70	-681
Gross domestic output per worker (∂p)	116	295	579	756	-23	1485
Participation opportunity (∂l)	-1	7	-141	-98	-136	-237
Potential support ratio (∂s)	-34	-86	-99	-266	-122	-469
Proportion of old population (∂o)	49	130	150	327	138	637
Population size (∂P)	75	142	139	135	45	533
Total increase in CO_2 emission (∇I)	237	325	725	481	-99	1668

Source: Author's calculations

Projections for the Period 2020-2050

According to the medium variant of population projections prepared by the United Nations Population Division, the population of the country is likely to increase to more than 1639 million by the year 2050 (Table 5). This increase will be associated with a decrease in the potential support ratio to less than 5 working age persons for every old person and an increase in the proportion of old population to almost 14 per cent by the year 2050. At the same time, the gross domestic product per capita in the country is projected to increase to almost 21200 international $ at 2017 purchasing power parity. On the other hand, the energy intensity of the gross domestic product is projected to decrease to around 91 Koe per unit gross domestic product in 2036 and then increase to almost 100 Koe per unit gross domestic product by the year 2050. The emission intensity of energy use is, however, projected to decrease continuously to around 1.72 by the year 2050. These projections suggest that the CO_2 emission in the country will increase to almost 6000 Mt by the year 2050 or an increase of 3770 Mt in the next 30 years. The increase in affluence or the increase in per capita gross domestic product will account for an increase of 4680 Mt in CO_2 emission whereas the change in population stock will account for an increase of 677 Mt in CO_2 emission during the next 30 years. By comparison, it is projected that technological advancement leading to changes in the energy intensity of gross domestic product and the decrease in the emission intensity of energy use is expected to account for a decrease of around 1559 Mt in CO_2 emission during this period.

Table 5: Projected CO_2 emission by the year 2050 in India

Particulars	2020	2050	Increase during 2020-2050	Contribution to increase in CO_2 emission
Emission intensity of energy use (*i*)	2.412	1.725	-0.688	-1264
Energy intensity of gross domestic product (*e*)	108	99	-8	-295
Gross domestic output per worker (*p*)	16827	48728	31901	4005
Participation opportunity (*l*)	0.541	0.642	0.101	645
Potential support ratio (*s*)	10	5	-5	-2751
Proportion of old population (*o*)	0.066	0.138	0.072	2780
Population size (*P*)	1380	1639	259	648
CO_2 emission (*I*)	2191	5961	3770	

Source: Author's calculations

Discussions and Conclusions

The period 2005-2012 has been a period of unprecedented economic growth in India. It is estimated that the gross domestic product of the country increased at a rate close to 10 per cent per year during this period (Chaurasia, 2019). The present analysis suggests that this period has also been the period during which the increase in CO_2 emission also increased at an unprecedented rate. This period is also characterised by only a marginal improvement in the energy efficiency of the gross domestic product and a significant increase in the emission intensity of energy use which implies an increase in the proportion of high carbon content fuels in the fuel mix. Another notable feature of this period was a very substantial decrease in the opportunity for participation in the social and economic production system as reflected through the marked decrease in the ratio of the labour force or workers to the working age population. This means that the rapid increase in affluence during this period has not been energy efficient. From the perspective of the perspective of the environment, this period may be regarded as the worst period as more than 43 per cent of CO2 emission in the country during the 30 years between 1990 and 2020 has been confined to these seven years only. Reasons for only a marginal improvement in the energy efficiency of the gross domestic product during this period are not known at present as the energy efficiency again improved rapidly during the period 2012-2018.

The present analysis also suggests that technological developments appear to have contributed little towards mitigating the environmental impact of population and affluence in India during the last 30 years. Technology has repeatedly been argued to be the answer for addressing environmental problems including CO_2 emission as the emission intensity of energy use if determined by the carbon content of the fuel used for producing energy, the higher the carbon content, the higher the emission intensity and the higher the emission even if other factors determining emission remain unchanged. However, the experience of the last 30 years in India suggests that technological change has contributed little to mitigate the challenge of increasing CO_2 emission in the country as the result of increase in affluence and the increase in the population stock.

There also appears little hope that technological changes in the next 30 years will contribute in a significant manner the increase in CO_2 emission in the country. The increase in affluence is expected to lead to a significant increase in CO_2 emission in the country and the improvement in both energy efficiency of the gross domestic product and the emission efficiency of energy use is expected to compensate for this increase only marginally. On the other hand, the increase in the population in the coming years is almost inevitable. The country has achieved replacement fertility, but population of the country will continue to increase in the coming years because of the momentum for growth built in the age composition of the population which remains young. The increase in population attributed to population momentum cannot be checked. It can, at best be delayed by adopting appropriate population policy. This means that the only hope for the country to counter the environmental impact of the increase in affluence in the country is to shift to a low carbon content fuel mix to produce energy. This appears to be a daunting task as 80 per cent of energy needs of the country, today, is met by three high carbon content fuels – coal, oil, and solid biomass (International Energy Agency, 2021).

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Human Development Surface: An Alternative Approach to Measure Human Progress

Ravendra Singh

Abstract

This paper proposes an alternative approach for the construction of human development index which is based on the concept of human development surface. The proposed index is the weighted average of the power mean of the order ½ of the health index, education index and the income index which are used to construct the human development index by the United Nations and address problems associated with constructing the index using arithmetic mean or geometric mean as the aggregation function. The level of human development across countries based on the alternative human development index is found to be similar to that obtained by the conventional human development index. The decomposition of the increase in the index between 1990 and 2021 suggests that progress in the education index has been the main driver of human progress in the world during the last 30 years whereas the contribution of the progress in the health dimension and income dimension has been small.

Introduction

The Human Development Index (*HDI*) is the most widely used index to measure and monitor human progress across the globe. Introduced by the United Nations in 1990, it was a response to the need of a measure that could better represent human progress in several basic capabilities than the conventional income-based measures (Kelly, 1991; Anand and Sen, 1994; Haq, 1995). It is the only index of human progress which is available on an annual basis since 1990 to chart the progress in human well-being at the country level. Although, the method of constructing the index has evolved over time, yet its basic conceptualisation has remained unchanged right since 1990 (Kovacevic, 2010; Chaurasia, 2013). The *HDI* has been successful in changing the way people think about development. The *HDI* and its three components serve as a report card of human progress. A high rank in *HDI* is used by countries as a means of aggrandisement whereas a low rank is used to highlight development insufficiencies. The index has also been used to measure the impact of economic policies on the quality of life (Davis and Quinlivan, 2006). *HDI* is now a universally recognised as the standard yardstick to measure human progress and compare human development across countries. It has also been used to highlight inequality in development within countries.

The popularity of *HDI* lies in its simplicity and conceptual clarity in characterising development and to the underlying message that it gives that development is much more than economic growth.

Despite its popularity as a standard yardstick for measuring and comparing human progress, *HDI* has widely been criticised primarily on the grounds of both conceptual foundation and method of construction. A comprehensive review of the criticism of *HDI* is given elsewhere (Kovacevic, 2010; Klugman et al, 2011). A major concern in the construction of HDI has been the selection of the aggregation function to combine the indexes of the three dimensions of human development. Initially, the simple arithmetic mean was used to construct *HDI* but, since 2010, geometric mean is being used which embodies imperfect substitutability across different dimensions of *HDI* (United Nations, 2010). However, concerns about the appropriateness of the geometric mean to construct the *HDI* have been raised in a recent paper and it is recommended that simple arithmetic mean should be used in place of geometric mean to construct *HDI* (Anand, 2018). Another technical criticism of *HDI* relates to the implied trade-offs across the three dimensions of human development used to construct HDI. The magnitude of this trade-offs depends upon the aggregation function (Ghislandi et al, 2019). It is also observed that the three dimensions of human development are highly correlated and, therefore, *HDI* may not reveal more than what is revealed by its individual dimensions (Ghislandi et al, 2019). Another point of discord is the relative importance given to the three dimensions of human development in the construction of *HDI*. Currently, all the three dimensions of human development are given equal importance in the construction of *HDI*. It may, however, be argued that from the perspective of human progress, more importance should be accorded to that dimension in which the progress is lagging compared to that dimension in which the progress is advanced in the construction of *HDI*.

Selection of the aggregation function to combine indexes of the three dimensions of human development into *HDI* is arbitrary and many alternatives have been proposed including arithmetic mean and the geometric mean. One alternative is to use the power mean or the generalised mean (Bullen, 2003). The use of power mean ensures that as the progress in any one dimension of human development advances, its relative importance in deciding *HDI* diminishes. Anand and Sen (1995, 1997) have recommended use of the power mean for the construction of the gender-sensitive development index and the human poverty index. One limitation of the power mean, however, is that there is inescapable arbitrariness in the selection of the power of the mean (Anand and Sen, 1997). Sagar and Najam (1998), on the other hand, have suggested the multiplicative aggregation function while Mishra and Nathan (2013) have proposed additive inverse of normalised Euclidean distance from the ideal for combining the indexes of different dimensions of human development into *HDI*. It may, however, be noted that the choice of the aggregation function has an influence on the value of the *HDI*, although, the upper and lower limits of *HDI* remain invariant. Using the same values of the three indexes that constitute *HDI*, the value of *HDI* is the highest when simple arithmetic mean is used as the aggregation function and the lowest when the multiplicative aggregation function is used. When the geometric mean is used as the aggregation function, the value of *HDI* is lower than when simple arithmetic mean is used as the aggregation function but higher than when the multiplicative aggregation function is used. When the power of the generalised mean is used as the aggregation function, the value of *HDI* depends upon the power of the mean. There is, however, a degree of arbitrariness in selecting the power of the mean.

Alternatively, the three dimensions of human development can be represented on a plain to constitute the human development surface and then connecting the levels attained in each of the three dimensions by straight lines produces the human development triangle. The surface area of the triangle can be calculated to give a dimensionless, abstract mathematical expression of human development that encompasses progress in all the three dimensions of human development and may be termed as the 'surface measure of human development.' This approach of measuring human development has many advantages. First, it helps in the visualization of the progress in the three dimensions of human development which are interrelated. Second, the surface of the human development triangle may be perceived as an illustration of the human progress. Third, the change in human development between two points of time can be decomposed into the change in the progress in its three dimensions and the change in the surface area of the human development triangle reflects the overall human progress independently of countervailing effects of different dimensions of human development that might possibly have taken place. Fourth, the shape of the human development triangle and the surface area of the triangle can be used for comparisons across countries or regions.

In this paper, we develop an alternative index which is based on the concept of human development surface discussed above. The index, to be termed as *H* is based on the same three basic dimensions of human development – health, education, income - which have been used for the construction of *HDI* by the United Nations. We also compute the index *H* for 191 countries of the world for which *HDI* has been constructed by the United Nations and compare the index *H* with *HDI*. Our analysis shows that, although, the rank in the index *H* and the rank in *HDI* is the same in most of the countries, yet, there are many countries in which the rank in *H* is found to be different than the rank in *HDI*.

The paper is organised as follows. The next section of the paper describes the construction of the index *H*. Section three presents estimates of the index HDS along with estimates of *H* for the world, for selected regions of the world and for 191 countries for which estimates of *HDI*. Section four decomposes the change in the index HDS during the period 1990 through 2021 into the change attributed to health, education, and income to explore how progress in the three basic dimensions of human development - health, education and income has contributed to overall human progress as measured by the index *H*. The last section of the paper summarises the findings of the analysis along with the recommendation of using the concept of human development surface in measuring and monitoring human progress.

Surface Measure of Human Development

Figure 1 depicts the conceptual basis for the construction of the surface measure of human development. The three dimensions of human development – health, education, and income – are presented on a plane. All the three dimensions range from 0 to 1 and the level attained in health dimension (*h*), the level attained in education dimension (*e*), and the level attained in the income dimension (*I*) are linked by straight lines to constitute the human development triangle. This conceptualisation suggests that the surface area of the human development triangle or a suitable transformation of it may serve as the surface measure of human development.

It may be seen from the figure 1 that human development triangle comprises of three sub-triangles, one constituted by dimensions of education and health, the other by dimensions of health and income, and the third by the dimensions of income and education. All the three triangles have the same vertex and the angle at the vertex is the same for all three sub-triangles. This means that the area, *A*, of the human development triangle may be calculated as

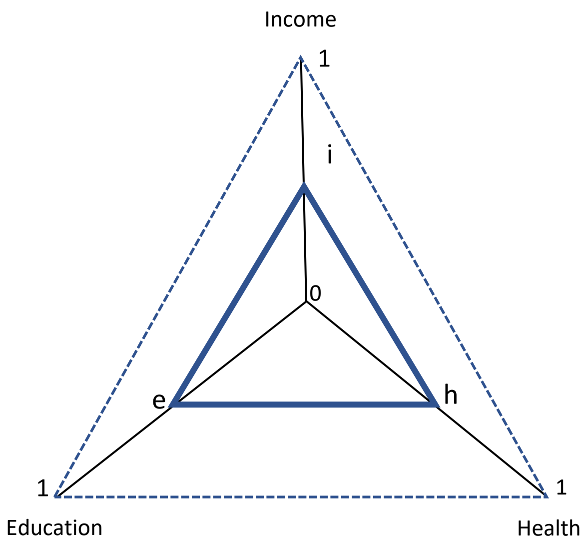

Figure 1: The human development triangle

$$A = \frac{h*e*\mathrm{Sin}(360^o/3)}{2} + \frac{e*i*\mathrm{Sin}(360^o/3)}{2} + \frac{i*h*\mathrm{Sin}(360^o/3)}{2} \qquad (1)$$

$$A = \frac{1}{2}(h*e + e*i + i*h)*\mathrm{Sin}(360^o/3) \qquad (2)$$

When h=e=i=0, A=0. When h=e=i=1, the area of the human development triangle is the maximum and is given by

$$A_{max} = \frac{1*1*\text{Sin}\ (360^o/3)}{2} + \frac{1*1*\text{Sin}\ (360^o/3)}{2} + \frac{1*1*\text{Sin}\ (360^o/3)}{2} = \frac{3}{2}\text{Sin}\ (360^o/3) \qquad (3)$$

Dividing (2) by (3), the normalised area of human development triangle, A_n, which varies between 0 (minimum) to 1 (maximum) is given by

$$A_n = \frac{A}{A_{max}} = \frac{\frac{1}{2}(h*e+e*i+i*h)*\text{Sin}(360^o/3)}{\frac{3}{2}\text{Sin}(360^o/3)} = \frac{(h*e+e*i+i*h)}{3} \qquad (4)$$

The normalised area of the human development triangle, A_n, can be used as an index of human development. However, the problem in using A_n is that the progress scale based on A_n is concave, not linear. With the increase in the three indexes that constitute A_n, the increase in A_n also increases. For example, when $h=e=i=0.200$, $A_n=0.040$ and when $h=e=i=0.300$, $A_n=0.090$ which means that an improvement of 0.100 in each of the three indexes leads to an increase of 0.050 in A_n, in absolute terms However, when $h=e=i=0.700$, $A_n=0.490$ and when $h=e=i=0.800$, $A_n=0.640$ so that the same improvement of 0.100 in each of the three indexes leads to an increase of 0.150 in the index A_n.

This problem associated with A_n can be addressed by using the positive square root of three indexes h, e, and i. This transformation also gives more weight to that dimension of human development in which the progress lags comparative to that dimension in which the progress is advanced. The alternative human development index, H, may now be defined as

$$H = \frac{(\sqrt{h*e})+(\sqrt{e*i})+(\sqrt{i*h})}{3} \qquad (5)$$

Notice that the index H may also be written as

$$H = h^{1/2} * \omega_h + e^{1/2} * \omega_e + i^{1/2} * \omega_i \qquad (6)$$

where

$$\omega_h = \frac{(\sqrt{e}+\sqrt{i})}{6} \qquad (7)$$

$$\omega_e = \frac{(\sqrt{h}+\sqrt{i})}{6} \qquad (8)$$

$$\omega_i = \frac{(\sqrt{h}+\sqrt{e})}{6} \qquad (9)$$

Equation (6) shows that the index H is the weighted power mean of the health index (h), education index (i), and the income index (i) with power of the mean equal to (1/2) as recommended by Anand and Sen (1997). The weights assigned to different dimensions of human development in the construction of the index H are data driven and dynamic and are different for different population. For example, the weight assigned to health index (h) is determined by the level attained in the dimension of education and in the dimension of income. This means that the construction of the index H also takes into account the association that exists between different dimensions of human development. Considering the association between different dimensions of human development is important as this association may vary from population to population. It is also obvious that when the level attained in the three dimensions of human development is the same or when h=e=i, then H is the simple arithmetic mean of the three indexes. This means that the difference between the maximum of the three index and the index H depicts the inequality in the level attained in the three dimensions of human development.

The change in the index H between two points of time can be decomposed in terms of the change in its three components. It follows from equation (5) that

$$H_2 - H_1 = \frac{\sqrt{h_2 * e_2} + \sqrt{e_2 * i_2} + \sqrt{i_2 * i_2}}{3} - \frac{\sqrt{h_1 * e_1} + \sqrt{e_1 * i_1} + \sqrt{i_1 * i_1}}{3} \tag{10}$$

$$H_2 - H_1 = \frac{1}{3}\{\sqrt{h_2 * e_2} - \sqrt{h_1 * e_1}\} + \frac{1}{3}\{\sqrt{e_2 * i_2} - \sqrt{e_1 * i_1}\} + \frac{1}{3}\{\sqrt{i_2 * h_2} - \sqrt{i_1 * h_1}\} \tag{11}$$

Now, following Kitagawa (1955)

$$\sqrt{h_2 * e_2} - \sqrt{h_1 * e_1} = \frac{1}{2}(\sqrt{h_2} - \sqrt{h_1}) * (\sqrt{e_2} + \sqrt{e_1}) + \frac{1}{2}(\sqrt{e_2} - \sqrt{e_1}) * (\sqrt{h_2} + \sqrt{h_1}) \tag{12}$$

$$\sqrt{e_2 * i_2} - \sqrt{e_1 * i_1} = \frac{1}{2}(\sqrt{e_2} - \sqrt{e_1}) * (\sqrt{i_2} + \sqrt{i_1}) + \frac{1}{2}(\sqrt{i_2} - \sqrt{i_1}) * (\sqrt{e_2} + \sqrt{e_1}) \tag{13}$$

$$\sqrt{i_2 * h_2} - \sqrt{i_1 * h_1} = \frac{1}{2}(\sqrt{i_2} - \sqrt{i_1}) * (\sqrt{h_2} + \sqrt{h_1}) + \frac{1}{2}(\sqrt{h_2} - \sqrt{h_1}) * (\sqrt{i_2} + \sqrt{i_1}) \tag{14}$$

Substituting from (12), (13) and (14) into (11) and rearranging, we get

$$H_2 - H_1 = \frac{1}{6}(\sqrt{h_2} - \sqrt{h_1}) * \{(\sqrt{e_1} + \sqrt{e_2}) + (\sqrt{i_1} + \sqrt{i_2})\} + \frac{1}{6}(\sqrt{h_2} + \sqrt{h_1}) * \{(\sqrt{e_1} - \sqrt{e_2}) + (\sqrt{i_1} + \sqrt{i_2})\} + \frac{1}{6}(\sqrt{h_2} + \sqrt{h_1}) * \{(\sqrt{e_1} + \sqrt{e_2}) + (\sqrt{i_1} - \sqrt{i_2})\} \tag{15}$$

or

$$H_2 - H_1 = (h_2 - h_i) * v_h + (e_2 - e_1) * v_e + (i_2 - i_1) * v_i \tag{16}$$

where

$$v_h = \frac{1}{6}\left\{\left(\frac{\sqrt{e_1} + \sqrt{e_2}}{\sqrt{h_1} + \sqrt{h_2}}\right) + \left(\frac{\sqrt{i_1} + \sqrt{i_2}}{\sqrt{h_1} + \sqrt{h_2}}\right)\right\} \tag{17}$$

$$v_e = \frac{1}{6}\left\{\left(\frac{\sqrt{h_1} + \sqrt{h_2}}{\sqrt{e_1} + \sqrt{e_2}}\right) + \left(\frac{\sqrt{i_1} + \sqrt{i_2}}{\sqrt{e_1} + \sqrt{e_2}}\right)\right\} \tag{18}$$

$$v_i = \frac{1}{6}\left\{\left(\frac{\sqrt{e_1} + \sqrt{e_2}}{\sqrt{i_1} + \sqrt{i_2}}\right) + \left(\frac{\sqrt{h_1} + \sqrt{h_2}}{\sqrt{i_2} + \sqrt{i_1}}\right)\right\} \tag{19}$$

Equation (16) shows that the difference in the index H between two points in time is the weighted sum of the difference in the health index (h), in the education index (e), and in the income index (i) with the weights for one index determines by the value of the other two indexes. When the three index are the same or when h=e=i, the difference in the index H between two points in time is nothing but the simple arithmetic mean of the difference between two points in time in the three indexes respectively.

Human Development Across Countries

We have calculated the index *H* for the world, for groups of countries with very high, high, medium, and low level of human development as classified by the United Nations, for different regions of the world as classified by United Nations, and for each country using the same values of the health index (*h*), the education index (*e*), and the income index (*i*) that have been used by the United Nations to calculate *HDI*. Table 1 presents estimates of *HDI* and the index *H* for the world and for different groups of countries and regions for the year 1990 and 2021 along with the summary measures of the inter-country variation in both indexes and the distribution of countries according to the level of human development. It may be seen from the table that the index *H* is higher than *HDI* in the world and in all groups of countries and regions of the world. However, the increase in the index *H* between 1990 and 2021 is more sedate than the increase in *HDI*. For example, in the Arab states, the *HDI* increased by 0.153 absolute points between 1990 and 2021, but the index *H* increased by only 0.148 absolute points. In Sub-Saharan Africa, on the other hand, *HDI* increased by 0.140 absolute points, but index *H* increased by 0.138 absolute points. It is obvious from the table that the selection of the aggregation function has an impact not only on the level of human development reflected by the composite index but also on the progress in human development. When the association between the three dimensions of human development is taken into consideration, the progress in human development (increase in the index *H*) appears to be slower than the progress in human development when the three indexes are treated independently of each other (increase in *HDI*). It is also clear that the difference in the level and the difference in the progress in human development based on the two indexes are different in different regions or groups of countries.

The index *H* and *HDI* are different in all the 191 countries for which *HDI* is estimated by the United Nations and in all countries, index *H* is higher than *HDI* (Table 2). However, the difference between the two indexes varies across countries. In Iceland, there is virtually no difference between the index *H* and *HDI*, although, the index *H* is marginally higher than *HDI* whereas this difference is the widest in Niger in the year 2021. The ranking of countries by the index *H* is also different from the ranking of countries by *HDI*, although, in most of the countries, the rank in index *H* is the same as the rank in *HDI* in the year 2021. There are, however, 40 countries where the rank in the index *H* in the year 2021 is not the same as the rank in *HDI*. In 21 of these countries, the rank in the index *H* is better than the rank in *HDI*, but in 19 countries, the rank in index *H* is poorer than the rank in *HDI*. On the other hand, the progress in human development during the period 1990 through 2021 as reflected by the increase in the index *H* is comparatively slower than the progress reflected by the increase in *HDI* in all but 13 countries. In these 13 countries, the progress in human development as reflected by the increase in the index *H* has been faster than the progress reflected by the increase in *HDI* between 1990 and 2021. There is no country where the progress in human development as reflected by the index *H* is the same as reflected by *HDI*.

Table 1: Estimates of the index *H*, and *HDI* for the world, for different groups of countries and for selected regions, 1990 and 2021.

World/Region	*HDI*		Index *H*	
	1990	2021	1990	2021
World	0.601	0.732	0.604	0.733
Countries with very high human development ($HDI \geq 0.800$)	0.784	0.896	0.785	0.896
Countries with high human development ($0.700 \leq HDI < 0.800$)	0.557	0.754	0.561	0.755
Countries with medium human development ($0.550 \leq HDI < 0.800$)	0.453	0.636	0.457	0.636
Countries with low human development ($HDI < 0.550$)	0.356	0.518	0.363	0.520
Regions				
Arab states	0.555	0.708	0.560	0.709
East Asia and Pacific	0.507	0.749	0.511	0.751
Europe and Central Asia	0.664	0.796	0.665	0.796
Latin America and the Caribbean	0.633	0.754	0.636	0.754
South Asia	0.442	0.632	0.446	0.633
Sub-Saharan Africa	0.407	0.547	0.410	0.547
Summary measures of inter-country distribution				
Minimum	0.216	0.385	0.230	0.388
Q1	0.479	0.599	0.483	0.601
Median	0.627	0.739	0.629	0.739
Q3	0.728	0.835	0.730	0.836
Maximum	0.872	0.962	0.872	0.962
IQR	0.248	0.236	0.247	0.235
Frequency distribution				
Countries with very high human development ($HDI \geq 0.800$)	16	66	16	66
Countries with high human development ($0.700 \leq HDI < 0.800$)	31	49	31	49
Countries with medium human development ($0.550 \leq HDI < 0.800$)	46	44	46	45
Countries with low human development ($HDI < 0.550$)	49	32	49	31
N	142	191	142	191

Source: Estimates of *HDI* are from United Nations database. Estimates of the index *H* are author's calculations.

Table 2: Estimates of *HDI* and index *H* for 191 countries, 1990 and 2021 and the increase in the two indexes between 1990 and 2021.

Country	*HDI*		Index *H*		Increase in	
	1990	2021	1990	2021	*HDI*	Index *H*
Afghanistan	0.273	0.478	0.291	0.480	0.205	0.190
Angola	na	0.586	na	0.586	na	na
Albania	0.647	0.796	0.649	0.797	0.150	0.148
Andorra	na	0.858	na	0.859	na	na
United Arab Emirates	0.728	0.911	0.737	0.911	0.183	0.174
Argentina	0.723	0.842	0.724	0.842	0.119	0.118
Armenia	0.656	0.759	0.657	0.760	0.103	0.103
Antigua and Barbuda	na	0.788	na	0.789	na	na
Australia	0.865	0.951	0.865	0.951	0.085	0.086
Austria	0.825	0.916	0.826	0.916	0.090	0.090
Azerbaijan	na	0.745	na	0.745	na	na
Burundi	0.290	0.426	0.295	0.431	0.137	0.137
Belgium	0.816	0.937	0.817	0.937	0.121	0.120
Benin	0.359	0.525	0.368	0.526	0.166	0.158
Burkina Faso	na	0.449	na	0.452	na	na
Bangladesh	0.397	0.661	0.401	0.662	0.264	0.261
Bulgaria	0.684	0.795	0.686	0.795	0.111	0.109
Bahrain	0.742	0.875	0.747	0.875	0.133	0.129
Bahamas	na	0.812	na	0.812	na	na
Bosnia and Herzegovina	na	0.780	na	0.780	na	na
Belarus	na	0.808	na	0.808	na	na
Belize	0.593	0.683	0.597	0.684	0.090	0.087
Bolivia (Plurinational State of)	0.550	0.692	0.550	0.692	0.142	0.142
Brazil	0.610	0.754	0.613	0.754	0.144	0.141
Barbados	0.725	0.790	0.726	0.790	0.064	0.064
Brunei Darussalam	0.770	0.829	0.775	0.831	0.059	0.056
Bhutan	na	0.666	na	0.668	na	na
Botswana	0.586	0.693	0.587	0.694	0.107	0.106
Central African Republic	0.338	0.404	0.342	0.405	0.066	0.063
Canada	0.860	0.936	0.860	0.936	0.077	0.076
Switzerland	0.851	0.962	0.853	0.962	0.111	0.110
Chile	0.706	0.855	0.707	0.855	0.149	0.148
China	0.484	0.768	0.489	0.770	0.284	0.281
Cote D'Ivoire	0.427	0.550	0.430	0.551	0.124	0.122
Cameroon	0.452	0.576	0.455	0.577	0.124	0.121
Congo (Democratic Republic of the)	0.386	0.479	0.387	0.481	0.093	0.094
Congo	0.522	0.571	0.523	0.572	0.049	0.049
Colombia	0.610	0.752	0.614	0.752	0.142	0.139
Comoros	na	0.558	na	0.560	na	na
Cabo Verde	na	0.662	na	0.664	na	na

Country	*HDI*		Index *H*		Increase in	
	1990	2021	1990	2021	*HDI*	Index *H*
Costa Rica	0.660	0.809	0.665	0.809	0.148	0.144
Cuba	0.680	0.764	0.682	0.765	0.083	0.083
Cyprus	0.716	0.896	0.719	0.896	0.180	0.176
Czechia	0.742	0.889	0.744	0.889	0.147	0.146
Germany	0.829	0.942	0.829	0.942	0.113	0.113
Djibouti	na	0.509	na	0.515	na	na
Dominica	na	0.720	na	0.721	na	na
Denmark	0.834	0.948	0.835	0.948	0.114	0.113
Dominican Republic	0.577	0.767	0.580	0.768	0.191	0.187
Algeria	0.591	0.745	0.596	0.747	0.154	0.151
Ecuador	0.651	0.740	0.652	0.740	0.089	0.088
Egypt	0.572	0.731	0.574	0.731	0.159	0.157
Eritrea	na	0.492	na	0.497	na	na
Spain	0.757	0.905	0.760	0.905	0.148	0.146
Estonia	0.732	0.890	0.733	0.890	0.158	0.158
Ethiopia	na	0.498	na	0.502	na	na
Finland	0.814	0.940	0.815	0.940	0.126	0.125
Fiji	0.642	0.730	0.643	0.731	0.088	0.088
France	0.791	0.903	0.793	0.903	0.112	0.110
Micronesia (Federated States of)	na	0.628	na	0.629	na	na
Gabon	0.610	0.706	0.613	0.706	0.096	0.093
United Kingdom	0.804	0.929	0.805	0.929	0.124	0.123
Georgia	na	0.802	na	0.802	na	na
Ghana	0.460	0.632	0.461	0.632	0.172	0.171
Guinea	0.269	0.465	0.282	0.468	0.195	0.186
Gambia	0.343	0.500	0.353	0.503	0.157	0.150
Guinea-Bissau	na	0.483	na	0.485	na	na
Equatorial Guinea	na	0.596	na	0.598	na	na
Greece	0.759	0.887	0.762	0.887	0.128	0.125
Grenada	na	0.795	na	0.795	na	na
Guatemala	0.484	0.627	0.492	0.630	0.144	0.138
Guyana	0.509	0.714	0.511	0.715	0.205	0.204
Hong Kong, China (SAR)	0.788	0.952	0.790	0.952	0.164	0.163
Honduras	0.516	0.621	0.521	0.623	0.105	0.102
Croatia	na	0.858	na	0.858	na	na
Haiti	0.429	0.535	0.433	0.536	0.106	0.103
Hungary	0.720	0.846	0.721	0.846	0.126	0.125
Indonesia	0.526	0.705	0.529	0.705	0.179	0.176
India	0.434	0.633	0.437	0.634	0.199	0.197
Ireland	0.737	0.945	0.740	0.946	0.208	0.205
Iran (Islamic Republic of)	0.601	0.774	0.603	0.774	0.173	0.171
Iraq	0.528	0.686	0.531	0.687	0.159	0.156

Country	*HDI*		Index *H*		Increase in	
	1990	2021	1990	2021	*HDI*	Index *H*
Iceland	0.811	0.959	0.812	0.959	0.148	0.147
Israel	0.787	0.919	0.788	0.919	0.132	0.131
Italy	0.778	0.895	0.781	0.895	0.116	0.114
Jamaica	0.659	0.709	0.662	0.709	0.050	0.048
Jordan	0.622	0.720	0.625	0.721	0.098	0.097
Japan	0.845	0.925	0.846	0.925	0.080	0.079
Kazakhstan	0.673	0.811	0.674	0.811	0.138	0.137
Kenya	0.474	0.575	0.478	0.575	0.101	0.097
Kyrgyzstan	0.638	0.692	0.638	0.693	0.054	0.055
Cambodia	0.378	0.593	0.382	0.596	0.215	0.214
Kiribati	na	0.624	na	0.625	na	na
Saint Kitts and Nevis	na	0.777	na	0.778	na	na
Korea (Republic of)	0.737	0.925	0.738	0.925	0.187	0.187
Kuwait	0.718	0.831	0.725	0.833	0.112	0.108
Lao People's Democratic Republic	0.405	0.607	0.408	0.610	0.202	0.202
Lebanon	na	0.706	na	0.708	na	na
Liberia	na	0.481	na	0.483	na	na
Libya	0.666	0.718	0.668	0.720	0.053	0.051
Saint Lucia	0.690	0.715	0.691	0.716	0.025	0.025
Liechtenstein	na	0.935	na	0.936	na	na
Sri Lanka	0.636	0.782	0.639	0.782	0.145	0.144
Lesotho	0.479	0.514	0.481	0.514	0.035	0.033
Lithuania	0.734	0.875	0.734	0.875	0.141	0.140
Luxembourg	0.786	0.930	0.791	0.930	0.144	0.140
Latvia	0.730	0.863	0.730	0.863	0.134	0.133
Morocco	0.447	0.683	0.458	0.684	0.235	0.227
Moldova (Republic of)	0.653	0.767	0.656	0.767	0.114	0.111
Madagascar	na	0.501	na	0.505	na	na
Maldives	na	0.747	na	0.750	na	na
Mexico	0.662	0.758	0.665	0.758	0.096	0.093
Marshall Islands	na	0.639	na	0.640	na	na
North Macedonia	na	0.770	na	0.770	na	na
Mali	0.237	0.428	0.256	0.433	0.191	0.177
Malta	0.730	0.918	0.733	0.918	0.188	0.185
Myanmar	0.333	0.585	0.338	0.586	0.252	0.248
Montenegro	na	0.832	na	0.832	na	na
Mongolia	0.579	0.739	0.579	0.739	0.160	0.160
Mozambique	0.238	0.446	0.242	0.448	0.208	0.207
Mauritania	0.397	0.556	0.414	0.559	0.159	0.145
Mauritius	0.626	0.802	0.629	0.802	0.176	0.173
Malawi	0.303	0.512	0.304	0.515	0.209	0.210
Malaysia	0.640	0.803	0.644	0.803	0.163	0.159

Country	*HDI*		Index *H*		Increase in	
	1990	2021	1990	2021	*HDI*	Index *H*
Namibia	0.579	0.615	0.581	0.615	0.036	0.035
Niger	0.216	0.400	0.230	0.407	0.185	0.177
Nigeria	na	0.535	na	0.535	na	na
Nicaragua	0.490	0.667	0.494	0.669	0.177	0.175
Netherlands	0.847	0.941	0.847	0.941	0.094	0.094
Norway	0.838	0.961	0.838	0.961	0.123	0.123
Nepal	0.399	0.602	0.403	0.603	0.202	0.201
New Zealand	0.806	0.937	0.806	0.937	0.131	0.131
Oman	na	0.816	na	0.816	na	na
Pakistan	0.400	0.544	0.412	0.548	0.144	0.136
Panama	0.669	0.805	0.671	0.806	0.137	0.135
Peru	0.621	0.762	0.621	0.762	0.142	0.141
Philippines	0.598	0.699	0.599	0.699	0.101	0.100
Palau	na	0.767	na	0.767	na	na
Papua New Guinea	0.370	0.558	0.383	0.560	0.187	0.177
Poland	0.716	0.876	0.717	0.876	0.160	0.160
Portugal	0.701	0.866	0.706	0.866	0.165	0.160
Paraguay	0.595	0.717	0.599	0.718	0.123	0.119
Palestine, State of	na	0.715	na	0.716	na	na
Qatar	0.758	0.855	0.764	0.857	0.097	0.094
Romania	0.703	0.821	0.704	0.821	0.118	0.118
Russian Federation	0.743	0.822	0.744	0.823	0.079	0.079
Rwanda	0.319	0.534	0.322	0.537	0.215	0.214
Saudi Arabia	0.678	0.875	0.686	0.875	0.197	0.189
Sudan	0.336	0.508	0.348	0.513	0.171	0.166
Senegal	0.373	0.511	0.384	0.517	0.138	0.132
Singapore	0.727	0.939	0.733	0.939	0.212	0.206
Solomon Islands	na	0.564	na	0.567	na	na
Sierra Leone	0.312	0.477	0.317	0.479	0.165	0.162
El Salvador	0.525	0.675	0.529	0.676	0.150	0.147
San Marino	na	0.853	na	0.855	na	na
Serbia	na	0.802	na	0.802	na	na
South Sudan	na	0.385	na	0.388	na	na
Sao Tome and Principe	0.485	0.618	0.488	0.619	0.134	0.132
Suriname	na	0.730	na	0.730	na	na
Slovakia	0.692	0.848	0.694	0.848	0.156	0.154
Slovenia	na	0.918	na	0.918	na	na
Sweden	0.810	0.947	0.812	0.947	0.137	0.135
Eswatini (Kingdom of)	0.545	0.597	0.548	0.597	0.052	0.049
Seychelles	na	0.785	na	0.785	na	na
Syrian Arab Republic	0.562	0.577	0.567	0.582	0.014	0.015
Chad	na	0.394	na	0.396	na	na

Country	*HDI*		Index *H*		Increase in	
	1990	2021	1990	2021	*HDI*	Index *H*
Togo	0.410	0.539	0.413	0.540	0.129	0.128
Thailand	0.576	0.800	0.582	0.801	0.224	0.219
Tajikistan	0.628	0.685	0.628	0.686	0.057	0.058
Turkmenistan	na	0.745	na	0.745	na	na
Timor-Leste	na	0.607	na	0.609	na	na
Tonga	0.645	0.745	0.645	0.746	0.100	0.100
Trinidad and Tobago	0.660	0.810	0.661	0.810	0.150	0.149
Tunisia	0.576	0.731	0.581	0.732	0.156	0.151
Turkey	0.600	0.838	0.606	0.838	0.238	0.232
Tuvalu	0.559	0.641	0.559	0.641	0.083	0.082
Tanzania (United Republic of)	0.371	0.549	0.374	0.551	0.177	0.177
Uganda	0.329	0.525	0.331	0.527	0.196	0.196
Ukraine	0.729	0.773	0.729	0.773	0.044	0.043
Uruguay	0.701	0.809	0.702	0.809	0.108	0.107
United States	0.872	0.921	0.872	0.921	0.049	0.050
Uzbekistan	na	0.727	na	0.727	na	na
Saint Vincent and the Grenadines	na	0.751	na	0.751	na	na
Venezuela (Bolivarian Republic of)	0.659	0.691	0.664	0.693	0.032	0.028
Viet Nam	0.482	0.703	0.488	0.704	0.221	0.216
Vanuatu	na	0.607	na	0.609	na	na
Samoa	na	0.707	na	0.708	na	na
Yemen	0.383	0.455	0.396	0.459	0.072	0.063
South Africa	0.632	0.713	0.633	0.714	0.081	0.080
Zambia	0.412	0.565	0.412	0.566	0.153	0.153
Zimbabwe	0.509	0.593	0.510	0.593	0.084	0.083

Source: Author
Remarks: na – Not available

Decomposition of the Progress in Human Development

The progress in human development, during 1990-2021, as measured by the increase in the index *H* has varied widely across the countries included in the analysis. The progress could be measured in only 142 countries for which estimates of the index *H* could be calculated for both the years 1990 and 2021. In the remaining countries, data are not available to estimate the index *H* for the year 1990. These estimates suggests that the increase in the index *H* has been slowest in the Syrian Arab Republic where the index *H* increased by just 0.015 absolute points, from 0.567 in 1990 to 0.582 in 2021. In addition to the Syrian Arab Republic, there are 5 more countries where there has been virtual little progress in human development between 1990 and 2021 as the increase in the index *H*, in these countries has been less than 0.005 absolute points. On the other hand, the increase in the index *H* has been the most rapid in China where it increased by almost 0.231 absolute points, from 0.489 in 1990 to 0.770 in 2021. In addition to China, there are 7 countries where the index *H* increase by at least 0.200 absolute points between 1990 and 2021.

The increase in the three dimensions that constitute the index *H* has also varied across countries. The health index decreased, instead increased, in 9 countries. The decrease in the index has been the most rapid in Lesotho where it decreased by almost 0.030 absolute points as the result of the decreased in the life expectancy at birth from around 59 years in 1990 to 53 years in 2021. On the other hand, the increase in the health index has been the most rapid in Malawi where the life expectancy at birth increased from around 43 years in 1990 to almost 63 years in 2021, an increase of almost 20 years. The education index did not decrease in any country during this period but the increase in the index has been the slowest in the Syrian Arab Republic but the highest in Turkey. Finally, the income index decreased in 19 countries with the decrease in the index being the most marked in the Bolivarian Republic of Venezuela whereas the increase in the index has been the most rapid in China, the most populous country of the world.

Equation (16) permits analysing how the change in the three dimensions of health, education and income that constitute the index *H* has contributed to the change in the index *H* between 1990 and 2021. Results of the decomposition analysis are presented in table 3 which suggests that the progress in human development during 1990-2021 has largely been driven by the progress in the education dimension of human welfare. For example, in the world, almost 57 per cent of the increase in the index *H* between 1990 and 2021 may be attributed to the increase in the education index (*e*) during this period whereas the increase in the health index (*h*) has accounted for an increase of almost 23 per cent in the index *H*. This means that the increase in the income index (*i*) between 1990 and 2021 has accounted for only around 20 per cent of the increase in the index *H*. In all regions and all groups of countries, progress in education dimension has been the prime driver of human progress. The contribution of the increase in income to the increase in human progress has been substantial in countries having high and medium level of human development. The increase in the health index has not been a dominating contributor in any region or in any group of countries.

The contribution of the change in the three components of human development to the change in the index *H* has been different in countries at different level of human development, although the primary contributor has been the change in the education index (*e*). In countries having at very high level of human development in 2021 ($HDI \geq 0.800$), and in countries at low level of human development ($HDI < 0.550$), almost 60 per cent of the increase in the index *H* is attributed to the increase in the index (*e*). By contrast, the increase in the income index (*i*) accounts for less than 20 per cent of the increase in the index *H* in countries at very high level of human development but only about 10 per cent in country at low level of human development. In countries at high level of human development ($0.700 \leq HDI < 0.800$) and in countries at medium level of human development (0.550≤*HDI*<0.700), increase in the education index accounts for only about 50 per cent of the increase in the index *H*, but the increase in the income index (*i*) accounts for a substantial increase in the index *H*. In these countries, the contribution of the increase in the index (*h*) to the increase in the index *H* is substantially lower than that in countries at very high or at low level of human development.

Table 3: Decomposition of the change in the index *H* between 1990 and 2021 in the world and in different groups of countries and regions.

World/Country groups/Region	Index *H*			Increase in *H* attributed to		
	1990	2021	Increase	*h*	*e*	*I*
World	0.604	0.733	0.129	0.029	0.074	0.026
Very high human development	0.785	0.896	0.111	0.024	0.066	0.022
High human development	0.561	0.755	0.194	0.033	0.098	0.063
Medium human development	0.457	0.636	0.180	0.038	0.092	0.049
Low human development	0.363	0.520	0.157	0.048	0.093	0.017
Arab States	0.560	0.709	0.148	0.037	0.096	0.015
East Asia and the Pacific	0.511	0.751	0.239	0.036	0.103	0.100
Europe and Central Asia	0.665	0.796	0.131	0.025	0.082	0.024
Latin America and the Caribbean	0.636	0.754	0.118	0.021	0.081	0.017
South Asia	0.446	0.633	0.187	0.039	0.095	0.053
Sub-Saharan Africa	0.410	0.547	0.138	0.048	0.078	0.012

Source: Author

The contribution of the change in the three dimensions of human development to the change in the overall human development as measured in terms of the index *H* is different in different regions of the world. In the East Asia and Pacific region, the progress in the education dimension and the progress in the income dimension has accounted for almost 85 per cent of the progress in human development during 1990-2021 whereas the progress in the health dimension has accounted for only about 15 per cent of the progress. On the other hand, in Arab states and in Latin America and the Caribbean, around two-third of the progress in human development is accounted by the progress in the education dimension alone whereas in sub-Saharan Africa, progress in the income dimension has accounted for less than 10 per cent of the progress in huma development. There is, however, no group of countries or no region of the world where the progress in the health dimension has been the main contributor to the progress in human development whereas the progress in the education dimension has been the main contributor to the progress in human development in all groups of countries irrespective of the level of human development and in all regions of the world between 1990 and 2021. The relative contribution of the change in indexes *h*, *e*, and *i* to the change in the index *H* during 1990-2021 has also been different in different countries (Table 4). There is no country where the contribution of the increase in the income index (*i*) has been more than 60 per cent of the increase in the index *H* whereas, there are only 3 countries where the contribution of the increase in the health index (*h*) to the index *H* has been more than 60 per cent. By contrast, there are 78 countries where the contribution of the increase in the education index (e) to the increase in the index H has been more than 60 per cent. The decomposition exercise confirms that, in most of the countries, the progress in human development has been driven primarily by the progress in the education dimension of human development.

Table 4: Decomposition of the increase in the index H between 1990 and 2021 into the increase attributed to the increase in the health index, education index and income index.

World/Country groups/Region	Index H			Increase in H attributed to the increase in		
	1990	2021	Increase	h	e	i
Afghanistan	0.291	0.480	0.190	0.066	0.141	-0.017
Albania	0.649	0.797	0.148	0.015	0.074	0.059
United Arab Emirates	0.737	0.911	0.174	0.034	0.148	-0.008
Argentina	0.724	0.842	0.118	0.018	0.079	0.022
Armenia	0.657	0.760	0.103	0.015	0.038	0.049
Australia	0.865	0.951	0.086	0.038	0.021	0.027
Austria	0.826	0.916	0.090	0.029	0.045	0.015
Burundi	0.295	0.431	0.137	0.067	0.093	-0.023
Belgium	0.817	0.937	0.120	0.029	0.074	0.016
Benin	0.368	0.526	0.158	0.028	0.108	0.022
Bangladesh	0.401	0.662	0.261	0.069	0.126	0.065
Bulgaria	0.686	0.795	0.109	0.002	0.075	0.033
Bahrain	0.747	0.875	0.129	0.030	0.100	-0.002
Belize	0.597	0.684	0.087	-0.001	0.073	0.015
Bolivia (Plurinational State of)	0.550	0.692	0.142	0.037	0.073	0.031
Brazil	0.613	0.754	0.141	0.032	0.093	0.016
Barbados	0.726	0.790	0.064	0.023	0.047	-0.005
Brunei Darussalam	0.775	0.831	0.056	0.015	0.046	-0.004
Botswana	0.587	0.694	0.106	0.003	0.072	0.031
Central African Republic	0.342	0.405	0.063	0.018	0.060	-0.015
Canada	0.860	0.936	0.076	0.026	0.032	0.019
Switzerland	0.853	0.962	0.110	0.033	0.071	0.006
Chile	0.707	0.855	0.148	0.030	0.069	0.049
China	0.489	0.770	0.281	0.043	0.106	0.132
Cote D'Ivoire	0.430	0.551	0.122	0.028	0.065	0.029
Cameroon	0.455	0.577	0.121	0.026	0.091	0.005
Congo (Democratic Republic of the)	0.387	0.481	0.094	0.047	0.071	-0.025
Congo	0.523	0.572	0.049	0.036	0.034	-0.021
Colombia	0.614	0.752	0.139	0.019	0.090	0.029
Costa Rica	0.665	0.809	0.144	0.002	0.105	0.037
Cuba	0.682	0.765	0.083	-0.002	0.062	0.022
Cyprus	0.719	0.896	0.176	0.037	0.119	0.020

World/Country groups/Region	Index H			Increase in H attributed to the increase in		
	1990	2021	Increase	h	e	i
Czechia	0.744	0.889	0.146	0.032	0.088	0.026
Germany	0.829	0.942	0.113	0.027	0.066	0.019
Denmark	0.835	0.948	0.113	0.033	0.055	0.025
Dominican Republic	0.580	0.768	0.187	0.026	0.107	0.054
Algeria	0.596	0.747	0.151	0.040	0.099	0.012
Ecuador	0.652	0.740	0.088	0.020	0.053	0.015
Egypt	0.574	0.731	0.157	0.029	0.094	0.034
Spain	0.760	0.905	0.146	0.029	0.099	0.018
Estonia	0.733	0.890	0.158	0.037	0.071	0.050
Finland	0.815	0.940	0.125	0.035	0.072	0.017
Fiji	0.643	0.731	0.088	0.008	0.071	0.008
France	0.793	0.903	0.110	0.027	0.068	0.015
Gabon	0.613	0.706	0.093	0.028	0.075	-0.010
United Kingdom	0.805	0.929	0.123	0.025	0.080	0.019
Ghana	0.461	0.632	0.171	0.038	0.088	0.045
Guinea	0.282	0.468	0.186	0.049	0.112	0.025
Gambia	0.353	0.503	0.150	0.045	0.106	-0.001
Greece	0.762	0.887	0.125	0.013	0.103	0.008
Guatemala	0.492	0.630	0.138	0.029	0.087	0.022
Guyana	0.511	0.715	0.204	0.015	0.070	0.119
Hong Kong, China (SAR)	0.790	0.952	0.163	0.036	0.086	0.040
Honduras	0.521	0.623	0.102	0.021	0.064	0.017
Haiti	0.433	0.536	0.103	0.046	0.068	-0.010
Hungary	0.721	0.846	0.125	0.026	0.071	0.028
Indonesia	0.529	0.705	0.176	0.020	0.106	0.049
India	0.437	0.634	0.197	0.037	0.093	0.066
Ireland	0.740	0.946	0.205	0.035	0.115	0.055
Iran (Islamic Republic of)	0.603	0.774	0.171	0.045	0.106	0.020
Iraq	0.531	0.687	0.156	0.056	0.085	0.015
Iceland	0.812	0.959	0.147	0.022	0.097	0.028
Israel	0.788	0.919	0.131	0.025	0.072	0.035
Italy	0.781	0.895	0.114	0.028	0.078	0.008
Jamaica	0.662	0.709	0.048	-0.008	0.052	0.004
Jordan	0.625	0.721	0.097	0.020	0.063	0.014
Japan	0.846	0.925	0.079	0.028	0.042	0.009
Kazakhstan	0.674	0.811	0.137	0.023	0.087	0.027
Kenya	0.478	0.575	0.097	0.013	0.072	0.013
Kyrgyzstan	0.638	0.693	0.055	0.027	0.034	-0.007
Cambodia	0.382	0.596	0.214	0.058	0.081	0.075
Korea (Republic of)	0.738	0.925	0.187	0.057	0.066	0.064

World/Country groups/Region	Index *H*			Increase in *H* attributed to the increase in		
	1990	2021	Increase	*h*	*e*	*i*
Kuwait	0.725	0.833	0.108	0.026	0.074	0.008
Lao People's Democratic Republic	0.408	0.610	0.202	0.063	0.073	0.065
Libya	0.668	0.720	0.051	0.012	0.037	0.003
Saint Lucia	0.691	0.716	0.025	0.004	0.014	0.007
Sri Lanka	0.639	0.782	0.144	0.020	0.059	0.064
Lesotho	0.481	0.514	0.033	-0.030	0.056	0.006
Lithuania	0.734	0.875	0.140	0.014	0.082	0.044
Luxembourg	0.791	0.930	0.140	0.035	0.096	0.010
Latvia	0.730	0.863	0.133	0.023	0.080	0.031
Morocco	0.458	0.684	0.227	0.049	0.145	0.033
Moldova (Republic of)	0.656	0.767	0.111	0.004	0.106	0.002
Mexico	0.665	0.758	0.093	0.001	0.082	0.010
Mali	0.256	0.433	0.177	0.048	0.112	0.018
Malta	0.733	0.918	0.185	0.037	0.114	0.034
Myanmar	0.338	0.586	0.248	0.036	0.099	0.112
Mongolia	0.579	0.739	0.160	0.061	0.056	0.044
Mozambique	0.242	0.448	0.207	0.058	0.095	0.054
Mauritania	0.414	0.559	0.145	0.019	0.119	0.006
Mauritius	0.629	0.802	0.173	0.020	0.104	0.049
Malawi	0.304	0.515	0.210	0.086	0.100	0.024
Malaysia	0.644	0.803	0.159	0.017	0.095	0.048
Namibia	0.581	0.615	0.035	-0.016	0.034	0.017
Niger	0.230	0.407	0.177	0.074	0.099	0.004
Nicaragua	0.494	0.669	0.175	0.046	0.097	0.032
Netherlands	0.847	0.941	0.094	0.024	0.049	0.021
Norway	0.838	0.961	0.123	0.033	0.061	0.029
Nepal	0.403	0.603	0.201	0.058	0.096	0.047
New Zealand	0.806	0.937	0.131	0.035	0.066	0.030
Pakistan	0.412	0.548	0.136	0.024	0.089	0.023
Panama	0.671	0.806	0.135	0.024	0.064	0.047
Peru	0.621	0.762	0.141	0.035	0.059	0.047
Philippines	0.599	0.699	0.100	0.016	0.044	0.040
Papua New Guinea	0.383	0.560	0.177	0.022	0.122	0.033
Poland	0.717	0.876	0.160	0.029	0.076	0.055
Portugal	0.706	0.866	0.160	0.032	0.111	0.018
Paraguay	0.599	0.718	0.119	0.011	0.089	0.020
Qatar	0.764	0.857	0.094	0.026	0.058	0.010
Romania	0.704	0.821	0.118	0.022	0.056	0.040
Russian Federation	0.744	0.823	0.079	0.005	0.063	0.011
Rwanda	0.322	0.537	0.214	0.073	0.096	0.045

World/Country groups/Region	Index *H*			Increase in *H* attributed to the increase in		
	1990	2021	Increase	*h*	*e*	*i*
Saudi Arabia	0.686	0.875	0.189	0.040	0.146	0.003
Sudan	0.348	0.513	0.166	0.064	0.090	0.012
Senegal	0.384	0.517	0.132	0.040	0.078	0.015
Singapore	0.733	0.939	0.206	0.038	0.137	0.031
Sierra Leone	0.317	0.479	0.162	0.070	0.096	-0.004
El Salvador	0.529	0.676	0.147	0.037	0.087	0.023
Sao Tome and Principe	0.488	0.619	0.132	0.027	0.078	0.027
Slovakia	0.694	0.848	0.154	0.020	0.103	0.030
Sweden	0.812	0.947	0.135	0.027	0.088	0.021
Eswatini (Kingdom of)	0.548	0.597	0.049	-0.029	0.062	0.017
Syrian Arab Republic	0.567	0.582	0.015	0.009	0.006	0.000
Togo	0.413	0.540	0.128	0.032	0.085	0.011
Thailand	0.582	0.801	0.219	0.037	0.138	0.045
Tajikistan	0.628	0.686	0.058	0.047	0.019	-0.008
Tonga	0.645	0.746	0.100	0.018	0.060	0.023
Trinidad and Tobago	0.661	0.810	0.149	0.023	0.086	0.039
Tunisia	0.581	0.732	0.151	0.016	0.105	0.030
Turkey	0.606	0.838	0.232	0.040	0.152	0.040
Tuvalu	0.559	0.641	0.082	0.014	0.033	0.036
Tanzania (United Republic of)	0.374	0.551	0.177	0.062	0.079	0.036
Uganda	0.331	0.527	0.196	0.071	0.078	0.047
Ukraine	0.729	0.773	0.043	0.009	0.046	-0.012
Uruguay	0.702	0.809	0.107	0.011	0.062	0.035
United States	0.872	0.921	0.050	0.010	0.016	0.024
Venezuela (Bolivarian Republic of)	0.664	0.693	0.028	-0.005	0.095	-0.062
Viet Nam	0.488	0.704	0.216	0.018	0.110	0.088
Yemen	0.396	0.459	0.063	0.019	0.080	-0.036
South Africa	0.633	0.714	0.080	-0.005	0.077	0.008
Zambia	0.412	0.566	0.153	0.064	0.066	0.023
Zimbabwe	0.510	0.593	0.083	-0.001	0.065	0.019

Source: Author

Table 5 classifies countries according to the contribution of the increase in the health index, education index and income index to the increase in the index *H* using the classification and regression tree method (Brieman et al, 1984). The classification exercise suggests that the 142 countries can be grouped into 10 mutually exclusive and exhaustive groups and the increase in the index *H* is different in different groups. There are 12 countries where there has been virtually no increase in the index *H* between 1990 and 2021. The increase in the index *H* in these countries ranges between 0.015 and 0.064 with the average of only 0.047 ± 0.015 in these countries. The contribution of the increase in the income index to the increase in the index H, in these countries, has, at best, been marginal whereas the contribution of the increase in the education index has been small. There are 9 countries where the increase in the index H has been very large, ranging between 0.185 to 0.281 with an average increase 0.230 ± 0.029 in the index H. The contribution of the increase in all the three indexes to the increase in the index H, in these countries, has been very substantial. The classification exercise also suggests that the most important dimension in deciding the increase in the index H is the education dimension whereas the least important one is the income dimension. The importance of the increase in the income index in deciding the increase in the index H is only around 55 per cent of the importance of the increase in the education index. On the other hand, the importance of the increase in the health index in deciding the increase in the index H is marginally higher, around 61 per cent of the importance of the increase in the education index. Table 5 also suggests highly uneven progress in human development across different groups of countries.

Table 5: Classification of the countries according to the contribution of the increase in health index, education index and income index to the increase in the index H.

Group	Increase in index			Increase in index H		Countries	
	h	e	i	Mean	SD	N	Name
1		≤0.065	≤0.008	0.047	0.015	12	Barbados
							Brunei Darussalam
							Central African Republic
							Congo
							Jamaica
							Kyrgyzstan
							Lesotho
							Libya
							Saint Lucia
							Syrian Arab Republic
							Tajikistan
							Ukraine
2		≤0.065	>0.008 ≤0.025	0.080	0.020	15	Austria
							Canada
							Cuba
							Ecuador
							Eswatini (Kingdom of)
							Honduras
							Japan
							Jordan
							Namibia
							Netherlands
							Qatar
							Russian Federation
							Tonga
							United States
							Zimbabwe

Group	Increase in index			Increase in index H		Countries	
	h	e	i	Mean	SD	N	Name
3	≤0.019	>0.065 ≤0.096	≤0.033	0.090	0.026	11	Argentina
							Belize
							Botswana
							Bulgaria
							Fiji
							Kenya
							Mexico
							Paraguay
							South Africa
							Venezuela (Bolivarian Republic of)
							Yemen
4		≤0.065	>0.025	0.118	0.024	12	Armenia
							Australia
							Denmark
							Mongolia
							Norway
							Panama
							Peru
							Philippines
							Romania
							Sri Lanka
							Tuvalu
							Uruguay
5	>0.019	>0.065 ≤0.096	≤0.033	0.129	0.017	33	Belgium
							Bolivia (Plurinational State of)
							Brazil
							Burundi
							Cote D'Ivoire
							Cameroon
							Colombia
							Congo (Democratic Republic of the)
							Czechia
							El Salvador
							Finland
							France
							Gabon
							Germany
							Guatemala
							Haiti
							Hungary
							Iraq
							Italy
							Kazakhstan
							Kuwait
							Latvia
							Luxembourg

Group	Increase in index *h*	Increase in index *e*	Increase in index *i*	Increase in index *H* Mean	Increase in index *H* SD	Countries N	Countries Name
							New Zealand
							Pakistan
							Sao Tome and Principe
							Senegal
							Sudan
							Sweden
							Switzerland
							Togo
							United Kingdom
							Zambia
6	≤0.033	>0.065 ≤0.096	≤0.033	0.146	0.018	11	Bahrain
							Benin
							Greece
							Iceland
							Mauritania
							Moldova (Republic of)
							Papua New Guinea
							Portugal
							Slovakia
							Spain
							Tunisia
7	≤0.033	>0.096	>0.033	0.164	0.025	14	Albania
							Chile
							Costa Rica
							Dominican Republic
							Egypt
							Guyana
							Indonesia
							Israel
							Lithuania
							Malaysia
							Mauritius
							Poland
							Trinidad and Tobago
							Viet Nam
8	>0.033	>0.065 ≤0.096	≤0.033	0.178	0.019	14	Afghanistan
							Algeria
							Cyprus
							Gambia
							Guinea
							Iran (Islamic Republic of)
							Malawi
							Mali
							Nicaragua
							Niger
							Saudi Arabia

Group	Increase in index			Increase in index H		Countries	
	h	e	i	Mean	SD	N	Name
							Sierra Leone Singapore United Arab Emirates
9	>0.033	>0.065 ≤0.096	>0.033	0.183	0.019	11	Cambodia Estonia Ghana Hong Kong, China (SAR) India Korea (Republic of) Lao People's Democratic Republic Mozambique Nepal Tanzania (United Republic of) Uganda
10	>0.033	>0.096	>0.033	0.230	0.029	9	Bangladesh China Ireland Malta Morocco Myanmar Rwanda Thailand Turkey

Source: Author

Summary and Conclusions

This paper has proposed an alternative approach of constructing an index of human development based on the concept of human development surface. It is also shown that the alternative index of human development is weighted generalised or power mean of power ½ of the indexes of health, education, and income. The alternative human development index addresses most of the problems associated with the human development index using either the arithmetic mean or the geometric mean as the aggregation function. An advantage of the alternative human development index is that change in the alternative human development index can be decomposed to the change in the three indexes that reflect the progress in health, education, and income dimensions of human development. This decomposition has relevance to human development policy and human development interventions as it helps in identifying the dimensions of human development in which the progress is lagging. The ranking of countries in human progress based on the alternative human development index is found to be very similar to that obtained using the conventional human development index, although there are important differences.

Application of the alternative human development index to 142 countries for which estimates could be prepared for the year 1990 and for the year 2021 suggests that the progress in human development varies widely across the countries and there are countries where progress in either health or income dimensions of human dimension appears to have reversed between 1990 and 2021. The analysis also suggests that the progress in human development in the world and in its most of the countries between 1990 and 2021 has largely been driven by the progress in the education dimension of human development whereas the contribution of the progress in the dimensions of health and income to the progress in human development has only been secondary which has relevance to human development policy. It is expected that improvement in the education dimension or broadening the opportunities for the people should have resulted in expanding their capacities and in enhancing sustenance. However, the experience of the human development movement in the world during the three decades between 1990 and 2021 suggests that this has not happened in most of the countries. This mismatch between the progress in the education dimension of human development and the health and income dimensions has implications for the efforts directed towards human progress at both international and national levels. There is a need to carry out country level analysis to explore the reasons for this mismatch.

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Spatial Decomposition of the Increase in Life Expectancy at Birth in India, 1981-2015

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Abstract

This paper decomposes the increase in the life expectancy at birth in India during 1981-1985 through 2011-2015 into the contribution of different states of the country which is determined by the increase in state life expectancy at birth and the change in the share of the population of the state to the population of the country. The analysis reveals that four states of the country – Bihar, Madhya Pradesh, Rajasthan, and Uttar Pradesh – have accounted for more than 60 per cent of the increase in the life expectancy at birth in India during the 30 years under reference. The analysis also reveals that the contribution of Andhra Pradesh, Karnataka, and Punjab to the increase in life expectancy at birth in India has been marginal because of the decrease in the population share of these states to the population of the country. The analysis suggests that attention should be focussed on accelerating the increase in life expectancy in those state of the country where the life expectancy at birth is above the national average.

Introduction

The life expectancy at birth (e_0) in India increased by around 13 years, from about 55 years during 1981-1985 to more than 68 years during 2011-2015 according to the life tables prepared by the Registrar General and Census Commissioner of India based on the age-specific death rates derived from India's official Sample Registration System (Government of India, 2020). The increase in e_0 in India has, however, not been uniform during the 30 years under reference. During 1981-1985 through 1991-1995, the e_0 in the country increased by almost 5 years or by about 0.5 years per year, on average. However, after 1991-1995, the increase in e_0 slowed down to just around 0.4 years per year, on average. Had the increase in e_0 observed during 1981-1985 through 1991-1995 would have been maintained during the post 1991-1995 period, the e_0 in India would have increased to more than 70 years during 2011-2015. The slowdown in the increase in e_0 is contrary to expectations as it is argued that advancements in medical technology and improvements in the standard of living contributes to hastening the increase in e_0. By international standards also, the e_0 in India remains low. India ranks 144 among the 201 countries for which estimates of e_0 have been prepared by the United Nations Population Division (United Nations, 2019). By comparison, Bangladesh ranks 120, China 72 and Sri Lanka 68.

Reasons for the slowdown in the increase in e_0 in India after 1991-1995 are not known at present. The increase in the life expectancy at birth is universally regarded as an indicator of the improvement in population health. A slowdown in the increase in e_0, therefore, reflects a deceleration in the improvement in population health in India. One possible explanation of the slowdown in the progress in population health is argued to be the shift in the basic strategy of health care services delivery away from the public health approach that focusses on promotive and preventive aspects of population health to the clinic-based approach that focusses on curing the sick (Cardona and Bishai, 2018). Using data from 139 countries for the period 1950 through 2009, Cardona and Bishai have concluded that the rate of increase in e_0 has fallen consistently throughout the world irrespective of the level of e_0. It is, however, argued that since human life span has a biological limit, the increase in e_0 is bound to slowdown as populations achieve higher and higher level of e_0 (Preston et al, 1972). The reason is that reduction in mortality is linked with policies that allow advances in such areas as income, education, sanitation, and medicine (Oeppen and Vaupel, 2002). Since, advances in these areas become harder to realise with the increase in e_0, the slowdown in the increase in e_0 needs to be analysed in the context of ceiling effects of these factors as well as in the context of ineffective policy, misapplication of health technology or other factors (Cardona and Bishai, 2018). Bourgeois-Pichat (1952) has argued that the causes of deaths can be grouped into what are known as the soft rock of mortality and the hard rock of mortality. When mortality is high, the soft rock of mortality is larger than the hard rock. As mortality decreases, an increasing proportion of deaths gets concentrated in the hard rock of mortality. It is easier to erode the soft rock of mortality but eroding the hard rock of mortality gets increasingly difficult with the decrease in mortality.

The e_0 in India may also be conceptualised as the weighted sum of e_0 in the constituent states/Union Territories of the country. This conceptualisation implies that the increase in e_0 in the country is contingent upon the increase in e_0 in its constituent states/Union Territories. The evidence available through the Sample Registration System shows that the e_0 varies widely across states of the country. During 2011-2015, e_0 ranged from more than 75 years in Kerala to less than 65 years in Assam, Uttar Pradesh, and Madhya Pradesh. A similar situation prevailed 30 years ago, during 1981-85, when an average individual in Kerala was expected to live almost 20 years longer than the length of life of an average individual in Uttar Pradesh. The gap in e_0 between Kerala, the state with the highest e_0, and Uttar Pradesh, the state with the lowest e_0 in the country, has increased marginally over the last 30 years, although the inter-state disparity in e_0 has decreased over time as the inter-state coefficient of variation in e_0 decreased from 0.088 during 1981-85 to 0.041 during 2011-2015 reflecting across states sigma-convergence in e_0. The decrease in inter-state coefficient of variation in e_0 also implies that the increase in e_0 has been relatively faster in states where e_0 was relatively low during 1981-85 compared to states where e_0 was high. There is, however, evidence to indicate that there has been only marginal change in the rank of states in terms of e_0.

The increase in e_0 has also been different in different states of the country. During the 30 years under reference, increase in e_0 has been the highest in Uttar Pradesh where e_0 increased my more than 15 years whereas the increase has been the slowest in Kerala where e_0 increased by less than 6 years between 1981-1985 and 2011-2015. The contribution of the e_0 in different states to the e_0 of the country is, however, not straightforward. This contribution of the e_0 of a state to the e_0 of the country also depends upon the share of the population of the state to the population of the country, the larger the population share, the larger is the contribution. This also means that the contribution of the increase in e_0 of a state to the increase in e_0 of the country is also influenced by the change in the population share of the state to the population of the country. If the population share of a state to the population of the country decreases over time, then the contribution of the increase in e_0 in the state to the increase in e_0 in the country may even be negative. From the comparative perspective, it is, therefore, pertinent to analyse how the increase in e_0 in different states have contributed to the increase in e_0 in the country during the 30 years under reference. Such an analysis has implications for both health policy and planning for health care services delivery directed towards improving the health of the population of the country. The differential contribution of different states to the increase in e_0 in of the country implies that the contribution of the improvement in the health of the population of different states to the improvement in the health of the population of the country is different for different states.

This paper analyses the contribution of the increase in e_0 in different states of the country to the increase in e_0 of the country to explore how the improvement in health of the population of different states has contributed to the improvement in the health of the population of the country as measured in terms of the life expectancy at birth. The analysis attempts to explore the importance of improvement in population health of different states in the improvement in the population health of the country. The analysis is expected to help in understanding why e_0 in India remains low by international standards and why the increase in e_0 in the country remains slower than expected.

The paper is organised as follows. The next section of the paper outlines the methodology adopted for the analysis. We follow a decomposition approach to analyse the contribution of the population health different states to the population health of the country in terms of the level and the improvement as measured through e_0. The third section of the paper describes the data source used in the analysis. The paper is based on the estimates of e_0 derived from the age-specific death rates for the country and for its different states available through the official Sample Registration System of India. The Sample Registration System is the only source in India that provides age-specific death rates for the country and for its constituent states on an annual basis. The fourth section of the paper presents and discusses the findings of the analysis while the last section of the paper summarises the main findings of the analysis and their policy and programme implications.

Methodology

Let e_c denotes the life expectancy at birth in India and e_s denotes the life expectancy at birth in the state, s of the country which are mutually exclusive and exhaustive. Then, e_c is the weighted sum of e_s with weights equal to the share of the state population to the population of the country (w_s). In other words,

$$e_c = \sum_{s=1}^{k} w_s * e_s \tag{1}$$

where $w_s=P_s/P_c$ is the share of the population of the state, s to the population of the country; P_s is the population of the state s and P_c is the population of the country. Equation (1) implies that the contribution of the e_0 of the state, s, to the e_0 of the country, c_s, is given by

$$c_s = w_s * e_s \tag{2}$$

The increase in e_c between two points in time, ∇e_c may now be decomposed as

$$\nabla e_c = e_c^2 - e_c^1 = \sum_{s=1}^{k} c_s^2 - \sum_{s=1}^{k} c_s^1 = \sum_{s=1}^{k} c_s^2 - c_s^1 \tag{3}$$

We can write

$$c_s^2 - c_s^1 = \frac{c_s^2 - c_s^1}{\ln\left(\frac{c_s^2}{c_s^1}\right)} * \ln\left(\frac{c_s^2}{c_s^1}\right) = L_{cs} * \ln\left(\frac{c_s^2}{c_s^1}\right) \tag{4}$$

Here, the term

$$L_{c_s} = \frac{c_s^2 - c_s^1}{\ln\left(\frac{c_s^2}{c_s^1}\right)} \tag{5}$$

is the logarithmic mean (Carlson, 1972; Lin, 1974). The logarithmic mean is smaller than the arithmetic mean and the generalized mean with exponent one third but larger than the geometric mean, unless there is no change in the contribution of the state to the increase in e_0 of the country over time, in which case all three means are equal to the contribution of the e_0 of the state (Carlson, 1966). Now, it can be shown that

$$\ln\left(\frac{c_s^2}{c_s^1}\right) = \ln\left(\frac{w_s^2 * e_s^2}{w_s^1 * e_s^1}\right) = \ln\left(\frac{e_s^2}{e_s^1}\right) + \ln\left(\frac{w_s^2}{w_s^1}\right) \tag{6}$$

Substituting from (4) in (3), we get

$$\nabla e_c = \sum_{s=1}^{k} L_{c_s} * \left[\ln\left(\frac{e_s^2}{e_s^1}\right) + \ln\left(\frac{w_s^2}{w_s^1}\right)\right] = \sum_{s=1}^{k} \partial e_s + \sum_{s=1}^{k} \partial p_s \tag{7}$$

Equation (7) shows that the increase in e_0 in the country can be decomposed into two components, one can be attributed to the increase in e_0 in the constituent states of the country while the other can be attributed to the change in the share of the population of different states to the population of the country. It may also be noticed from equation (7) that the contribution of a state to the increase in e_0 of the country may be both positive or negative depending upon the increase or the decrease in the share of the population of the state to the population of the country. It can be shown that

$$\ln\left(\frac{w_s^2}{w_s^1}\right) = \ln\left(\frac{P_s^2}{P_s^1}\right) - \ln\left(\frac{P_c^2}{P_c^1}\right) \tag{8}$$

Equation (8) suggests that when the growth of the population of a state is more rapid than the growth of the population of the country, the contribution of the change in population share of the state to the increase in e_0 of the country is positive. In this case, the contribution of the state to the increase in e_0 of the country is always positive. However, when the growth of population of the state is slower than the growth of the population of the country, the contribution of the change in the population share of the state to the increase in e_0 of the country is negative. In this case, the contribution of the state to the increase in the e_0 of the country is positive only when

$$\ln\left(\frac{e_s^2}{e_s^1}\right) > \ln\left(\frac{w_s^2}{w_s^1}\right) \tag{9}$$

The foregoing discussions suggest that the increase in e_0 in a state does not automatically contributes to the increase in e_0 of the country. There may be a situation where the e_0 of a state increases but the population share of the state decreases and the magnitude of the contribution of the increase in e_0 is less than the magnitude of the contribution of the decrease in population share so that the net contribution of the state to the increase in e_0 is negative. In other words, when the growth in the population of a state is slower than the growth of the population of the country, the contribution of the state to the increase in e_0 of the country will be positive only when the increase in the e_0 of the state is such that it compensates for the negative contribution of the state to the increase in e_0 of the country emanating from the slow growth of the population of the state relative to the growth of the population of the country. There may be a situation that the e_0 in a state increases but the contribution of the state to the increase in e_0 of the country may be negative because of the decrease in the share of the population of the state to the population of the country.

Data Source

The analysis is based on the data from two sources. Estimates of e_0 for India and its selected states have been derived from the age-specific death rates available through official Sample Registration System of the country. The MORTPAK software package developed by the United Nations Population Division (United Nations, 2004) was used to construct abridged life tables based on the age-specific death rates available from the Sample Registration system. The Sample Registration System, however, does not provide estimates of age-specific death rates for all states/Union Territories of the country. During 2011-2015, the Sample Registration System provided estimates of age-specific death rates for 21 states of the country whereas estimates of age-specific death rates for the period 1981-1985 are available for only 16 states from the Sample Registration System. Moreover, three states – Bihar, Madhya Pradesh, and Uttar Pradesh – as they existed during 1981-1985 were divided, respectively, into states of Bihar and Jharkhand; Chhattisgarh and Madhya Pradesh; and Uttar Pradesh and Uttarakhand in the year 2001. Estimates of age-specific death rates for the period earlier than 2001 are not available for Chhattisgarh, Jharkhand, and Uttarakhand from the Sample Registration System. Therefore, for the present analysis, existing Chhattisgarh and Madhya Pradesh were combined into undivided Madhya Pradesh as it existed prior to 2001. Similarly, existing Jharkhand and Bihar were combined into undivided Bihar; and Uttarakhand and Uttar Pradesh were combined into undivided Uttar Pradesh as they existed prior to 2001. The e_0 in undivided Bihar during 2011-15 has then been estimated as the weighted average of e_0 in the existing Bihar and Jharkhand with the population share of the two states serving as weights. Similarly, e_0 in undivided Madhya Pradesh is obtained as the weighted average of e_0 in the existing Madhya Pradesh and Chhattisgarh while e_0 in undivided Uttar Pradesh has been obtained as the weight average of e_0 in the existing Uttar Pradesh and Uttarakhand. Estimates of e_0 for the National Capital Territory of Delhi and Jammu and Kashmir are not available for 1981-85 from the Sample Registration System and, therefore, these have not been included in the present analysis.

Estimates of age-specific death rates available from the Sample Registration System are known for random, year-to-year, fluctuations of unknown origin. The convention, therefore, is to use five-year average age-specific death rates available from the System for the construction of life tables. We have adopted the same convention. The estimates of e_0 used in the present analysis refer to the period 1981-1985; 1991-1995; 2001-2005; and 2011-2015 and are assumed to be located at the mid-year of the interval. Thus, e_0 for the period 1981-1985 is assumed to refer to the year 1983. There are many studies that suggest that there is some under-reporting of vital events in the Sample Registration System particularly in older ages with considerable variation across states/Union Territories (Government of India, 1983; 1988; Mari Bhat, 2002; Swami et al, 1992). It has, however, been observed in a recent study that completeness in the death registration under the System has improved while inter- states/Union Territories has decreased over time (Basu and Adair, 2021).

On the other hand, estimates of the population of the country and its constituent states are taken from the decennial population censuses 1981; 1991; 2001; and 2011. Estimates of population available through population census are also associated with error of undercount which varies from state to state. The post enumeration survey carried out after the 2011 population census revealed an undercount of around 23 persons for every 1000 persons enumerated (Government of India, no date). We have, however, made no corrections either in the age-specific death rates or in population size available through different population censuses.

Inter-State Variation in e_0.

Table 1 presents estimates of e_0 in India and states during 1981-2015. During 1981-1985, Kerala with e_0 was more than 65 years whereas Uttar Pradesh was the only with e_0 less than 50 years. During 2011-2015, Kerala was again the only state with e_0 more than 75 years whereas e_0 was less than 65 years in Assam, Uttar Pradesh, and Madhya Pradesh. In 1981-1985, there were 6 states where e_0 was lower than the national average. In 2011-2015 also, the e_0 was lower than the national average in these 6 states suggesting that despite increase in e_0, states having e_0 below the national average have remained unchanged. There has been only a marginal change in the ranking of states. The Spearman's rank order correlation coefficient between rank in 1981-85 and rank in 2011-2015 is estimated to be 0.844 which confirms that states having above average e_0 in 1981-1985 are also the states having above average e_0 in 2011-2015.

Table 1: Life expectancy at birth in India and states.

Country/State	1981-85	1991-95	2001-05	2011-15
India	55.29	60.28	64.30	68.34
Andhra Pradesh	58.06	61.78	65.03	69.05
Assam	51.52	55.75	59.20	64.73
Bihar	52.74	59.28	64.17	68.15
Gujarat	58.49	61.04	65.67	69.10
Haryana	59.40	63.44	66.50	69.13
Himachal Pradesh	59.08	64.49	69.46	72.00
Karnataka	60.45	62.50	66.09	69.00
Kerala	69.40	72.85	73.57	75.20
Madhya Pradesh	51.46	54.73	59.65	64.87
Maharashtra	60.10	64.77	67.95	72.02
Odisha	52.78	56.47	60.80	66.87
Punjab	64.58	67.24	68.81	72.08
Rajasthan	53.33	59.06	64.50	67.93
Tamil Nadu	56.64	63.31	67.21	71.00
Uttar Pradesh	49.79	56.79	60.82	64.82
West Bengal	57.24	62.07	67.16	70.49
Rest of India	40.64	52.20	59.00	67.97

Source: Sample Registration System

Remarks: Bihar includes Jharkhand; Madhya Pradesh includes Chhattisgarh; and Uttar Pradesh includes Uttarakhand. Rest of India includes remaining states and Union Territories of the country.

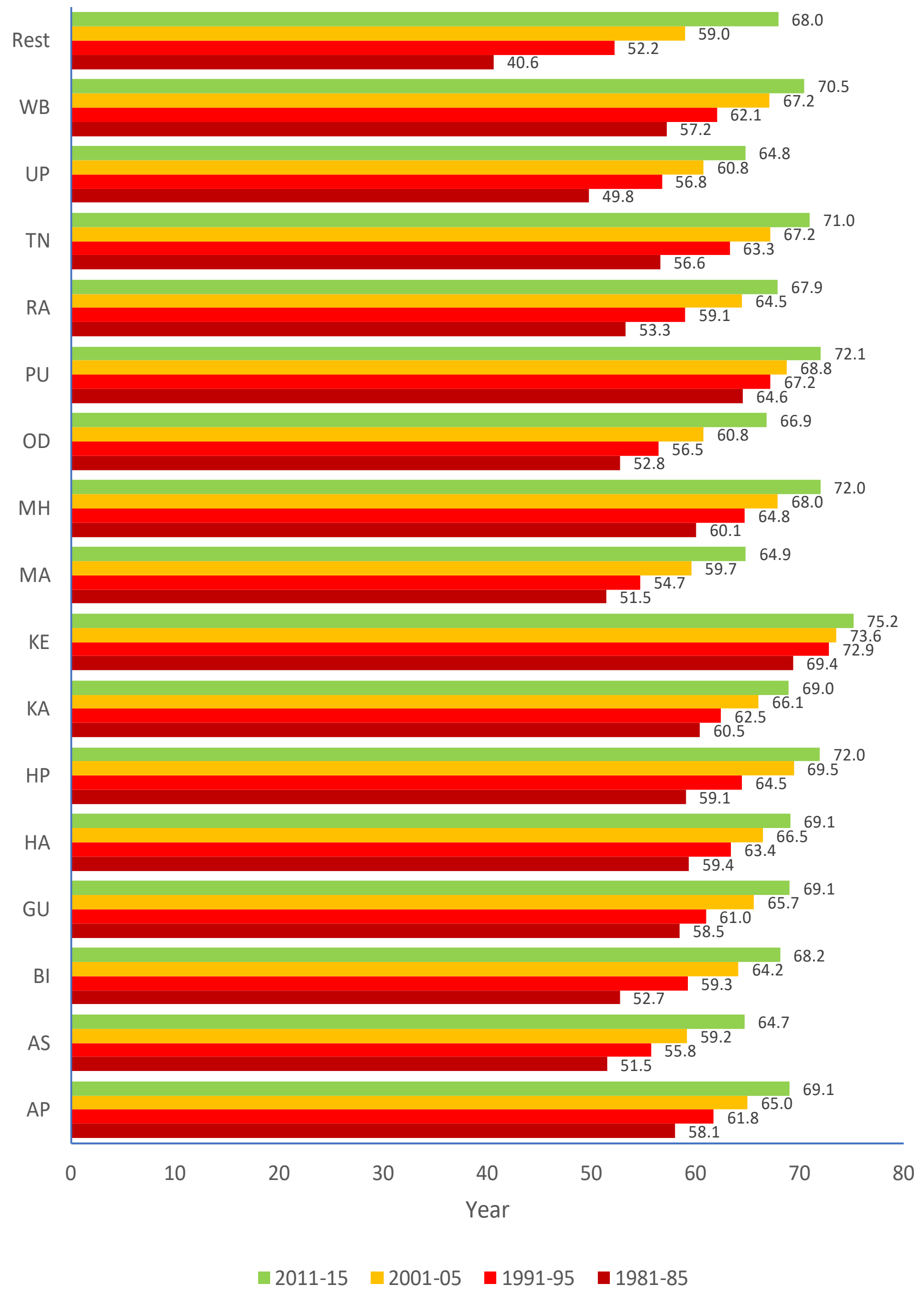

Figure 1: Life expectancy at birth in Indian states, 1981-85 through 2011-15

Table 2: Contribution of different states to the e_0 of the country.

Country/State	1981-1991	1991-1995	2001-2005	2011-2015
India	100.00	100.00	100.00	100.00
Andhra Pradesh	8.23	8.05	7.49	7.06
Assam	2.46	2.45	2.39	2.44
Bihar	9.76	10.04	10.67	11.29
Gujarat	5.28	4.94	5.03	5.05
Haryana	2.03	2.05	2.13	2.12
Himachal Pradesh	0.67	0.65	0.64	0.60
Karnataka	5.94	5.51	5.28	5.09
Kerala	4.68	4.15	3.54	3.04
Madhya Pradesh	7.11	7.10	7.32	7.70
Maharashtra	9.99	10.02	9.95	9.78
Odisha	3.68	3.50	3.38	3.39
Punjab	2.87	2.67	2.53	2.42
Rajasthan	4.84	5.09	5.51	5.63
Tamil Nadu	7.26	6.93	6.34	6.19
Uttar Pradesh	14.61	15.48	16.06	16.44
West Bengal	8.27	8.28	8.14	7.78
Rest of India	2.34	3.07	3.60	4.00

Source: Author's calculations.

Remarks: Bihar includes Jharkhand; Madhya Pradesh includes Chhattisgarh; and Uttar Pradesh includes Uttarakhand. Rest of India includes remaining states and Union Territories of the country.

Table 2 shows how e_0 in different states contributes to e_0 in the country. As discussed earlier, the proportionate contribution of state e_0 to country e_0 is determined by both level of state e_0 and proportionate share of state population. For example, Uttar Pradesh accounted for around 14.6 per cent of the e_0 of the country in 1981-1985 but more than 16.4 per cent in 2011-2015 because of the increase in both e_0 and the proportionate share of the population. On the other hand, contribution of the e_0 in Kerala to the e_0 of the country decreased from around 4.7 per cent in 1981-1985 to just around 3 per cent in 2011-2015 because of the decrease in the share of the state population as state e_0 increased from around 69 years to 75 years during this period. Similarly, contribution of e_0 of 5 states – Andhra Pradesh, Himachal Pradesh, Karnataka, Punjab, and Tamil Nadu – to the e_0 of the country decreased consistently throughout the 30 years under reference because of the decrease in the share of the population of these states to the population of the country. On the other hand, the contribution of e_0 in Bihar and Rajasthan to the e_0 of the country increased consistently during the 30 years under reference because not only the e_0 increased in these states but also the share of the population of these states to the population of the country increased with time. The contribution of e_0 in other states to e_0 of the country, on the other hand, has not been consistent during the 30 years period under reference. In these states, the contribution of state e_0 increased in one but decreased in other time intervals.

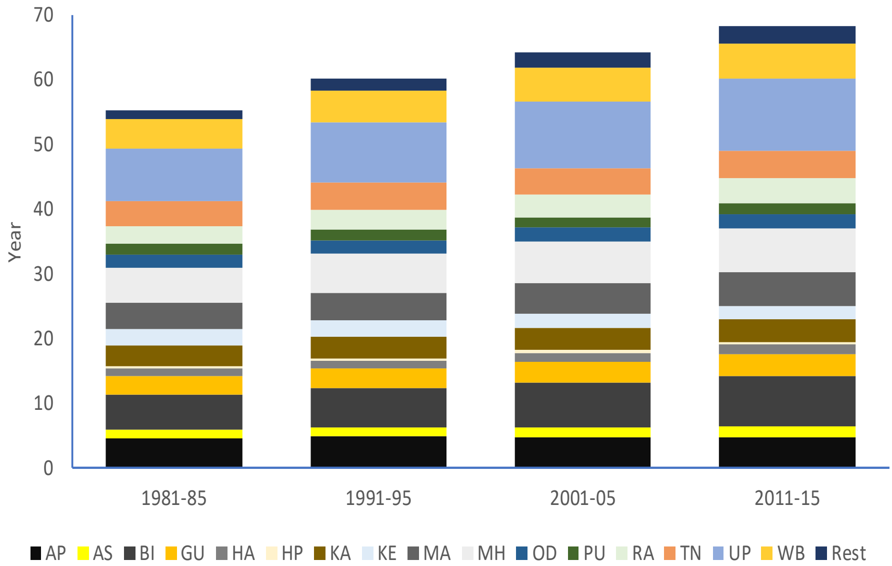

Figure 2: Contribution of different states to e_0 in India

Increase in e_0 in States

The increase in e_0 in different states of the country has been different in different 10-year time intervals (Table 3). Madhya Pradesh and Odisha are the only two states of the country where the increase in e_0 accelerated with time throughout the period under reference. By contrast, in Bihar, Haryana, Himachal Pradesh, Rajasthan, Tamil Nadu, and Uttar Pradesh, increase in e_0 consistently decelerated throughout the period under reference. In other states, increase in e_0 has been inconsistent, accelerated in one time interval but decelerated in other. In Uttar Pradesh, Tamil Nadu and Bihar, the increase in e_0 was very rapid during 1981-1985 with the most rapid increase in e_0 recorded in Uttar Pradesh during this time interval. However, the increase in e_0 decelerated considerably in all the three states after 1985. By contrast, the increase in e_0 was quite moderate in Odisha and Madhya Pradesh during 1981-1985 but the increase in e_0 accelerated after 1985 in both states so that the increase in e_0 in Odisha was the highest across the states of the country during 2011-2015 while that in Madhya Pradesh was the third highest. In 11 of the 16 states included in the present analysis, the increase in e_0 slowed down by a varying degree during the period 1991-1995 through 2001-2005 compared to the period 1981-1985 through 1991-1995 with the slowdown being the most marked in Kerala where e_0 increased by less than 1 year during the ten years between 1991-1995 through 2001-2005. There are only five states – Gujarat, Karnataka, Madhya Pradesh, Odisha, and West Bengal – where the increase in e_0 was more rapid during the period 1991-1995 through 2001-05 as compared to the increase in e_0 during the period 1981-1985 through 1991-1995. However, in three of these five states – Gujarat, Karnataka, and West Bengal – the increase in e_0 decelerated markedly during the period 2001-2005 through 2011-2015 relative to the period 1991-1995 through 2001-2005. Table 3 suggests that the trajectory of the improvement in e_0 during the 30 years under reference has been different in different states of the country. Reasons for the variation in the trajectory of the improvement in e_0 across states are not known at present. It appears that there are state-specific factors both exogenous and endogenous to the public health care delivery system and the level of social and economic development that may have played a dominant role in deciding the mortality improvement path in different states. As a result, the contribution of the increase in e_0 in different states to the increase in e_0 of the country in different time-intervals has also been different. The differential contribution of the increase in e_0 in different states to the increase in e_0 in the country has been further conditioned by the change in the population share of different states to the population of the country because population growth rate also varied across states as states are at different stages of demographic transition.

Table 3: Increase in e_0 in India and states during 1981-2015.

Country/States	1981-1985 to 1991-1995	1991-1995 To 2001-2005	2001-2005 To 2011-2015	1981-1985 To 2011-2015
India	4.99	4.02	4.04	13.05
Andhra Pradesh	3.72	3.25	4.02	10.99
Assam	4.23	3.45	5.53	13.21
Bihar	6.54	4.89	3.98	15.41
Gujarat	2.55	4.63	3.43	10.61
Haryana	4.04	3.06	2.63	9.73
Himachal Pradesh	5.41	4.97	2.54	12.92
Karnataka	2.05	3.59	2.91	8.55
Kerala	3.45	0.72	1.63	5.80
Madhya Pradesh	3.27	4.92	5.22	13.41
Maharashtra	4.67	3.18	4.07	11.92
Odisha	3.69	4.33	6.07	14.09
Punjab	2.66	1.57	3.27	7.50
Rajasthan	5.73	5.44	3.43	14.60
Tamil Nadu	6.67	3.90	3.79	14.36
Uttar Pradesh	7.00	4.03	4.00	15.03
West Bengal	4.83	5.09	3.33	13.25
Rest of India	11.56	6.80	8.97	27.33

Source: Author's calculations.

Remarks: Bihar includes Jharkhand; Madhya Pradesh includes Chhattisgarh; and Uttar Pradesh includes Uttarakhand. Rest of India includes remaining states and Union Territories of the country.

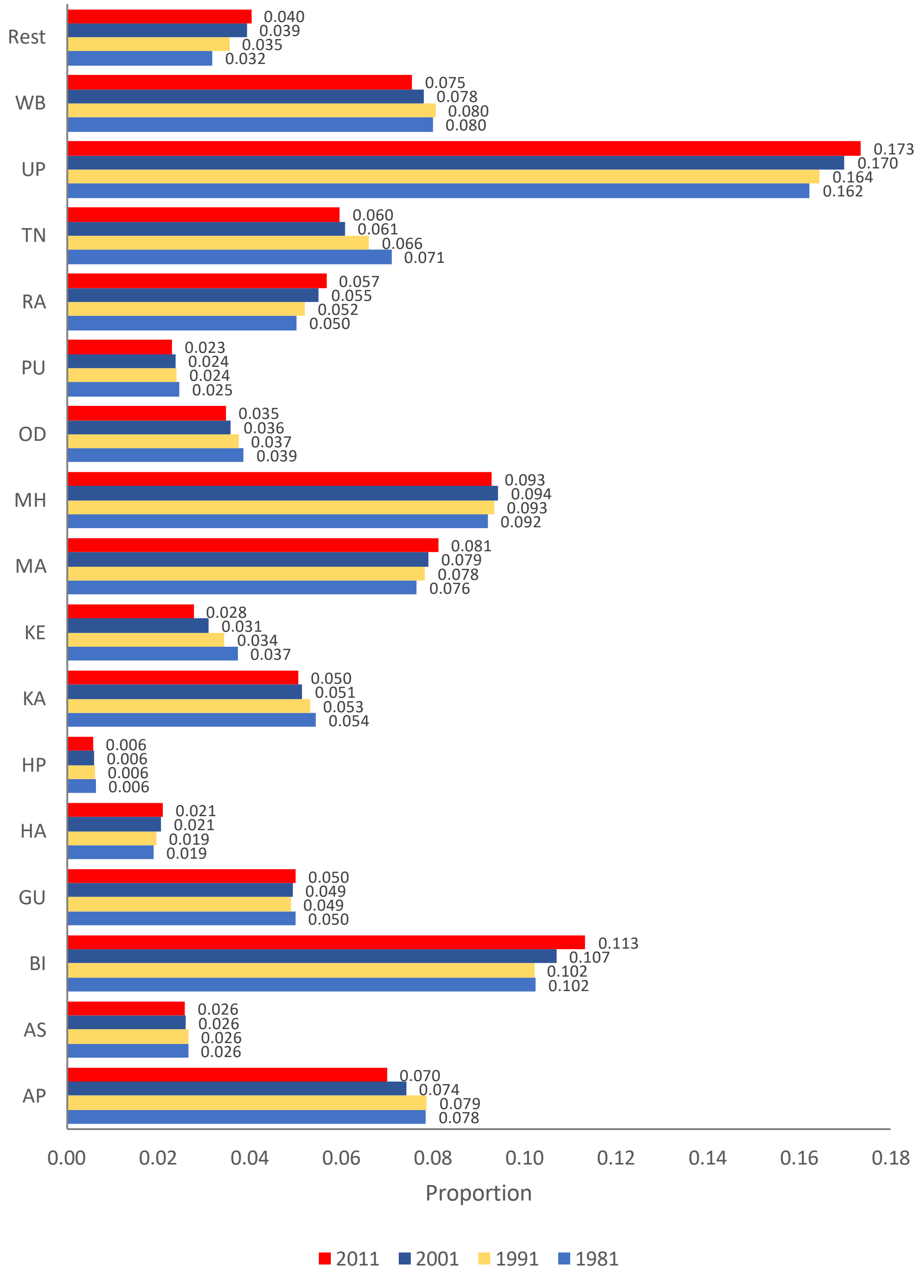

Figure 3: Proportionate share of different states of India, 1981-2011

Transition in Population Share

The share of the population of different states to the population of the country has also changed during the period under reference because the population growth rate in different states has been different during the period under reference (Table 4). In 1981, Uttar Pradesh accounted for more than 16 per cent of the population of the country, followed by Bihar (more than 10 per cent) so that the two states accounted for more than one fourth of the population of the country. This proportion increased to almost 29 per cent in 2011. Table 4 suggests that the population share of 6 states – Bihar, Haryana, Madhya Pradesh, Maharashtra, Rajasthan, and Uttar Pradesh – has increased over time while the population share of 7 states – Andhra Pradesh, Karnataka, Kerala, Odisha, Punjab, Tamil Nadu, and West Bengal – has decreased over time. On the other hand, the population share of Assam, Gujarat, and Himachal Pradesh – has remained virtually unchanged during the 30 years under reference. The population share decreased the most rapidly in Kerala from around 3.7 per cent in 1981 to around 2.8 per cent in 2011. An increase in population share of a state implies an increase in the contribution of the increase in e_0 of the state to the increase in e_0 of the country whereas a decrease in population share of a implies a decrease in the contribution of the increase in e_0 of the state to the increase in e_0 of the country. This means that the influence of the increase in e_0 in Bihar, Haryana, Madhya Pradesh, Maharashtra, Rajasthan, and Uttar Pradesh in deciding the increase in e_0 in India has increased over time whereas the influence of the increase in e_0 in Andhra Pradesh, Karnataka, Kerala, Odisha, Punjab, Tamil Nadu, and West Bengal in deciding the increase in e_0 in India has decreased over time. The increase in population share of a state means that population growth rate of the state is faster than the population growth rate of the country. Similarly, the decrease in population share of the state means that the population growth rate of the state is slower than population growth rate of the country. The population growth rate may be high because either the decrease in the birth rate is slow or the decrease in death rate is quite rapid or there is a high rate of in-migration or a combination of the change in the three components of population growth. Similarly, the population growth rate may be slow because there is either a rapid decrease in the birth rate or an increase in the death rate or the rate of out-migration is quite substantial. An analysis of the contribution of the change in the birth rate, death rate, and the net migration rate to the change in the population growth rate may provide the evidence about which of the three factors has been responsible for the increase or the decrease in the population share of a state to the population of the country. In any case, the change in the population share of a state to the population of the country over time has implications for the contribution of the increase in e_0 in different states to the increase in the e_0 of the country. Separating the change in the population share of the state to the population of the country is required to assess how mortality transition, as reflected by the increase in e_0 of the state has actually contributed to the mortality transition in the country as reflected by increase in the e_0 of the country. Results of this decomposition analysis are presented and discussed in the next section.

Decomposition of the Increase in e_0

The e_0 in India increased by almost 13 years between 1981-85 through 2011-15. This increase has been the result of both increase in e_0 in different states of the and change in inter-state distribution of the population of the country. Table 5 decomposes the increase in the e_0 of the country during 1981-85 through 2011-15 into two components – one attributed to the increase in e_0 in different states, and second attributed to the change in the proportionate share of the population of different states to the population of the country. This decomposition exercise suggests that the increase in e_0 in different states of the country accounted, cumulatively, for an increase of almost 13.4 years in the e_0 of the country during the period under reference. However, the change in the proportionate share of the population of different states has resulted in a decrease of around 0.3 years in the e_0 of the country so that the net increase in e_0 of the country decelerated to around 13 years.

Table 4: Proportionate share of the population of different states to the population of India, 1981-2011

State	1981	1991	2001	2011
Andhra Pradesh	0.078	0.079	0.074	0.070
Assam	0.026	0.026	0.026	0.026
Bihar	0.102	0.102	0.107	0.113
Gujarat	0.050	0.049	0.049	0.050
Haryana	0.019	0.019	0.021	0.021
Himachal Pradesh	0.006	0.006	0.006	0.006
Karnataka	0.054	0.053	0.051	0.050
Kerala	0.037	0.034	0.031	0.028
Madhya Pradesh	0.076	0.078	0.079	0.081
Maharashtra	0.092	0.093	0.094	0.093
Odisha	0.039	0.037	0.036	0.035
Punjab	0.025	0.024	0.024	0.023
Rajasthan	0.050	0.052	0.055	0.057
Tamil Nadu	0.071	0.066	0.061	0.060
Uttar Pradesh	0.162	0.164	0.170	0.173
West Bengal	0.080	0.080	0.078	0.075
Rest of India	0.032	0.035	0.039	0.040

Source: Author's calculations.
Remarks: Bihar includes Jharkhand; Madhya Pradesh includes Chhattisgarh; and Uttar Pradesh includes Uttarakhand. Rest of India includes remaining states and Union Territories of the country.

The contribution of the increase in e_0 in different states to the increase in e_0 in the country has been different because the pace of increase in e_0 has been different in different states and the share of the population of different states to the population of the country also changed over time. In 9 of the 16 states, the proportionate share of state population decreased during the period under reference so that it contributed to the decrease in the contribution of the increase in e_0 of a state to the increase in e_0 of the country. For example, the share of the population of Andhra Pradesh to the population of the country decreased from around 7.8 per cent in 1981 to around 7.0 per cent in 2011 whereas the e_0 of the state increased by almost 11 years during this period so that the increase in e_0 in the state contributed 0.81 years to the increase in e_0 in the country. However, the decrease in the proportionate share of the population contributed to a decrease of 0.51 years to the increase in the e_0 of the country so that the increase in e_0 in the state contributed only 0.27 years or only 2 per cent of the increase in e_0 of the country. In Kerala, the e_0 increased by around 5.8 years between 1981-85 and 2011-15 whereas the share of the population of the state decreased from around 3.7 per cent to around 2.8 per cent during this period. As the result, the increase in e_0 in the state contributed around 0.19 years to the increase in e_0 in the country but the decrease in population share contributed a decrease of around 0.70 years to the increase in the e_0 in the country. This means that even though the e_0 in Kerala increased during the period under reference, the increase has not been large enough to compensate for the decrease in the contribution of the state to the increase in e_0 in the country.

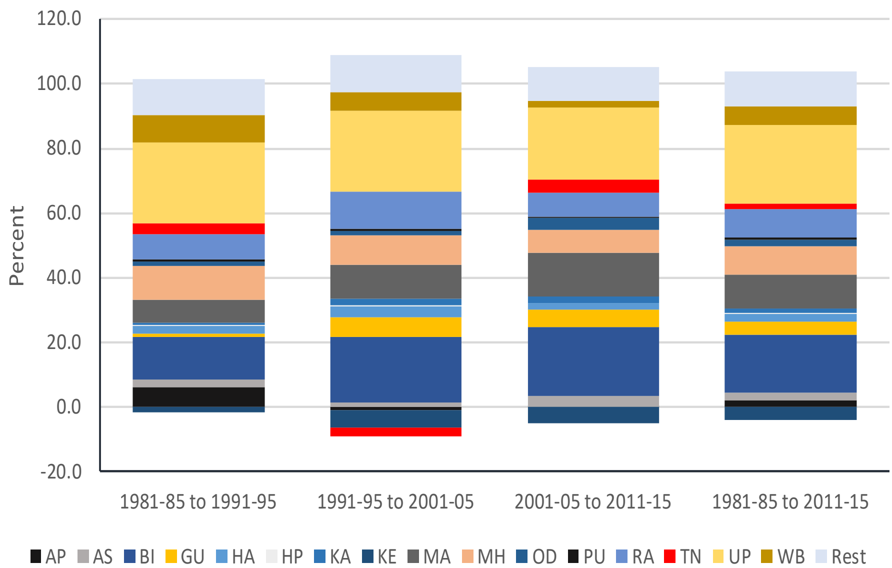

Figure 4: Contribution of different states to increase in e_0 in India during 1981-2015

On the other hand, e_0 in Uttar Pradesh increased by more than 15 years during 1981-2015 and, the population share of the state increased from around 16.2 per cent to around 17.3 per cent so that the increase in e_0 in the state contributed around 2.52 years of the increase in e_0 of the country whereas the increase in the population share contributed around 0.63 years so that the total contribution of the state to the increase in e_0 of the country has been around 3.16 years. A similar situation may also be seen in Bihar also. The two states contributed almost 42 per cent of the increase in e_0 of the country but more than 10 per cent of this contribution is attributed to the increase in the population share of these states. This is in quite contrast to Andhra Pradesh and Tamil Nadu where increase in e_0 contributed more than 1.7 years to the increase in e_0 of the country but the decrease in population share contributed a decrease of around 1.3 years to the increase in e_0 of the country so that the net contribution of these states to the increase in e_0 of the country has been marginal.

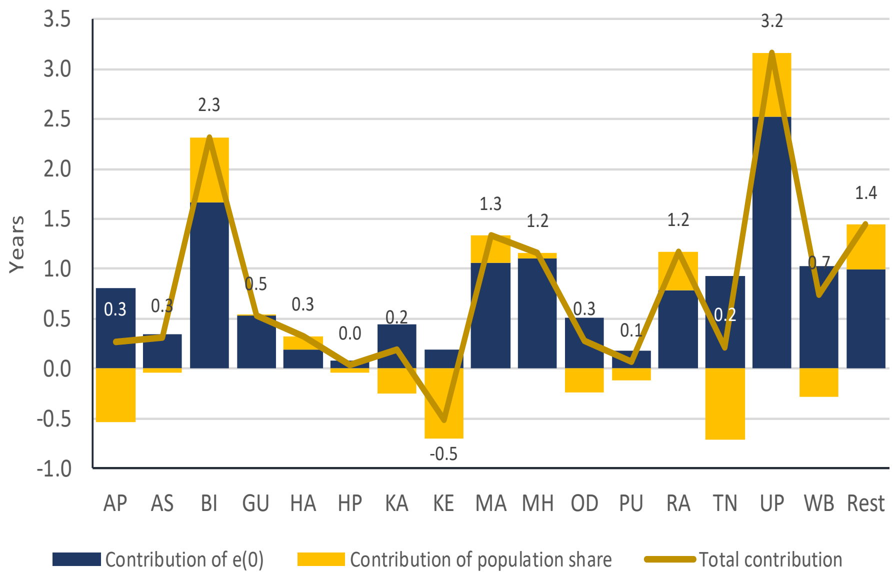

Figure 5: Contribution of different states to the increase in e_0 in India during 1981-2015

The states of the country can be classified into six group based on a two-dimensional classification in terms of the change in e_0 and the change in the population share (Table 5). In Andhra Pradesh, Karnataka, Kerala, and Punjab, the increase in e_0 was less than the national average and share of the population also decreased. The increase in e_0 was less than the national average in Haryana and Maharashtra but population share of these states increased over time. In Gujarat and Himachal Pradesh, increase in e_0 was less than the national average while there was virtually little change in population share. By contrast, in Odisha, Tamil Nadu and West Bengal, the increase in e_0 was more than the national average but the share of the population decreased whereas in Bihar, Madhya Pradesh, Rajasthan, and Uttar Pradesh, the increase in e_0 was more than the national average and, at the same time, the share of the population increased. Finally, Assam is the only state where the increase in e_0 was more than the national average but there was virtually little change in the share of the population.

Table 5: Spatial decomposition of the increase in e_0 in India, 1981-2015.

Country/State	1981-85 to 1991-95			1991-95 to 2001-05			2001-05 to 2011-15			1981-95 to 2011-15		
	∂e	∂p	∇e	∂e	∂p	∇e	∂e	∂p	∇e	∂e	∂p	∇e
India	5.10	-0.11	4.99	4.13	-0.11	4.02	4.11	-0.07	4.04	13.36	-0.31	13.05
Andhra Pradesh	0.29	0.01	0.30	0.25	-0.28	-0.04	0.29	-0.28	0.01	0.81	-0.54	0.27
Assam	0.11	0.00	0.12	0.09	-0.03	0.06	0.14	-0.01	0.13	0.34	-0.04	0.31
Bihar	0.67	-0.02	0.65	0.51	0.30	0.81	0.44	0.42	0.86	1.66	0.66	2.32
Gujarat	0.13	-0.06	0.06	0.23	0.03	0.26	0.17	0.04	0.21	0.53	0.00	0.53
Haryana	0.08	0.03	0.11	0.06	0.07	0.13	0.05	0.03	0.08	0.19	0.13	0.32
Himachal Pradesh	0.03	-0.01	0.02	0.03	-0.01	0.02	0.01	-0.02	0.00	0.08	-0.04	0.04
Karnataka	0.11	-0.07	0.04	0.19	-0.11	0.07	0.15	-0.06	0.09	0.45	-0.25	0.20
Kerala	0.12	-0.20	-0.08	0.02	-0.25	-0.23	0.05	-0.25	-0.20	0.19	-0.70	-0.51
Madhya Pradesh	0.25	0.10	0.35	0.39	0.04	0.43	0.42	0.13	0.55	1.06	0.27	1.33
Maharashtra	0.43	0.09	0.52	0.30	0.06	0.36	0.38	-0.10	0.28	1.10	0.06	1.16
Odisha	0.14	-0.06	0.08	0.16	-0.10	0.06	0.21	-0.07	0.14	0.51	-0.23	0.28
Punjab	0.06	-0.04	0.02	0.04	-0.02	0.02	0.08	-0.05	0.02	0.18	-0.11	0.06
Rajasthan	0.29	0.10	0.40	0.29	0.18	0.47	0.19	0.11	0.30	0.78	0.39	1.17
Tamil Nadu	0.46	-0.29	0.17	0.25	-0.35	-0.10	0.23	-0.07	0.15	0.93	-0.71	0.22
Uttar Pradesh	1.14	0.11	1.26	0.67	0.32	0.99	0.69	0.22	0.91	2.52	0.63	3.16
West Bengal	0.39	0.03	0.42	0.40	-0.16	0.24	0.26	-0.18	0.08	1.03	-0.29	0.74
Rest of India	0.39	0.17	0.56	0.25	0.21	0.46	0.36	0.06	0.42	0.99	0.45	1.44

Source: Author's calculations.

Remarks: Bihar includes Jharkhand; Madhya Pradesh includes Chhattisgarh; and Uttar Pradesh includes Uttarakhand. Rest of India includes remaining states and Union Territories of the country.

Table 6: Classification of states by the increase in *e*0 and the change in population share during 1981-2015.

Increase in e_0	Share of the population											
	Decreased				Increased				No change			
	State	∂e_s	∂p_s	∇e_s	State	∂e_s	∂p_s	∇e_s	State	∂e_s	∂p_s	∇e_s
Less than national average	Andhra Pradesh	0.81	-0.57	0.24	Haryana	0.19	0.13	0.32	Gujarat	0.53	0.00	0.53
	Karnataka	0.45	-0.25	0.20	Maharashtra	1.10	0.06	1.16	Himachal Pradesh	0.08	-0.04	0.04
	Kerala	0.19	-0.70	-0.51								
	Punjab	0.18	-0.11	0.06								
	Total	1.62	-1.60	0.02	Total	1.29	0.19	1.49	Total	0.61	-0.04	0.57
More than national average	Odisha	0.51	-0.23	0.28	Bihar	1.66	0.66	2.32	Assam	0.34	-0.04	0.31
	Tamil Nadu	0.93	-0.71	0.22	Madhya Pradesh	1.06	0.27	1.33				
	West Bengal	1.03	-0.29	0.74	Rajasthan	0.78	0.39	1.17				
					Uttar Pradesh	2.52	0.63	3.16				
	Total	2.47	-1.23	1.24	Total	6.02	1.96	7.98	Total	0.34	-0.04	0.31

Source: Author's calculations.

Remarks: Bihar includes Jharkhand; Madhya Pradesh includes Chhattisgarh; and Uttar Pradesh includes Uttarakhand. Rest of India includes remaining states and Union Territories of the country.

The contribution of different groups of states to the increase in e_0 in the country has radically been different. Andhra Pradesh, Karnataka, Kerala, and Punjab virtually accounted for little to the increase in the e_0 of the country because of both increase in e_0 which was slower than the national average and the decrease in the share of the population. In these states, increase in e_0 accounted for around 12 per cent of the increase in e_0 of the country but almost all increase was compromised by the decrease in the share of the population of these states. By contrast, more than 60 per cent of the increase in e_0 in the country is attributed to Bihar, Madhya Pradesh, Rajasthan, and Uttar Pradesh. In these states, the increase in e_0 was more than the national average and, at the same time, the population share of these states also increased over time. The increase in the share of the population of these states accounted for almost 15 per cent of the increase in the e_0 of the country. On the other hand, Haryana and Maharashtra accounted for more than 11 per cent increase in the e_0 because of the increase in population share of these states as the increase in e_0 in these states was slower than the national average. In Odisha, Tamil Nadu and West Bengal, the increase in e_0 was more than the national average but these states accounted for less than 10 per cent of the increase in e_0 of the country because of the decrease in the share of the population. The increase in e_0 in these states accounted for almost 19 per cent of the increase in e_0 of the country but almost half of this increase was compromised by the decrease in the share of the population of these states.

Discussions and Conclusions

The e_0 in India remains low by international standards and the increase in e_0 has also been slow. It is generally assumed that e_0 should increase at a rate of 0.5 years per year till it reaches 70 years. This means that during 1981-85 through 2011-15, the e_0 in India should have increased by 15 years but the actual increase in e_0 in the country was only around 13 years. The increase in e_0 of the country is contingent upon the increase in e_0 in its constituent states and Union Territories which vary widely in terms of their population size. As such, the increase in e_0 in a state does not contributes directly to the increase in e_0 of the country but this contribution is determined by the share of the population of the state to the population of the country. This means that even if the level and the increase in e_0 in two states is the same, their contribution to the increase in the e_0 of country will depend upon the level and the change in the population share of the two states. The spatial decomposition of the increase in e_0 provides an understanding of the dynamics of the increase in e_0 of the country. Since the level and the increase in e_0 as well as the population share and the change in population share of different states is different, it is obvious that their contribution to the increase in e_0 of the country is different.

The present analysis reveals that only four states – Bihar, Madhya Pradesh, Rajasthan, and Uttar Pradesh – have accounted for more than 60 per cent of the increase in e_0 of the country during the 30 years between 1981-85 through 2011-15. On the other hand, the contribution of Andhra Pradesh, Karnataka, and Punjab to the increase in e_0 of the country has been marginal because the increase in e_0 in these states has been almost entirely compromised by the decrease in population share. In Tamil Nadu also, a substantial proportion of the increase in e_0 is compromised by the decrease in the population share of the state so that the contribution of the state to the increase in e_0 of the country is reduced substantially. On the other hand, the contribution of Kerala to the increase in e_0 of the country has been negative because the contribution of the increase in e_0 in Kerala has been less than the contribution of the decrease in the share of the population of the state.

The present analysis suggests that, to hasten the pace of increase in e_0 in India, there is a need to focus attention on accelerating the pace of increase in e_0 in states like Andhra Pradesh, Himachal Pradesh, Karnataka, Maharashtra, Gujarat, and Punjab. Although, the e_0 in these states is above the national average, yet it is still less than 75 years which means that there is sufficient scope for accelerating the improvement in e_0 in these states. The slow improvement in mortality in these states may be one reason for the decrease in the share of the population of these states to the population of the country which has a negative effect on the contribution of these states to the increase in e_0 of the country. This is important as the change in the share of the population of a state has a strong impact on the contribution of the state to the increase in the e_0 of the country.

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Social Protection Perspective of Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) and Targeted Public Distribution System (PDS) in Madhya Pradesh

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Abstract

The present paper examines the implementation of the Mahatma Gandhi National Rural Employment Scheme (NREGS) and Targeted Public Distribution System (PDS) in Madhya Pradesh from the social protection perspective. The paper reveals that there is substantial scope for improving the organisational efficiency of the two schemes in the context of universal social protection. The paper recommends that innovative approaches should be adopted to increase the protection cover under these schemes.

Background

Universal social protection has been identified as a key development intervention to accelerate the progress towards sustainable development goals (SDGs) as laid down in the United Nations 2030 Agenda for Sustainable Development (United Nations, 2015) and in leaving no one behind. Social protection has also been identified as a key element of national strategies in India to promote human development, and inclusive growth. Universal social protection contributes significantly to the reduction of poverty, vulnerability and inequality and supports social cohesion. It plays an important role in re-building societies after a conflict or after natural disasters including promoting and sustaining gender equality and women's empowerment. Social protection has also been found to contribute to a strong, sustainable, and inclusive economic growth. The contribution of social protection to the increase in productivity, improvement of skills and employability by enhancing human capabilities is well known. It facilitates investment in productive assets. By raising household income, it enhances consumption and savings that boosts aggregate demand. Social protection also improves risk management at the household level and prevents households from harmful coping strategies such as selling productive assets. It enhances people's resilience in the face of shocks and structural transformations.

Achieving universal social protection, however, is challenging because of both endogenous and exogenous factors and requires of innovative implementation approaches. There is also a need to improve the efficiency and efficacy of different social protection schemes. It has also been emphasised that that involvement of civil society organisations and democratically institutions and application of digital technology can contribute to significantly improving the social protection cover.

This study examines the awareness and utilisation of two social protection schemes in Madhya Pradesh – Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) and Targeted Public Distribution System (PDS). The MGNREGS is directed towards promoting income security at the household level by guaranteeing daily wages employment for at the most 100 days in a year and providing unemployment allowance if the employment is not provided (Government of India, 2005). The PDS is directed towards promoting food security at the household level by providing food items at subsidised rates (Government of India, 1997). The MGNREGS is open to all individuals seeking work. The PDS, however, is limited to below poverty line households only. The food insecurity is the highest in these households. The study attempts to provide the benchmark about the knowledge and the utilisation of the two schemes. These benchmarks can serve as the basis for designing, pilot testing, and scaling up the innovative approaches to universalise the use of these schemes to achieve both income security and food security at the household level. Securing income and food security is critical to achieve the cherished goal of universal social protection cover, especially to the poor, vulnerable and the marginalised population groups.

The paper is organised as follows. The next section outlines the methodology of the study. Findings of the study are presented in section three which includes a snapshot of the characteristics of the household surveyed. This section also presents findings related to the use of the two schemes and reasons for not using the schemes including the obstacles faced in getting benefits under the schemes. The last section of the paper summarises the main findings of the study and discusses their implications in the context of universal social protection.

Methodology

The study is based on a survey carried out in three districts of Madhya Pradesh – Panna; Sehore; and Vidisha. In Panna and Vidisha districts, one sub-district – Panna in district Panna and Vidisha in district Vidisha was selected while in Sehore district, two sub-districts –Budni and Sehore were selected purposively. Within selected sub-districts, however, households were selected statistically. The study was confined to the rural areas only. In each selected sub-district, 500 households were selected so that total number of the households planned to be surveyed was 2000. The households were selected following a two-stage selection process. At the first stage of selection, villages were selected following the circular systematic sampling procedure. The village list of the 2011 population census served as the sampling frame for the selection of villages.

In the second stage sample selection, 10 households were selected in each of the selected villages again following the circular systematic sampling procedure. The number of residential households in each village were obtained from the Primary Census Abstract of the 2011 population census to serve as the basis for the identification of the households within the selected village for the survey. The selected households were contacted in person to collect the information related knowledge and awareness and the two social protection schemes.

Total number of households actually surveyed was 2041 against the planned 2000 households in the four sub-districts of the state. The information required for the study was collected through the direct interview preferably with the head of the family based on a pre-designed and pre-tested questionnaire. More than 82 per cent of the households surveyed were the pre-identified households. Primary reason for not contacting a pre-identified household was that a competent respondent was not available.

Findings of the Survey

Characteristics of the Households Surveyed

The key characteristics of the households surveyed, and the characteristics of the population of these households are presented in table 1. More than 74 per cent of the respondents were male whereas close to 30 per cent respondents were female. The proportion of female respondents varied across the four sub-districts covered under the study but was the highest in Sehore sub-district of district Sehore. It may be seen from the table that the basic characteristics of the surveyed households and the population in these households were more or less the same although there are some interesting differences.

More than 42 per cent of the respondents contacted, primarily, the head of the household, were illiterate. The proportion of illiterate respondents was the highest in Panna sub-district but the lowest in Sehore sub-district. Only around 5 per cent of the respondents were having education at least up to the intermediate level. This proportion was the highest in Sehore sub-district but the lowest in Panna sub-district.

Majority of the respondent were in the age group 30-50 years. There were, however, a small proportion of respondents with age below 20 years. These respondents were contacted because the head of the household was not available at the time of the visit to the household.

Most of the households surveyed were nuclear households comprising of husband, wife, and their children. More than one fifth of the households surveyed were extended households having husband, wife, their parents, and children. Less than 5 per cent of the households surveyed were joint households.

More than 96 per cent of the households surveyed were Hindu households. Muslim households constituted less than 4 per cent of the total households surveyed. More than 44 per cent of the households Scheduled Castes households. Scheduled Tribes households constituted around 23 per cent of the households surveyed whereas households of other social classes constituted around 33 per cent of the households surveyed.

Almost 65 per cent of the households were below the poverty line as revealed through the type of the Ration Card the households were having.

Ration Card was available in only around 65 per cent of the households. In around one fifth of the households having the Ration Card, the colour of the Ration Card was yellow whereas in only around 14 per cent of the households, the colour of the Ration Card was white. Most of the households with the Ration Card were having the blue Ration Card. More than 85 per cent of the households having the Ration Card were entitled for food subsidy.

The Samagra Card issued by the Government of Madhya Pradesh to identify the beneficiaries for the delivery of selected social protection services was available in more than 92 per cent of the households surveyed. In Panna sub-district, however, the Samagra Card was available in only around four-fifth of the households surveyed.

In almost 12 per cent of the households having the Samagra Card, all members of the household were not listed in the Card which means that the Card was not updated on a regular basis.

Almost 80 per cent of the households which were having the BPL Ration Card were also having the 'eligibility slip' that entitles the household to receive the ration at the subsidised rate under the Targeted Public Distribution System (PDS).

More than 96 per cent of the households surveyed were having a mobile phone whereas more than 56 per cent of the households were having either a motorcycle or scooter or moped. More than 55 per cent of the households surveyed were having television.

The total population enumerated in the surveyed households was 11021. This means that the average size of the households surveyed was around 5.4 persons per household. The sex ratio of the population was, however, unfavourable to females. There were only about 888 females for every 1000 males in the households surveyed under the study.

More than 27 per cent population enumerated in the surveyed household was below 15 years of age. Children less than 5 years of age constituted around 9 per cent of the enumerated population.

Almost 99 per cent of persons in the surveyed households were found to be having the Aadhar Card but only about 95 per cent had their name listed in the Samagra Card launched by the Government of Madhya Pradesh.

Table 1: Characteristics of the households surveyed.

Characteristics	Total	Sub-district			
		Panna	Budni	Sehore	Vidisha
Respondent relationship with the head of the household					
Household head	72.7	93.2	76.3	51.5	57.6
Other	27.3	6.8	23.7	48.5	42.4
Gender of the respondent					
Female	24.4	12.5	27.6	33.8	25.5
Male	74.0	84.8	68.7	66.2	74.5
Education of the respondent					
Illiterate	42.4	77.7	34.8	24.9	27.6
Literate but below primary	13.5	11.4	18.2	10.2	15.6
Primary but below middle	14.1	5.6	13.6	12.9	25.2
Middle but below High School	15.8	3.4	16.2	22.4	22.3
High School but below Intermediate	8.6	1.3	9.3	18.8	5.3
Intermediate but below Graduate	2.8	0.2	3.8	6.3	1.4
Graduate and above	2.8	0.4	4.0	4.6	2.6
Age of the respondent					
Below 20 years	4.7	0.4	12.7	1.7	6.3
20-30 years	14.3	9.4	8.0	22.2	16.5
30-40 years	24.0	19.3	24.4	28.4	24.1
40-50 years	25.4	25.6	27.9	23.6	25.3
50-60 years	15.2	19.9	15.1	13.9	11.4
60 years and above	16.4	25.6	11.9	10.1	16.5
Type of Household					
Nuclear	74.6	83.8	68.5	61.9	83.1
Extended	20.5	3.7	29.6	35.2	16.1
Joint	4.9	12.5	1.9	2.9	0.9
Household religion					
Hindu	96.3	99.1	95.2	94.1	96.5
Muslim	3.4	0.4	4.3	5.7	3.5
Others	0.3	0.6	0.5	0.2	0.0
Social class of the household					
Scheduled Castes	44.1	25.0	34.4	69.8	44.4
Scheduled Tribes	22.7	47.6	21.1	12.8	6.5
Other Castes	33.1	27.3	44.4	17.4	49.0
Households having BPL Card	64.9	69.5	64.5	47.8	77.7
Household having Ration Card	65.7	78.3	60.1	53.0	69.8
Type of Ration Card					
Yellow	20.2	18.2	27.0	21.9	16.6
Blue	65.7	62.6	58.7	55.9	81.0
White	14.1	19.2	14.3	22.2	2.3

Characteristics	Total	Sub-district			
		Panna	Budni	Sehore	Vidisha
Households having Samagra Card	92.4	79.1	94.3	98.9	98.0
All members listed in Samagra Card					
Yes, all registered	88.1	88.9	93.8	80.0	91.7
No, some not registered	11.9	11.1	6.2	20.0	8.3
Household having the Eligibility Slip	78.9	90.7	74.7	72.5	79.7
Usual occupational engagement of household members					
Agriculture	66.7	50.9	63.7	78.1	67.0
Unskilled labour	92.2	96.4	94.4	79.8	97.5
Skilled labour	8.5	10.7	7.8	9.9	4.0
Paid job	5.9	6.3	10.2	7.5	0.0
Business	5.2	6.4	13.0	4.8	1.0
Usual occupational engagement of women					
Only household work	84.9	88.2	71.4	95.2	73.5
Agriculture	51.1	53.9	63.3	55.7	19.2
Unskilled labour	77.6	94.9	84.0	63.4	81.8
Skilled labour	10.1	60.7	33.8	0.0	1.1
Business	5.6	38.9	19.0	0.9	1.2
Household assets					
Bicycle	63.2	92.3	50.6	48.9	69.5
Radio/Transistor	7.7	4.7	12.8	5.9	5.2
Television	55.5	28.7	66.2	43.6	77.8
Mobile phone	93.4	93.2	88.8	94.3	96.3
Computer	6.2	13.5	10.6	2.5	5.8
Two-wheeler	56.6	73.7	55.6	55.8	49.1
Four-wheeler	8.7	16.7	10.8	7.6	4.7
Cooler	27.4	17.5	40.6	26.1	4.8
Washing machine	3.9	7.5	7.4	2.1	0.7
Refrigerator	5.5	14.0	7.6	4.6	0.0
House owned or rented					
Own	96.6	97.1	90.7	97.5	99.8
Rented	3.4	2.9	9.3	2.5	0.2

Source: Author

Remarks: The distribution of the occupational engagement of the members of the households and women members of the household does not add up to 100 as household members were reported to be engaged in more than one occupation. For example, a person may be engaged in the agricultural activities as the household was having land for agriculture. However, the same person is engaged in some other occupation also presumably because the income from agriculture may not be sufficient to earn the livelihood for the household.

The status of the knowledge and utilisation of the MGNREGS and PDS based on the information provided by the respondents surveyed under the study is discussed in the following pages.

Mahatma Gandhi National Rural Employment Guarantee Scheme

Only about 57 per cent of the respondents reported that they had heard about the Scheme. This proportion was less than 5 per cent in Panna sub-district and around 13 per cent in Budni sub-district but more than 95 per cent in Sehore sub-district and almost 90 per cent in Vidisha sub-district. Among those who had not heard about the Scheme, around 54 per cent had the knowledge that the Government had started scheme which provided work (Table2).

About half of the respondent knew that the Job Card was necessary to take benefits under the scheme. However, around 58 per cent of the respondents who knew that Job Card was necessary reported that application for the Job Card was to be submitted to the Gram Panchayat. Around 39 per cent did not know where to submit the application.

Only about one third of the respondents knew that work under the scheme was to be demanded and the application for the demand of work was to be submitted to the Gram Panchayat. Around 35 per cent respondent did not know that the work was to be demanded under the scheme.

More than 55 per cent of the respondents surveyed did not know that the duration of the work demanded under the scheme must invariably be mentioned in the application for the demand of work. Similarly, more than 58 per cent of the respondents did not know the maximum number of days for which the work could be demanded under the scheme.

Almost 75 per cent of the respondents did not know that if the work was not provided then the unemployment allowance would be admissible and almost 10 per cent respondents were of the view that no unemployment allowance was admissible. Only about 11 per cent of the respondents knew that application would have to be submitted for getting unemployment allowance. In Panna and Budni sub-districts, at least three-fourth of the respondents were of the view that no such application was necessary. Among those respondents who knew that application was to be submitted to get the unemployment allowance if the work was not provided, majority did not know where to submit the application. Around one-fourth of the respondents reported that the application was to be submitted to the Gram Panchayat while a very small proportion reported that the application was to be submitted to the Janpad Panchayat.

Only about 22 per cent of the respondents reported that their household had benefitted from the scheme. Among those who reported that the household was not benefited from the scheme, almost 85 per cent reported that nobody ever contacted the household and told about the scheme and the benefits under the scheme while around 55 per cent of the respondents reported that they were not knowing the procedure of getting the benefit from the scheme. About 46 per cent of the respondents reported that the household did not have the Job Card necessary to get benefits under the scheme.

More than 90 per cent of the households without Job Card did not apply for the Job Card. Primary reason for not applying for the Job Card was the lack of knowledge about the process of getting the Job Card. At the same time, around 18 per cent of the respondents reported that nobody contacted them for the issue of Job Card.

More than 50 per cent households which applied for the Job Card could not cite any reason for not getting the Job Card issued. Application of a small proportion of households was rejected but they did not know the reason of rejection.

Almost 98 per cent of the respondents reported that the household did not get the any work under the scheme in the current year. Among those who got work in the current year, only a small proportion demanded the work. Among the very few which demanded work, the majority demanded work for more than 7 days but around 37 per cent got work for less than 7 days.

Only a negligible proportion of households who did not get work even after demand and who applied for the unemployment allowance received the unemployment allowance. In Panna, Budni and Vidisha sub-districts no household received the unemployment allowance.

More than 83 per cent of the respondents reported that women of their household did not work under the scheme. Among the households from which women worked under the scheme, less than 15 per cent reported that women took their children with them to the place of work. Majority of women left their children at home while they went out for work under the scheme.

There was virtually no arrangement for the care of children at the place of work. There was no Jhoola Ghar or Aya to take care of children of women working under the scheme in any of the four sub-districts covered under the present study.

About one third of the respondents, however, reported that drinking water facility was available at the place of work while a very small proportion reported that shed and first aid facility was available

When asked about why women of the household did not work under the scheme, the most common response was that women of the household did not go out for work. Another dominant reason was that there was nobody in the house to take care of children. There was also concern about the behaviour of the contractors.

An attempt was also made to verify the work that households got under the scheme. However, almost 60 per cent of the household could produce the Job Card. Many of the Job Cards were more than five years old and were not renewed so that households having expired Job Card were not eligible for work under the Scheme.

On the other hand, entries in the available Job Cards which were not expired were found to be mostly incomplete and irregular. The respondents were found to be grossly ignorant about relevance and the need of maintaining the Job Card up-to-date to receive the entitlements that are provided under the scheme.

Table 2: Awareness and use of Mahatma Gandhi National Rural Employment Guarantee Scheme (MNREGS).

Particulars		Sub-district			
	Total	Panna	Budni	Sehore	Vidisha
Heard about MGNREGA	56.8	4.6	12.5	95.6	89.9
Knowledge about scheme	54.0	3.1	16.1	76.5	86.7
Job Card necessary	49.9	3.0	9.6	92.1	78.6
Where to apply for Job Card					
Do not know	39.0	30.4	41.3	24.8	51.8
Gram Panchayat	58.4	17.4	43.5	74.5	47.8
Janpad Panchayat	1.7	34.8	13.0	0.5	0.0
Others	0.8	17.4	2.2	0.2	0.4
Knowledge that work to be demanded	33.0	3.0	5.9	92.1	27.0
Knowledge about where to apply for work					
Do not know	45.1	36.4	45.7	14.0	73.8
Gram Panchayat	53.6	36.4	40.0	85.5	26.0
Janpad Panchayat	0.8	9.1	14.3	0.3	0.0
Others	0.5	18.2	0.0	0.3	0.2
Knowledge that it is necessary to mention days of work required					
Yes	39.5	33.3	13.0	79.4	7.5
No	5.1	33.3	55.6	1.2	2.0
Do not know	55.4	33.3	31.5	19.4	90.5
Knowledge about maximum days of work	36.8	25.0	19.6	73.5	6.0
Knowledge about unemployment allowance if work was not given	16.3	0.0	3.8	33.9	2.2
Knowledge about application is necessary for unemployment allowance	11.4	11.1	5.0	24.7	0.7
Knowledge about where to apply for unemployment allowance					
Do not know	72.4	66.7	66.7	72.5	73.9
Gram Panchayat	25.7	33.3	16.7	26.5	17.4
Janpad Panchayat	1.2	0.0	16.7	0.3	8.7
Others	0.7	0.0	0.0	0.8	0.0
Household benefitted from the scheme	21.6	0.4	2.0	35.6	39.4
Reasons for not getting benefitted					
Do not know about the scheme	23.1	2.3	74.2	91.5	21.5
Process of getting benefit not known	44.9	0.7	56.2	80.0	86.8
No adult member in the household	10.7	0.5	37.0	82.2	4.9
Not engaged in unskilled work	9.8	2.9	32.6	50.0	7.8
Nobody contacted	84.6	15.4	87.7	98.5	81.9
No Job Card	46.3	10.0	74.4	97.3	34.7

Particulars		Sub-district			
	Total	Panna	Budni	Sehore	Vidisha
Not required	19.7	0.0	80.6	80.0	12.9
Ever applied for Job Card	6.5	2.4	7.8	13.6	0.0
Reasons for not getting Job Card					
Do not know	50.3	0.0	69.2	74.2	42.5
Application rejected	6.5	33.3	15.4	16.1	1.9
Others	43.1	66.7	15.4	9.7	55.7
Reason for not applying for Job Card					
No knowledge	60.7	64.9	74.0	82.5	23.2
Necessary documents not available	5.7	18.9	7.7	2.2	2.0
No time to apply	2.0	0.0	2.9	1.1	3.3
No literate member in the family	1.4	2.7	1.0	0.0	2.6
Nobody contacted	17.6	0.0	14.4	10.4	37.1
Others	12.7	13.5	0.0	3.8	31.8
Anybody came home to prepare Job Card	2.2	6.1	2.1	2.9	0.0
Anybody asked to get Job Card	2.5	8.1	2.8	3.2	0.0
Got work under the scheme this year	2.1	0.5	0.7	5.4	1.7
Applied for work	2.9	6.9	0.0	7.2	0.0
Got work even without applying	28.2	0.0	1.3	26.0	41.2
Who told you about work					
Village Chowkidar	9.2	0.0	0.0	9.8	9.1
Gram Panchayat Sachiv	52.7	0.0	100.0	86.3	41.6
Asha/AWW	0.5	0.0	0.0	0.0	0.6
Panchayat representative	21.7	0.0	0.0	2.0	28.6
Relatives or acquaintances	15.5	100.0	0.0	0.0	20.1
Others	0.5	0.0	0.0	2.0	0.0
Received travel allowance	13.4	0.0	0.0	8.2	43.5
Household women got work	16.9	0.0	0.0	37.0	24.3
Do women take children to work					
Yes, take children to work	13.8	na	na	17.5	6.2
No leave them at home	26.2	na	na	21.1	36.6
No young child	7.9	na	na	10.2	3.1
Other	1.8	na	na	1.2	3.1
Arrangements for care of children at place of work					
Jhoola Ghar	0.0	0.0	na	0.0	0.0
Aya to take care of children	0.0	0.0	na	na	0.0
Drinking water facility	31.3	0.0	na	63.9	3.9
Shade for the rest of workers	3.0	0.0	n	5.7	1.3
First Aid	5.6	5.6	na	7.7	1.3
Reasons for women not working under the scheme					
Ladies do not work outside home	12.1	6.6	23.4	6.6	35.5
Nobody else for household work	10.4	1.1	16.1	6.1	55.9

Particulars		Sub-district			
	Total	Panna	Budni	Sehore	Vidisha
Small children in the family	4.5	2.3	6.5	9.4	1.1
No arrangement for care of children	1.2	0.7	4.8	0.5	0.0
Low wages	2.4	0.5	15.3	0.0	0.0
Work not appropriate for ladies	1.8	0.9	6.5	1.9	0.0
Place of work very far	0.2	0.0	1.6	0.0	0.0
Contractor behaviour inappropriate	4.1	3.4	16.9	0.0	0.0
Job Card available in the household	40.8	24.1	14.0	40.8	60.0

Source: Author

Targeted Public Distribution System (PDS)

Almost 78 per cent respondents knew about the scheme. Knowledge about the scheme, however, varied across the four sub-districts. The proportion of respondents knowing about the scheme was only around 41 per cent in Panna sub-district but nearly universal in Sehore and Vidisha sub-districts (Table 3).

Nearly half of the households had blue Ration Card while less than 5 per cent of the households were having yellow Ration Card which means that around 53 per cent of the households were entitled to receive subsidised ration under the scheme. Almost 25 per cent of the households were not having any type of Ration Card.

More than 76 per cent of those households which had a Ration Card of any type reported that all members of the households were listed in the Ration Card. However, only around 56 per cent of those households which did not have all members listed on the Ration Card informed that they applied for getting the unlisted household members listed in the Ration Card.

One condition for getting the benefit under the scheme is that the household must be listed in the list of beneficiary households available at the PDS shop. Only around 68 per cent respondents reported that their household was listed in the list of beneficiaries.

Almost 90 per cent of the households eligible for taking the benefit under the scheme reported that they regularly obtained the ration from the Ration shop whereas more than 93 per cent of these respondents reported that they obtained ration from the ration shop during the month prior to the survey.

In Panna sub-district, there was virtually no knowledge about the norm of getting ration under the scheme (5 Kg per person per month). By contrast, more than 90 per cent respondents in Budni and Vidisha sub-districts knew about the ration per person per month.

More than 40 pe cent of the respondents informed that the Ration Shop owner refused to give ration as per the norm under one pretext or the other. Moreover, about 17 per cent of these respondents reported that they could not obtain full ration as they did not have the money to purchase full ration. On the other hand, more than 43 per cent of the households in sub-district Budni reported that the ration in sufficient quantity was not available in the ration shop so that they could not get the quantity of the ration as provided under the scheme.

The main reason for not getting the benefit under the scheme was that the household was not having the eligibility slip that is issued to the household by the government. Even if a household is having a BPL Ration Card, it may not get the ration from the dedicated PDS shop if the household is not having the eligibility slip.

More than 27 per cent of those households who received ration under the scheme were, however, not satisfied with the quality of the ration although this proportion varied across sub-districts.

However, only about 8 per cent of those respondents who reported that they were not satisfied with the quality of ration received under the scheme at the subsidised rate reported that they had lodged a complaint about the poor quality of the ration available from the PDS shop to the competent authority. Majority of the respondents reported that they did not lodge the complaint because they did not have any knowledge about the process of lodging the complaint if the quality of ration available from the PDS shop was not satisfactory.

The respondents were also having little knowledge about the competent authority to which the complaint was to be lodged regarding the poor quality of the ration available under the scheme. It was found during the survey that the competent authority to which the complaint about the poor quality of ration available under the scheme was to be lodged was different in different sub-districts covered under the scheme. In the Sehore sub-district, all complaints were lodged to the State Food Commission that has been constituted by the state government. In Panna sub-district, on the other hand, more than three fourth of the complaints lodged were registered in the Chief Minister Helpline. In Vidisha sub-districts, complaints regarding the poor quality of the ration available under the scheme were lodged to multiple agencies including the district Collector, the Chief Minister helpline, and the Janpad Panchayat. In sub-district Budni, complaints were lodged to the Janpad Panchayat and the Gram Panchayat. It appears that there was not well-defined centralised system of registering complaints related to the poor quality of the ration available under the scheme. At the same time, there was no respondent who reported that some action was taken on the complaint lodged and there was an improvement in the quality of the ration available under the scheme.

There is also a provision of food security allowance under the scheme. However, knowledge about the food security allowance was virtually zero in all the four sub-districts covered under the study. Only one respondent in sub-district Panna had reported that the household had received the food security allowance as provided under the scheme. In Budni, Sehore and Vidisha sub-districts, there was no respondent who reported that the household had received the food security allowance.

Table 3: Knowledge and use of Targeted Public Distribution System

Particulars	Total	Sub-district			
		Panna	Budni	Sehore	Vidisha
Knowledge about PDS	77.9	41.8	75.1	98.7	97.9
Type of Ration Card					
Blue - below poverty line	48.9	32.5	42.8	44.7	74.4
Yellow - Antyoday	4.8	4.7	10.8	0.8	4.7
White - General	21.7	48.7	23.2	12.1	3.0
No Ration Card	24.6	14.0	23.2	42.4	17.8
All members entered in the Ration Card					
All members	76.1	86.3	78.0	62.6	75.9
Some members	20.3	6.4	17.3	36.6	22.8
If no, applied for addition	56.0	51.3	51.3	66.7	45.3
Family is listed in beneficiaries list	68.5	52.6	65.2	63.7	80.9
Taken ration from PDS shop					
Yes, every month	89.7	87.3	81.3	95.8	93.3
Occasionally	3.7	8.5	5.7	0.8	0.0
No	6.5	4.2	13.0	3.4	6.7
Took ration in the last month					
Yes	93.3	94.0	84.5	96.1	96.9
No	6.7	6.0	15.5	3.9	3.1
Know about the ration per person					
Do not know	32.0	95.4	6.8	0.6	1.2
Yes	60.8	1.7	91.9	81.3	96.9
Others	7.2	2.9	1.3	18.2	1.8
Reason for taking ration less than due					
No money	16.7	12.5	18.9	17.8	0.0
Not required	12.0	5.0	5.4	14.7	12.5
Quantity not available	13.4	0.0	43.2	11.0	0.0
Supplier refused	41.7	12.5	16.2	51.3	75.0
Others	16.3	70.0	16.2	5.2	12.5
Reason for not taking the ration					
No money	4.8	7.5	6.9	3.5	3.1
No Eligibility Slip	58.3	7.5	17.2	86.0	84.4
Shop owner refused	12.8	2.5	65.5	3.5	3.1
PDS shop closed	1.1	2.5	3.4	0.0	0.0
Machine out of order	2.7	7.5	0.0	1.2	3.1
Could not match with records	1.1	2.5	0.0	0.0	3.1
Poor quality	0.5	0.0	0.0	0.0	3.1
Others	18.7	70.0	6.9	5.8	0.0
Satisfied with the quality of ration					
Fully satisfied	57.9	6.7	40.5	79.6	94.2

Particulars	Total	Sub-district			
		Panna	Budni	Sehore	Vidisha
Satisfied to some extent	10.6	8.2	29.4	17.3	0.8
Cannot say	2.1	2.8	11.9	0.3	0.0
Not satisfied	27.1	78.6	7.9	2.5	4.8
Fully unsatisfied	2.3	3.6	10.3	0.3	0.3
If not satisfied complained	10.0	3.9	9.1	15.1	42.5
State Food Commission	33.3	25.0	0.0	100.0	na
CM Helpline	80.0	77.8	na	na	100.0
Collector	50.0	0.0	na	na	100.0
Public hearing portal	0.0	0.0	na	na	na
Public hearing	0.0	0.0	na	na	na
Janpad Panchayat	66.7	0.0	100.0	na	100.0
Gram Panchayat	95.8	0.0	100.0	100.0	100.0
Vigilance committee	40.0	25.0	na	100.0	na
Know about food security allowance	0.5	0.5	0.8	1.0	0.0
Not received food security allowance	75.6	80.0	na	78.4	33.3

Source: Author

Discussions and Conclusions

Universal social protection has been advocated to strengthen household economic security, household resilience to external shocks and protection from vagaries of nature such as the COVID-19 pandemic and risks and uncertainties associated with the market economy (Chaurasia, 2022). It has been argued to contribute significantly to the well-being, especially of the vulnerable, poor, and marginalised groups of the population, including well-being of children and women.

Government of India has launched a number of schemes that provide protection cover to the population and to specific population groups who are vulnerable to one or the other social, economic, and environmental risks and hazards to promote their well-being and to ensure that no one is left behind in the process of economic, social, and human development.

The present study has examined the status of implementation of two of these schemes – Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) and Targeted Public Distribution System (PDS) through the social protection perspective so as to make these schemes more effective in protecting individuals and households, especially children and women from economic, social, and environmental shocks and to provide them opportunities for their full development and growth. The study contacted more than 2000 households in four sub-districts of Madhya Pradesh to explore different dimensions of the implementation of the two schemes.

The study has revealed that the current status of the implementation of the two schemes from the social protection perspective is far from satisfactory and there is substantial scope of improvement in the implementation of these scheme so as to provide effective protection cover to the potential beneficiaries who are entitled to get benefits under the scheme.

It has been observed that both the schemes are being implemented in the conventional bureaucratic manner and this approach of implementation appears to be the main reason these schemes are not able to provide protection cover to all the potential beneficiaries. The findings of the study suggest that there is a need of improving the needs effectiveness of these scheme by reaching all the potential beneficiaries and informing them about the schemes and their benefits. At present, a selective approach appears to have been adopted to reaching out the potential beneficiaries under these schemes so that a substantial section of the population, especially, vulnerable population remains devoid of the benefits of these schemes. This selective approach also appears to be the reason behind the limited knowledge of the community in general and potential beneficiaries in particular about these schemes.

The study suggests that the organisational efficiency of the two schemes needs to be enhanced significantly through innovative approaches of implementation so as to ensure that the potential beneficiaries of these schemes receive the full entitlements that have been provided under the scheme. At present, both the needs effectiveness and the capacity efficiency of these schemes remains poor so that only a small proportion of the potential beneficiaries receive full entitlements that have been provided under these schemes.

Both the schemes are currently provider driven. This means that their implementation is critically dependent upon the providers of services under these schemes – the Secretary of the Gram Panchayat in case of MGNREGS and the owner of the PDS shop in case of PDS. There is a need that the implementation of these schemes is driven by the community and community organisations so as to make these schemes more effective in meeting the social protection needs of the people, especially children and women who are regarded as the most vulnerable group of population irrespective of religion, class, and standard of living.

There is also a need of establishing a functional grievances redressal system to improve the efficiency of the two schemes. There is an in-built grievances redressal system in place under both the schemes, but this system is hardly functional at the grass roots level, the interface with the community. The study has revealed that the beneficiaries have little faith in the grievances redressal system because it hardly contributes to improving the delivery of services under these schemes. Another problem is that the procedure of lodging grievances is very cumbersome and most of the beneficiaries, primarily the poor and the deprived ones are simple incapable of using the system to lodge their grievances and to get the grievances addressed through the system.

The findings of the present study may serve as the basis for designing and implementing alternative yet innovative approaches for improving the organisational efficiency of these schemes. In the context of universal social protection, it is imperative that these schemes must be driven by the community and their social protection needs and not by the arbitrariness of the services delivery agencies. In this context, establishment of a community-based system of monitoring the implementation of these schemes and evaluating their impact is very important.

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Hypertension Treatment and its Consequences in Rural North Karnataka

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Abstract

This study analyses hypertension treatment effect and its outcome in North Karnataka based on a survey of 712 rural women aged 40-55 years. It is observed that systolic BLOOD PRESSURE increased significantly by the age of women. Menopause attained was associated with an increase in systolic BLOOD PRESSURE by age. Diastolic BLOOD PRESSURE did not show any trend by menopause status. Systolic and diastolic BLOOD PRESSURE were the highest in women with ‘Hypertension without treatment’ and ‘Diabetes with treatment’, and lowest in the ‘heart disease with the treatment group. Odds in Hypertension with and without treatment were highly significant than no Hypertension. The Odds in favour of ‘diabetes without treatment’ in Hypertension was 2.27 times, whereas 1.25 times in ‘diabetes with treatment’ than ‘no diabetes’. The sensitivity and Specificity of the model were 77.5per cent and 69.4per cent respectively. Higher sensitivity can be used for treatment and higher specificity for screening purposes as per the need of health providers using ROC curve. The study will be useful for planners, policymakers, and system-level interventions. Further, it can be used for health and screening the community to minimize consequences.

Introduction

There are many factors that have contributed to the rise in the occurrence of lifestyle diseases. These include, among others, tobacco use, harmful use of alcohol, poor diet, and physical inactivity (Nagheer at al 2017). These causes are reflected in terms of raised blood pressure, high glucose level, abnormal blood lipids, overweight and obesity. There are modifiable risk factors as well as non-modifiable risk such as age and heredity, that describe most of the life style diseases including heart diseases, stroke, chronic respiratory diseases and even cancers. The association between main modifiable risk factors and the leading chronic diseases is similar in all regions of the world (WHO, 2005).

Hypertension and type-2 diabetes (T2D) are the two main modifiable risk factors that are associated with most of the life style diseases. The prevalence of both these factors is increasing in the low middle-income countries and pose a major health challenge to be addressed (Boutayeb , 2006; Lim et al, 2012). Hypertension is an important modifiable risk factor for the cardiovascular diseases (CVD) (Gupta, 2004) which has now emerged as a major cause of death worldwide (Forouzanfar, 2017). The prevalence of hypertension is the highest in Africa (46 per cent) (WHO, 2015). Low birth weight has been found to be associated with the increase in the blood pressure, heart diseases, stroke, and diabetes in the later life. Ageing is an essential indicator of accumulation of modifiable risks for chronic diseases (WHO, 2005).

In India, a significantly increased burden of hypertension has been reported from both urban and rural areas (Gupta et al, 1996; Gupta, 2016). In the mid-1950s, epidemiological studies of urban India, using older World Health Organization criteria for the diagnosis of hypertension (known hypertension or BLOOD PRESSURE ≥ 160 mm Hg systolic and/or 95 mm Hg diastolic), reported a hypertension prevalence of 1.2–4.0 per cent in adults (Gupta et al, 1996). In the 1960s, the prevalence of hypertension in the urban areas was reported to be 3.0-4.5 per cent, whereas in the 1990s, the prevalence of hypertension increased to 11.0–15.5 per cent (Gupta et al, 1996). The prevalence of hypertension was reported to be lower in the rural population compared to the urban population in the mid-20th century but there has been a significant increase in the prevalence even in the rural areas from around 1 per cent in the 1960s to 5–7 per cent in the 1990s (Forouzanfar et al, 2017; Gupta et al, 1996; Gupta and Yusuf, 2014).

Hypertension exerts a considerable public health burden on cardiovascular health status and healthcare systems in India (Leeder et al, 2004; Reddy et al, 2005). Hypertension has been found to be directly responsible for 57 per cent of all stroke deaths and 24 per cent of all deaths due to coronary heart diseases (CHD) in India (Gupta and Yusuf, 2014). According to the World Health Organization, hypertension as one of the most important causes of premature deaths worldwide (Mackay et al, 2004). The global burden of diseases project suggests that, in India 20.6 per cent men and 20.9 per cent women were suffering from hypertension in 2005 (Kearney, 2005). It is also projected that the prevalence of hypertension in India will increase to 22.9 per cent in men and 23.6 per cent in women in India by 2025 (Ayah et al, 2013). Recent studies have suggested that the prevalence of hypertension in the country is around 25 per cent in the urban areas and 10 per cent in the rural areas (Gupta, 1997; Zachariah et al, 2003; Das et al, 2005). According to estimates prepared by the World Health Organization, the prevalence of elevated blood pressure in Indians was 32.5 per cent (31.7 per cent in women and 33.2 per cent in men) (WHO, 2014). It has, however, been observed that only around 25.6 per cent of those persons who are receiving treatment for hypertension have their blood pressure within the normal limits (Hypertension Study Group, 2001). Prevalence of hypertension of hypertension in India reported in other studies ranges between 13.9 per cent to 48.2 per cent in the urban areas and 4.5 per cent to 45 per cent in the rural areas (Devi et al, 2013; Gupta et al, 2012). Similar variations have also been reported in the prevalence of cardiovascular diseases. There have also been regional differences in prevalence of chronic heart diseases (CHD) and stroke in the country. The prevalence and the mortality from CHD is reported to be higher in southern and eastern India (Gupta et al, 2012). However, to the best of our knowledge, there has been no study that has examined the prevalence of hypertension in the rural areas of north Karnataka. There is also little information about the prevalence of hypertension and the effect of the treatment on the prevalence of hypertension in this part of the country.

It is in the above context, that the present study has been undertaken. The study estimates, for the first time, the prevalence of hypertension in women living in the rural areas of North Karnataka and examines how the treatment of hypertension received by the women has influenced the prevalence of hypertension. It is argued that proper treatment of hypertension contributes to the change in the prevalence dynamics of hypertension.

The paper is organised as follows. The next section of the paper describes the data and the method adopted for the analysis of the data. The study is based on the primary data collected from a sample of rural women aged 40-55 years in one of the districts located in the northern Karnataka. Results of the findings of the study are presented and discussed in section three of the paper. The last section of the paper summarises the findings of the analysis and discusses it implications for meeting the health needs of the people.

Materials and methods

The study is based on a survey of 712 rural women aged 40-55 years in the rural areas of the Belagavi district of north Karnataka that was carried out during the period October 2016 through April 2017. The women covered under the survey were selected using the inverse cluster sampling technique. During the survey, the blood pressure – systolic and diastolic – was measured for each women and data were collected about status of menopause along with selected socio-economic characteristics of the respondents, anthropometric measurements – weight and height - and the disease(s) that they were suffering at the time of the survey. The status of menopause was classified in three categories – no menopause, menopause, and surgically induced menopause. Surgically induced menopause occurs when premenopausal women have their ovaries surgically removed. This removal causes an abrupt menopause. Women with surgically induced menopause often experience more severe menopausal symptoms as compared to women who have not removed their ovaries surgically.

Bivariate and logistic regression analyses was carried out to assess the effect of a set of explanatory variables on the prevalence of hypertension. The explanatory variables included age of the respondent, the menopausal status, hypertension, and whether the respondent was suffering from diabetes and any heart disease. All respondents were also asked whether they were undergoing any treatment for hypertension or not. Odds ratio was calculated using the Logistic Regression in the presence of explanatory variables in those women who were receiving treatment for hypertension and women who were not receiving treatment for hypertension. The Logistic regression model is defined as

$$f(x) = Log_e\left(\frac{p}{1-p}\right) = a_i + \sum_{i=1}^{k} a_i x_i \quad (1)$$

where

$$p = \frac{e^{f(x)}}{1+ e^{f(x)}} \quad (2)$$

Here, a_i is the regression coefficient and x_i are the explanatory variables. The 95 per cent confidence interval of the Odds ratio has been computed as:

$$\text{95 per cent CI of Odds ratio} = e^{\left(\log_e(\mathrm{OR}) \pm 1.96\sqrt{\frac{1}{a}+\frac{1}{b}+\frac{1}{c}+\frac{1}{d}}\right)} \quad (3)$$

Here a and b are the number of women with hypertension in the positive attribute of the explanatory variables, and c and d are similar figures for the reference group. The collected data were cleaned for errors using Excel and analysis was carried out using the Statistical Package for Social Sciences (SPSS) version 22.

Results

Table 1 presents the mean systolic and diastolic blood pressure by the age of women surveyed their menopause status and the body mass index (BMI). The table shows that the systolic blood pressure increases, and the increase with age is found to be statistically significant ($p<0.05$). The diastolic blood pressure also increases with age, but the increase is not statistically significant. Menopause results in an increase in the systolic blood pressure but the increase is not statistically significant whereas the diastolic blood pressure does not show any increase with age. In the surgically induced group, the diastolic blood pressure was found to be the highest (Mean=93.6; SD= 18.0) but was the lowest in women having BMI less than 25 (Mean= 87.6, SD = 12.1). There was, however, no difference in the diastolic blood pressure in women having higher BMI. The systolic blood pressure was the lowest in women having BMI between 25 and 29.9 but the difference was not statistically significant.

Table 2 presents mean systolic and diastolic blood pressure by the disease history and treatment status. Both systolic and diastolic blood pressure were the highest in women who were hypertensive but were not taking any treatment. On the other hand, both systolic and diastolic blood pressure were the highest in those women who were diabetic but under treatment, whereas the blood pressure was the lowest in women having heart disease but were taking treatment.

Table 1: Systolic and diastolic blood Pressure by age, menopause status and BMI in women aged 40-55 years.

Variable	N	Systolic blood pressure		Diastolic blood pressure	
		Mean	SD	Mean	SD
Total	712	134.3	17.9	89.5	13.0
Age in Years					
<45	52	134.0	13.8	92.1	12.8
45-49	184	131.4	13.3	88.1	12.9
50+	476	135.5	19.6	89.8	13.0
Menopause					
No	122	132.9	14.2	90.3	11.7
Yes	550	134.4	19.0	89.1	12.8
Surgically induced	40	138.0	9.8	93.6	18.0
BMI					
<25	115	135.7	11.7	87.6	12.1
25-30	489	133.7	19.5	89.9	13.5
≥30	108	135.8	15.3	89.8	11.2

Source: Authors

Table 2: Systolic and diastolic blood pressure by disease history and treatment status in women aged 40-55 years.

Variable	N	Systolic blood pressure		Diastolic blood pressure	
		Mean	SD	Mean	SD
Total	712	134.3	17.9	89.5	13.0
Hypertension					
No hypertension	297	127.9	9.8	82.9	8.0
Without treatment	41	145.4	14.5	98.4	13.8
With treatment	373	138.2	21.2	93.8	13.7
Diabetes					
No diabetes	494	132.3	12.3	88.0	11.5
Without treatment	35	137.1	12.7	84.6	7.9
With treatment	183	139.2	27.8	94.6	15.7
Heart Disease					
No heart disease	669	134.2	18.3	89.6	13.2
Without treatment	22	138.8	5.7	90.3	5.1
With treatment	21	133.8*	8.0	86.3	9.8

Source: Authors

Table 3 presents results of the logistic regression analysis. The dependent variable is a dichotomic variable which takes value 1 if the woman was found to be hypertensive at the time of the survey and 0 other wise. The explanatory variables, on the other hand include selected demographic and physiological characteristics of the woman, the disease history, and the hypertension treatment status. The table shows that women with surgically induced menopause are 2.6 times more likely to have hypertension than non-menopausal women and the difference was statistically significant at $p<0.05$. Similarly, women having diabetes but not taking any treatment of diabetes are 2.3 times more likely to have hypertension as compared to women not having diabetes. However, women having diabetes and taking treatment of diabetes are only about 1.25 times more likely to have hypertension as compared to women without diabetes and the difference is not statistically significant. Women having heart disease but not taking any treatment are found to be four times more likely to have hypertension as compared to women without heart disease but women with heart disease and taking treatment are found to be less likely to have hypertension as compared to women having no heart disease but the different is not found to be statistically significant.

The ROC Curve (Figure 1) exhibits the Sensitivity and Specificity of the logistic regression model. The model correctly identified 77.9 per cent of the women covered in the study in terms of their hypertension status along with a 95 per cent Confidence Interval of 74.3 per cent to 81.4 per cent.

Table 3: Results of the logistic regression analysis.

Variables	Odds ratio	Confidence interval	
		Lower	Upper
Age of women			
50-55	1.00		
40-45	1.03	0.45	2.34
45-50***	0.35	0.22	0.54
Menopause status			
No	1.00		
Yes	0.80	0.45	1.41
Surgical*	2.67	1.06	6.75
Hypertension treatment			
No hypertension	1.00		
No treatment***	7.01	2.89	16.99
Treatment***	7.16	4.91	10.43
Diabetes			
No Diabetes	1.00		
No treatment	2.27	0.95	5.40
Treatment	1.25	0.82	1.92
Heart disease			
No heart disease	1.00		
No treatment*	4.09	1.09	15.35
Treatment	0.75	0.28	2.00

Source: Authors

Remarks: *** $p<0.001$, * $p<0.05$

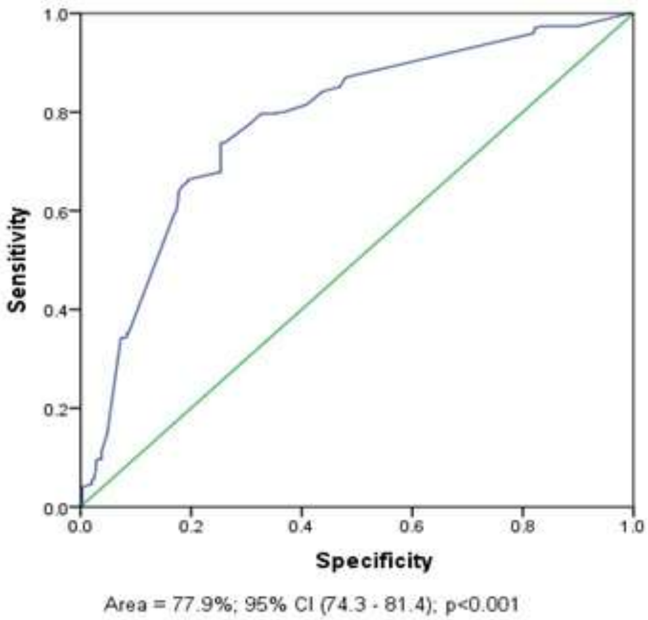

Figure 1: ROC Curve for hypertension using age of woman, menopause status, BMI, heart disease, diabetes and hypertension treatment
Source: Authors

Table 4: Sensitivity and specificity of the logistic regression model as computed by the ROC Curve for the diagnosis of hypertension

Positive ≥ p	Sensitivity	Specificity
0.351947	0.872	0.514
0.369706	0.870	0.521
0.393049	0.851	0.531
0.401614	0.842	0.562
0.404636	0.816	0.590
0.450867	0.799	0.646
0.524924	0.797	0.674
0.560603	0.775	0.694
0.626115	0.678	0.747
0.634107	0.664	0.802
0.644855	0.662	0.806
0.681827	0.650	0.816
0.786394	0.629	0.823
0.790726	0.600	0.826
0.792462	0.596	0.830

Source: Authors

Discussion

Hypertension wields a considerable public health burden on cardiovascular health status and health care system in India. Moreover, regional disparities in mortality and morbidity prevalence of coronary heart disease (CHD) and stroke have been observed. South India had higher CHD mortality, and eastern India has higher stroke rate (Gupta et al, 2021). Some studies are available on hypertension, but, to the best of our information, no study assessed morbidity pattern of hypertension in both untreated and treated population in Karnataka. Hence, the current study has been undertaken. Systolic and diastolic Blood Pressure by disease history and their treatment status in women of age 40-55 years were estimated to provide reference for health care personnel. Logistic regression analysis was carried out, to know the effect of demographic and physiological characteristics of women surveyed and their and disease history and treatment status on the prevalence of hypertension. Similar study had been carried out by Patil et al (2020) to study the impact of physiological, demographic characteristics and disease history on perimenopause symptoms in the same age group of women. Another study has used the Poisson regression model (Prenissl et al, 2019).

The analysis reveals that diastolic blood pressure does not change with the increase in age, but the systolic blood pressure increases with the age. The similar results have been observed in other studies (Mkuu et al, 2019). A recent study conducted by Geldsetzer et al (2018), among 1.3 million adults in India has observed that 25 per cent Indian adults have raised blood pressure but the prevalence of high blood pressure was low in adults aged 18-25 years (12per cent). Menopause results an increase in the systolic blood pressure but not in the diastolic blood pressure. However, the diastolic blood pressure has been found to be the highest in women with surgically induced menopause. The diastolic blood pressure is found to be the lowest in women with BMI less than 25 but increases with the increase in BMI. The systolic blood pressure, however, was found to be the lowest in women with BMI 25-30. According to other studies, overweight or obese women are at higher risk of hypertension (Ayah et al, 2013; Olack et al, 2015). In general, women aged 30 years and above have higher risk of having hypertension (Mkuu et al, 2019). Other studies have also reported higher risk for hypertension among older women (Ayah et al, 2013; Olack et al, 2015). Hypertension is reported to be the result of the combination of demographic and epidemiological transition, changing lifestyle with an increase in dietary fat and salt and low physical activity (Ibrahim and Damasceno, 2012; Gupta et al, 2016; Gupta and Gupta, 2017). There has been a rapid increase in the prevalence of overweight and obesity in India in the last 20 years, resulting higher prevalence of hypertension (Siddiqui and Donato, 2016; Shrivastava et al, 2017).

The systolic and diastolic blood pressure have been found to be the highest in hypertension women who are not taking any treatment. Blood pressure has also been found to be high in women with diabetes, although taking treatment but the lowest in women having heart disease but taking treatment. There is evidence that awareness, treatment, and control of hypertension is increasing in Indians, although there are huge rural-urban disparities (Anchala et al, 2014; Gupta et al, 2018). The awareness of treatment and control of hypertension has been found to be, respectively, 42.0 per cent, 37.6 per cent and 20.2 per cent in urban Indians, and 25.3 per cent, 25.1 per cent and 10.7 per cent in rural Indians (Gupta et al, 2018). Increasing the awareness about hypertension through screening programs is expected to lead to greater chances of treatment and better control of hypertension (Angell, 2015). The policy and system-level interventions should, therefore, be focused on public education and screening along with focus on reducing the intake of salt and alcohol, smoking cessation, promotion of healthy diet and facilitation of physical activity. Individual-level interventions should be on better physician education who should promote individual lifestyle changes, appropriate pharmacotherapy, and control of vascular risk factors along with the effort to improve treatment adherence (Gupta and Yusuf, 2014; Angell et al, 2015; Frieden and Bloomberg, 2018). The Million Hearts Initiative in the United States of America is focused on increasing hypertension control using policy, population-level, and clinic-based interventions (Lloyd-Jones et al, 2017). Similar programme needs to be developed and implemented to reduce hypertension-related cardiovascular morbidity and mortality in Karnataka.

The odds of having hypertension in women with surgically induced menopause found to be very high. Similarly, the odds of having hypertension in women with high blood pressure irrespective of their treatment status are also found to be high. Women having diabetes but not taking any treatment and women having heart disease but not taking any treatment have also been found to be at higher risk of having hypertension. A study supports these observations and have shown that that hypertension was directly responsible for around one-fourth of all deaths from coronary heart disease in India (Gupta and Yusuf, 2014), which is one of the most important causes of premature death worldwide (Mackay et al, 2004).

Conclusions

The present study has found that the systolic blood pressure increases with age but not the diastolic blood pressure. Menopause results in an increase in the systolic blood pressure but not the diastolic blood pressure. The increase in the diastolic blood pressure is, however, found to be very high in women with surgically induced menopause. Diastolic blood pressure is found to be the lowest in women with BMI less than 25 while the systolic blood pressure is found to be the lowest in women with BMI ranging between 25 and 30. The blood pressure is found to be the highest in hypertensive women who were not taking any treatment for hypertension. The blood pressure is also found to be high in diabetic women even though they were taking diabetic treatment. The blood pressure was the lowest in women with heart disease and taking treatment. There is a need to enhance health education and medical care to the women reaching menopause and in women with surgically induced menopause.

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Family Planning Methods Use in Madhya Pradesh, India: Evidence from National Family Health Survey

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Abstract

In this paper, we analyse trend in the use of different family planning methods and determinants of the use of different family planning methods in Madhya Pradesh, India using the data available through the National Family Health Survey. Bivariate analysis and multinomial logistic regression have been used to analyse the determinants of the use of different family planning methods. The analysis shows that the prevalence of family planning in the state has increased from 50 per cent to 72 per cent in the state and terminal family planning methods are the most commonly used in the state. The prevalence of female sterilisation is 53 per cent in the state according to the latest round of the National Family Health Survey.

Introduction

India was the first country in the world to adopt population policy and launch official family planning programme in 1952. During its early years, the programme focussed on the health rationale of family planning. Family planning as a strategy for population stabilisation received attention only after 1971 population census (Chaurasia, 2008). This strategy resulted in an increase in the proportion of couples effectively protected from 12.4 per cent during 1971-72 to 47 per cent during 1995-96 but remained stagnant during 1995-96 through 2003-04 and decreased to 40 per cent during 2010-11. After the launch of the National Rural Health Mission in 2005, the official family planning programme has been subsumed in the reproductive and child health component of the Mission (Chaurasia, 2013).

Universal adoption of small family norms still remains a distant dream in India. During 2007-08, only about 54 per cent of the currently married women aged 15–49 years or their husband were using a family planning method to regulate their fertility (Government of India, 2010) and the contraceptive prevalence rate appears to have stagnated after 2004 (United Nation, 2012). From 1965 to 2009, family planning use in the country has more than tripled from 13 per cent in 1970 to 48 per cent in 2009 while the total fertility rate has more than halved from 5.7 in 1966 to 2.4 live births per woman of reproductive age in 2012, It is estimated that India adds up to 1,000,000 people to its population in every 20 days (Pati, 2003; Rengel, 2000; Bongaarts et al, 2012; Ramu, 2006; Adlakha, 1997; WHO, 2009). Extensive family planning has become a priority in an effort to reduce the projected population of two billion by the end of the twenty-first century. Women in India are not being fully educated on contraception usage (Jain, 2016). Contraceptive usage has been rising gradually in India. In 1970, 13 per cent of married women used modern contraceptive methods, which rose to 35 per cent by 1997 and 48 per cent by 2009 (Rengel, 2000). Awareness of contraception is near-universal among married women in India (Ramesh et al, 2006). In 2009, 48.4 per cent of currently married women of reproductive age were using a family planning method. About three-fourth of these women were sterilised, which is by far the most prevalent birth-control method in India (Parappil et al, 2015). It is important to note that sterilisation is a common practice in India. It is common to use temporary medical facilities like specially organised camps to undergo sterilisation. Comparative studies have indicated that increased female literacy is correlated strongly with a decline in fertility (Robey, 1990). Studies have indicated that female literacy levels are an independent strong predictor of the use of family planning even when women do not otherwise have economic independence (Dharmalingam and Morgan, 1996). Successful implementation of sexual and reproductive programmes, basically, depends on the fulfilment of the reproductive rights and choices of individuals (United Nations, 2014).

Family planning is crucial for achieving Sustainable Development Goals as articulated in the United Nations 2030 Agenda for Sustainable Development (United Nations, 2015). Family planning has direct impact on the health of the women and is an important indicator for tracking progress in improving women health. Family planning use in high fertility states in India like Madhya Pradesh is known to be heavily skewed towards terminal methods, which means that family planning is practised primarily to limit births rather than to ensure proper spacing between successive births or between marriage and first birth. It is well-known that to prevent unwanted births or to ensure spacing between successive births, efforts need to be made to improve the access and quality of family planning services.

In this paper we examine the trend in family planning use in Madhya Pradesh and analyse the determinants of the use of different family planning methods. The paper examines cross-sectional patterns in the prevalence of different methods of family planning which have been categorised into two categories – terminal methods, and non-terminal methods. The paper also examines the likelihood of using a terminal family planning method and a non-terminal family planning method after taking into consideration a number of social, demographic and other characteristics of currently married women of reproductive age in Madhya Pradesh. The findings of the analysis suggest the there is a need of increased investment in the health and education of children in Madhya Pradesh. Investment in the health and education of children, it may be argued, is ultimately an investment in the future of Madhya Pradesh.

Data and Methods

The study is based on the data available from third (2005-2006), fourth (2015-2016) and fifth (2019-2021 rounds of the National Family Health Survey (NFHS). The NFHS provides information on population, health, nutrition and family welfare for both men and women at national and state level including information on the use of different family planning methods. In the fifth round of the survey, 43,522 households were surveyed in which 48,410 women, and 7,025 men were covered and 46,829 currently married women in the reproductive age group (15-49 years) were interviewed in the state. The survey covered all districts of the state as they existed at the time of the survey.

Bivariate analysis has been carried out to estimate the prevalence of different family planning methods among currently married women of reproductive age by selected individual characteristics of the respondents. Multinomial logistic regression has been used to examine the likelihood of using a family planning method by currently married women of reproductive age or their husband. For the purpose of regression analysis, different family planning methods were categorised into two categories – terminal family planning methods and non-terminal family planning methods. Terminal family planning methods included female and male sterilisation. All other family planning methods were categorised as non-terminal family planning methods. The explanatory variables included in the regression analysis included place of residence, religion, caste, age, education, wealth-index and working status of currently married women of reproductive age.

Suppose there are $r + 1$ possible outcomes for the dependent variable, 0, $1 \ldots r$, with $r > 1$. The multinomial regression analysis involves picking one of the outcomes as the reference outcome and conduct r pairwise logistic regression analysis between the reference outcome and other outcomes. In the present analysis, currently married women of reproductive age are classified into three categories: 1) women or their husband not using any family planning method and are given a value 0; 2) women or their husband using a terminal family planning method and are given a value 1; 3) women or their husband using a non-terminal method and are given a value 2. The binary logistic regression model for the outcome h, h=1, and 2, is defined by

$$logit(p_{ih}) = ln\frac{p_{ih}}{p_{i0}} = b_{0h} + b_{1h}x_{i1} + b_{2h}x_{i2} + \cdots + b_{kh}x_{ik} = \sum_{j=0}^{k} b_{jh}x_{ij}$$

where p represents the possible outcomes and b are the regression coefficient of k explanatory variables. The log-likelihood statistic for multinomial logistic regression is given by

$$LL = ln\, L = \sum_{i=1}^{n} . \sum_{h=0}^{r} y_{jh} \ln p_{ih}$$

The dependent variable used in the analysis has three values 0, 1, and 2. The independent variables include birth order, residence, religion, social class, woman's age, education, wealth index and work status.

Results

Table 1 shows that the proportion of women or their husband not using any family planning method increased from 40 per cent in 2005 to 50 per cent in 2015 but decreased to 29 per cent in 2019 in Madhya-Pradesh. This means that there was a decrease in the use of family planning methods between 2005-2006 and 2015-2016 but the use increased after 2014-2015. The decrease was the most marked in the use of female sterilisation between 2005-2006 and 2015-2016 but the increase in the use of female sterilisation has also been the most marked between 2015-2016 and 2019-2021. A similar pattern is observed in the use of male sterilisation rates, but the use of male sterilisation is substantially lower than the use of female sterilisation.

Among the non-terminal family planning methods, condom is the most commonly used family planning method and its use increased in use from 4.75 per cent to 7.34 per cent between 2015-2016 and 2019-2021. The use of all the non-terminal methods has also increase between 2014-2015 and 2019-2021 in the state as may be seen from the table. However, the use of all non-terminal family planning methods in the state decreased between 2005-2006 and 2015-2016.

Table 1. Use of different family planning methods by currently married women of reproductive age or by their husband in Madhya Pradesh, 2005-2021.

Use of family planning methods	2005-2006	2015-2016	2019-2021
Not using any method	39.53	49.94	28.45
Using terminal Method			
Female sterilisation	43.73	41.50	52.64
Male sterilisation	1.56	0.41	0.68
Using non-terminal methods			
Condom	8.15	4.75	7.34
Rhythm/periodic abstinence	1.95	1.03	3.96
Withdrawal	1.06	0.47	2.21
Pill	2.52	1.24	1.90
IUD	1.18	0.49	0.97
Injections	0.04	0.08	0.36
Others	0.28	0.09	1.50
Using any family planning method	60.47	50.06	71.56

Source: Government of India (2008; 2017; 2021).

Table 2 presents bivariate analysis of the use of terminal family planning methods and non-terminal family planning methods by selected characteristics of currently married women of reproductive age or by their husband. The table shows that the use of both terminal methods of family planning and non-terminal methods of family planning varies widely by the selected characteristics of currently married women of reproductive age. The prevalence of both terminal methods and non-terminal of family planning decreased in 2015-2016 compared to 2005-2006 but increased during the period 2019-2021.

Table 2: Use of terminal and non-terminal methods of family planning by currently married women of reproductive age (15-49 years) or by their husband in Madhya Pradesh, 2005-2021.

Background characteristics	2005-2006		2015-2016		2019-2021	
	Terminal Methods	Non-Terminal Methods	Terminal Methods	Non-Terminal Methods	Terminal Methods	Non-Terminal Methods
Birth order						
1	2.79	30.54	4.43	15.77	8.61	38.06
2	41.38	27.17	45.31	10.46	61.08	19.59
3 & above	65.81	7.79	59.63	4.94	72.22	11.46
Place of residence						
Rural	42.50	24.40	34.30	15.41	41.42	28.79
Urban	48.09	5.97	44.86	5.34	56.31	15.57
Religion						
Hindu	46.61	13.45	43.10	7.33	54.31	17.49
Muslim	31.99	26.95	27.19	17.36	33.53	32.14
Caste						
Schedule Castes	46.58	10.64	43.15	6.54	53.37	16.81
Schedule Tribes	43.83	4.72	43.85	3.23	58.15	13.92
Other Backward Classes	48.88	13.15	42.94	8.92	53.65	18.85
Others	40.18	26.98	36.18	15.23	45.10	25.13
Age of woman						
<25 years	8.25	15.19	9.23	9.94	9.98	28.67
25-35 years	46.69	20.36	42.09	10.62	49.11	23.39
≥ 35 years	66.25	10.14	58.91	5.01	74.40	9.56
Education of woman						
No education	53.96	5.33	52.40	3.09	71.41	8.57
Primary	45.94	11.86	46.84	5.87	63.40	13.45
Secondary	37.89	22.38	29.65	12.98	39.28	24.49
Higher	24.43	46.58	19.15	24.53	19.29	41.46
Wealth-Index						
Low	46.85	4.48	45.35	3.61	57.98	13.66
Middle	46.70	10.16	42.74	8.56	53.25	18.16
High	43.61	25.71	35.79	15.44	43.93	27.52
Work status of woman						
Not Working	37.51	19.79	35.77	11.03	44.99	21.02
Working	53.35	10.39	56.23	6.41	69.25	11.95
All	45.30	15.17	41.90	8.16	53.32	18.22

Source: Authors calculations based on the data available from third, fourth and fifth rounds of the National Family Health Survey (Government of India, 2008; 2017; 2021).

There is a noticeable difference in the use of different family planning methods among currently married women of reproductive age from 2005-06 to 2019-21 by the characteristics of women. The use of terminal methods of family planning is very high in women having at least two births compared to women having 1 birth only. An important observation of table 2 is that the use of terminal methods of family planning has increased consistently since 2005-2006, although the use remains low. On the other hand, the use of these methods decreased in 2015-2016 relative to 2005-2006 in woman having 3 or more children. By contrast, the use of non-terminal methods decreases with the increase in the number of children. On the other hand, the per centages for non-terminal methods decrease as birth order increases.

The pattern of use of family planning methods is different in rural and urban areas. In the rural areas, the use of non-terminal methods is higher as compared to the urban areas, but the use of terminal methods is higher in the urban areas relative to the rural areas. The same is the case with religion and caste. The use of terminal methods is higher in the Hindu women, but the use of non-terminal methods is higher in the Muslim women. Similarly, the use of terminal methods is the lowest in Other Castes which constitute the upper castes of the society whereas use of non-terminal methods is the highest in this caste group. In case of education and wealth index also, a similar pattern may be seen from the table. The use of terminal methods decreases with the increase in the education of women and in their living standard as reflected through the wealth index but the use of non-terminal methods increases. In case of the work status of the woman also, the use of terminal methods of family planning is higher in working women as compared to non-working women but the use of non-terminal methods is higher in non-working women as compared to working women.

Tables 3, 4, and 5 present results of the multinomial regression analysis for the period 2019-2021. When women not using any family planning method are compared with women using terminal methods of family planning, the relative probability of use is higher in women with at least two children as compared to women having one child; in rural women compared to urban women; in Hindu women compared to Muslim women; in older women compared to younger women; and in working women compared to non-working women. However, the relative probability of using a terminal method of family planning is found to be lower in women having higher education compared to women having no education. On the other hand, the standard of living of women as captured through the wealth index does not appear to have any effect on the use of terminal methods of family planning as compared to no use of family methods as the probability of the use of terminal methods of family planning in women with medium and high standard of living has not been found to be significantly different from the probability of using a terminal method of family planning in women with low standard of living with reference to the women not using any family planning method. It appears that the variation in the use of terminal methods of family planning by standard of living is actually a reflection of the variation in the use of terminal methods of family planning by such characteristics of women as education and working status.

Table 3: Probability of the use of terminal methods of family planning relative to no use of any family planning method in Madhya Pradesh, 2019-21. Results of the multinomial logistic regression.

Individual Characteristics	Relative probability of use	'p'	95% C.I. Lower	Upper
Not using any method vs. using terminal methods				
Birth Order				
1	Ref			
2	13.66	0.00	9.99	18.68
3 & above	11.53	0.00	8.39	15.84
Place of Residence				
Urban	Ref			
Rural	1.45	0.00	1.15	1.83
Religion				
Hindu	Ref			
Muslim	0.42	0.00	0.29	0.61
Age of the Women				
< 25 years	Ref			
25-35 years	5.03	0.00	3.76	6.73
≥35 years	10.16	0.00	7.43	13.89
Education of women				
No education	Ref			
Primary	1.16	0.20	0.91	1.48
Secondary	0.82	0.07	0.66	1.01
Higher	0.37	0.00	0.24	0.56
Wealth index				
Low	Ref			
Medium	1.12	0.33	0.88	1.41
High	1.15	0.23	0.91	1.46
Working status of women				
Not working	Ref			
Working	2.10	0.00	1.75	2.52

Source: Authors

The effect of the characteristics of women on the use of non-terminal methods relative to no use of method is however different (Table 4). For example, the relative probability of the use of non-terminal methods is statistically significant in women having two children but not in women having 3 and more children. The relative probability of use is statistically significantly higher only in women aged 25-35 years, in women having at least secondary level education, in women with high standard of living index.

Table 4: Probability of the use of non-terminal methods of family planning relative to no use of any family planning method in Madhya Pradesh, 2019-21. Results of the multinomial logistic regression.

Individual characteristics	Relative probability of use	'p'	95% C.I.	
Not using any method vs. using non-terminal methods				
Birth Order				
1	Ref			
2	1.42	0.00	1.12	1.80
3+	1.21	0.16	0.92	1.58
Place of Residence				
Urban	Ref			
Rural	0.88	0.33	0.68	1.13
Religion				
Hindu	Ref			
Muslim	1.07	0.70	0.74	1.55
Age of the Women				
<25 years	Ref			
25-35 years	1.42	0.00	1.11	1.82
≥35	1.10	0.51	0.81	1.50
Education of women				
No education	Ref			
Primary	1.14	0.41	0.82	1.58
Secondary	1.72	0.00	1.32	2.25
Higher	2.12	0.00	1.43	3.15
Wealth index				
Low	Ref			
Medium	1.01	0.93	0.76	1.33
High	1.57	0.00	1.20	2.04
Working status of women				
Not Working	Ref			
Working	1.17	0.13	0.94	1.46

Source: Authors

Finally, comparing women using non-terminal methods with women using terminal methods of family planning reveals the method-specific dynamics of family planning use in the state (Table 5). The relative probability of use of terminal methods is statistically significantly higher in women having at least two children compared to women having one child, in rural women compared to urban women, in Hindu women compared to Muslim women, in older women compared to younger women, in women having education less than secondary level compared to women having at least secondary level education, in women with high standard of living compared to women with low and medium standard of living, and in working women compared to non-working women. The probability of use of terminal family planning methods has not been found to be statistically different from the probability of use of non-terminal family planning methods in women having primary level education when compared with women having no education. Tables 3 through 5 reflect the dynamics of family planning use in the state and reveal the preferences and choices of currently married women of reproductive age regarding the use of terminal and non-terminal methods of family planning that have both policy and programme implications as far as promotion of family planning is concerned.

Table 5: Probability of the use of terminal methods of family planning relative to the use of non-terminal family planning methods in Madhya Pradesh, 2019-21. Results of the multinomial logistic regression.

Individual characteristics	Relative probability of use	'p'	95% C.I.	
Using non-terminal methods vs. using terminal methods				
Birth Order				
1	Ref			
2	9.69	0.00	6.88	13.65
3+	9.93	0.00	6.97	14.14
Place of Residence				
Urban	Ref			
Rural	1.63	0.00	1.27	2.10
Religion				
Hindu	Ref			
Muslim	0.38	0.00	0.25	0.57
Age of the Women				
<25 years	Ref			
25-35 years	3.23	0.00	2.31	4.50
≥35	8.45	0.00	5.87	12.17
Education or women				
No education	Ref			
Primary	1.08	0.62	0.79	1.47
Secondary	0.49	0.00	0.37	0.63
Higher	0.17	0.00	0.11	0.27
Wealth index				
Low	Ref			
Medium	1.04	0.75	0.78	1.38
High	0.73	0.02	0.56	0.96
Working status of women				
Not working	Ref			
Working	1.74	0.00	1.41	2.15

Source: Authors

Discussions and Conclusions

The variation in the use of family planning methods by different groups of women in Madhya Pradesh reflects the varied demand for family planning services in the state. Family planning use is very low in women having no child and low in women having only one child but is quite substantial in women having at least two children. This pattern of family planning use suggests that the dominating perception across currently married women of reproductive age group in the state is to produce the desired number of children quickly with little spacing between successive births and then opt for terminal methods of family planning to stop childbearing by adopting a terminal method of family planning, especially female sterilisation. The evidence available from the National Family Health Survey suggests that the use of family planning methods in the state decreased during 2015-2016 relative to 2005-2006 but increased during 2019-2021 and the use of terminal methods of family planning is more common than the use of non-terminal methods. Among different non-terminal methods of family planning, the use of condom and rhythm/periodic abstinence appears to be more common in the state. The use of non-terminal methods in the state is low presumably because these methods have high failure rates and high discontinuation rates. The high failure rate of non-terminal methods is commonly attributed to improper knowledge and inconsistency in the use of these methods (Russo and Nelson, 2006).

The present analysis also suggests that the number of children a woman has, place of residence, religion, age of woman and her education, standard of living and work status have important bearings on the use of family planning methods both terminal and non-terminal family planning methods in Madhya-Pradesh. The family planning use is directly related to the number of children a woman has. This is expected because use of family planning methods, especially when the family planning use is dominated by terminal family planning methods is used only when the desired family planning size is achieved. This is the case in Madhya Pradesh as the low use of non-terminal methods of family planning indicates that family planning is practised in the state primarily for birth limitation and not for birth spacing.

The analysis suggests that the standard of living does not appear to play an important role in family planning use. The reason appears to be the dominance of terminal family planning methods in family planning use. Terminal methods of family planning are generally not preferred by women with high standard of living. On the other hand, education of women plays an important role in the use of terminal methods but the educational status of currently married women in the reproductive age group in the state appears to be quite low.

From the policy and programme perspective, the present analysis may help in understanding the gap between the use of terminal methods of family planning and the use of non-terminal methods of family planning that appears to be quite substantial in Madhya Pradesh and may contribute to improving family planning use in the state.

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