Health Status: Progress and Challenges

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Abstract Achieving grand convergence in global health and bridging the gap between the countries, within country and between the states are important targets of ongoing SDGs. India is often described as a country with substantial progress in average health status alongside sizable geographical, rural–urban, social, economic and bio-demographic disparities. Although the country is witnessing a considerable improvement in health status across the states, alongside a steeper inter- and intra-state differentials in the speed of improvement coexist. Lack of equity with progress in the health status of the population in the laggard states of India is one of the key features in its growth story. In this backdrop, the paper examines the hypothesis that whether the districts of Uttar Pradesh are converging towards a homogenous state or diverging and explores its determinants. We have used the data from Census 2001 and 2011 published by Registrar General of India (RGI) for estimation of district-wise life expectancy for all persons, males and females separately. Further, for assessing the determinants, we have used multiple data sources for various indicators which are considered as predictors of Life Expectancy at Birth (LEB) in the previous literature. We have estimated LEB at the district level for all persons, males and females for the year 2001 and 2011 using the well-known Brass method for indirect estimation of IMR, child mortality rate (CMR) and corresponding LEB of different model life table parameters. We have adopted novel approaches to the objective of testing of convergence hypothesis in average health status and health inequalities across the districts. The inequality measures range from absolute inequality measured through Dispersion Measure of Mortality (DMM) to relative inequality measured through Gini index. The convergence in health status was examined by using the standard parametric models (absolute β- and σ-convergences). Further, non-parametric econometric models (kernel density estimates) have also been used to detect the presence of convergence clubs, and finally we have analysed the determinant of convergence through panel regression model. Findings revealed that the inequality-based measures of convergence suggest that convergence process is underway regarding both

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absolute and relative inequalities in LEB across the districts, during 2001–2011. Similarly, the findings based on catching-up plots and absolute β-convergence and sigma convergence measures affirm the convergence across districts of Uttar Pradesh. The presence of a strong evidence of convergence clubs indicates that growth process is not inclusive and is skewed to few district clusters of the state. LEB growth process has favoured some districts compared to other. Further, findings of determinants of health status suggest that decrease in infant mortality, progress in income level, improvement in literacy rate, full immunisation of children and health infrastructure in laggard districts would help in convergence of the health status across the geographical space in the state of Uttar Pradesh. Achieving health goals of SDGs in Uttar Pradesh will not possible unless acceleration in the speed of the convergence is achieved with equity. The state should prioritise the agenda for reduction of IMR, a substantial increase in literacy rate and major investment in healthcare infrastructural availability and accessibility, universal access to immunisation services, especially in the laggard districts of the state.

Keywords Life expectancy at birth · Convergence · Determinants

1 Introduction

This chapter presents progress and challenges in the health status of people living in different regions of Uttar Pradesh. Along with economic and educational status, health status is a critical component of human well-being. It occupies an important place in contemporary development discourse worldwide. The United Nations bestowed a unique place to health in its previously adopted Millennium Development Goals (MDGs) and the ongoing Sustainable Development Goals (SDGs), set for the world countries to be achieved by 2030. The world has become a better place; people are living a longer and healthier life with greater access to modern healthcare technologies (Deaton 2013). However, the dark side of this intriguing success story is that the world has witnessed a '*great divide*' in health and well-being than ever before in human history (Stiglitz 2015; Mormot 2015; Piketty 2014; Oxfam 2017). The socio-economic gradient in health status had become more pronounced, and the increasing cost of socio-economic inequality is becoming unbearable (Marmot 2015; World Health Organisation [WHO] 2015; Milanovic 2016). When it comes to the regional difference in health status (Wagstaff 2002), the forerunners are almost all developed countries, where humans tend to live longer and healthier as compared to their counterparts in developing or underdeveloped regions. The gap in life expectancy between the countries had been evident in almost all developed and developing regions of the world (Global Health Observatory [GHO] 2017).

Similar is the case of India, which is often described as a country with substantial progress in average health status alongside sizable geographical, rural–urban, social, economic and bio-demographic disparities in it (Goli and Arokiasamy 2013). Health for all had been a priority of public health policy-makers since its inception at *Alma*

Ata Declaration which has been showing a notable impact on improvements in mortality and life expectancy of the Indian population. But, the country is also known for its peculiar characteristics of demographic, epidemiological and economic transition, increasing inequality in health and wealth with the most hierarchical healthcare system, meagre social safety nets and low level of human development which is commonly considered as an 'uncertain glory of India' (Drèze and Sen 2013; James and Goli 2016).

The gap in average life expectancy at birth (LEB) across states was 19.0 years in 1970 which reduced to 12.3 years in 2010 (Office of RGI 2014). Although the country is witnessing a considerable improvement in health status across the states, yet steeper inter- and intra-state differentials in the speed of improvement coexist (Goli and Arokiasamy 2013). Lack of equity with progress in the health status of the population in the laggard states of India is one of the key features in its growth story (Drèze and Sen 2013). Health and socio-demographic indicators of states such as Kerala are comparable with the most developed countries like Switzerland, whereas states such as Uttar Pradesh are comparable for a least underdeveloped country like Uganda. These stark differentials in socio-economic and health status across the Indian states seemed to suggest the presence of a 'tale of two worlds' (Goli and Arokiasamy 2013; Office of RGI 2016). The LEB in Uttar Pradesh remains lowest with the highest share of the country's population. The state is also lagging in many of the key socio-economic and health indicators: almost 50% of children are not fully immunised; 40% children are underweight; it stands second in maternal mortality, highest in maternal anaemia and highest one in infant mortality rate; and it ranked bottom in human development indicator (IIPS and MoHFW 2017). However, a significant issue which has not received necessary attention in the literature is the presence of stark intra-state differences in health status, which is the main focus of this study.

2 Background and Rationale

Achieving grand convergence in global health and bridging the gap between the countries, within the country and between the states are important targets of ongoing SDGs (Lim et al. 2016). There are efforts to investigate the progress in inter-country and interstate inequality in health status using convergence models (Smith et al. 2009; McMichael et al. 2004; Moser et al. 2005; Goli and Arokiasamy 2013, 2014a, b). Without acceleration of improvements among laggard states, convergence in LEB in India cannot be achieved. Moreover, laggard states suffer from huge intra-state inequalities (Goli et al. 2013). In spite of the fact that the improvement in the state average of LEB is not comparable to an earlier period, the literature showing whether such progress is leading to convergence or divergence across the smaller administrative units such as districts within the states is scant in India. In this backdrop, the paper examines the hypothesis whether the districts of Uttar Pradesh are converging towards a homogenous state or following a path towards a heterogeneous state in

health and explores its determinants. The rationale of investigating the geographical differentials in LEB among the districts of Uttar Pradesh is: first, as pointed earlier, it is the biggest state regarding population and occupies a laggard position in many socio-economic and demographic indicators. Secondly, the regional convergence in LEB across the state is important for the future improvements in the LEB as it showed one of the lowest among other states.

Our approach is very similar to Goli and Arokiasamy (2014b), wherein they have assessed the transition in the health status of Indian states using different convergence metrics. They found that South Indian states with higher life expectancy are showing less gain as compared to North Indian states with lower life expectancy and higher gain which indicates that states are converging towards the homogenous state, but with the very slow speed of convergence. Here, we are interested in investigating whether the findings from Goli and Arokiasamy (2014b) still hold true in the recent period and across districts within states, especially in underperforming ones like Uttar Pradesh.

The anticipated fresh contribution of this study is that we have estimated the LEB at the district level and for all populations, including for males and females separately. Further, we have assessed the gender and geographical difference in health status and predicted their future trajectories to achieve the geographical convergence in health status by sex in order to achieve national and state health targets. We have arranged this paper in the order as follows: first, we describe the contextual importance of the present study. Second, we have explained data description and methodological approach. Third, the findings of the study start with trend analysis of life expectancy at birth among males and females over the years. This is followed by trends in dispersion measures of mortality (DMM) and Gini index of LEB, parametric and non-parametric convergence measures and determinants of convergence in health status across the districts of Uttar Pradesh. Finally, we discuss our empirical findings and suggest the policy implications for achieving progress in health status and thereby a convergence in LEB.

3 Methodology

3.1 Data Source

We have used the data from Census 2001 and 2011 published by Registrar General of India (RGI) for estimation of district-wise life expectancy for all people, males and females separately. Both the rounds of Census have asked the question to ever-married women about their total number of children surviving and dead and tabulated them according to the age of mother and sex of the children. This information is available for smaller units such as districts, by which we have estimated the life expectancy at birth of males, females and all people for the districts of Uttar Pradesh. Further, for assessing the determinants, we have used multiple data sources for various indicators

Box A Study variables and data sources

Variables	Data source
Children ever born and children surviving by the age of the mother and sex of the children	Office of RGI (Registrar General of India) and Census Commissioner (2001, 2011)
Population proportion	RGI and Census Commissioner (2001, 2011)
Full immunisation	National Family and Health Survey (NFHS) (1992–93, 1998–99, 2006–07) and Annual Health Survey (AHS) Report (2011–12)
Female literacy rate	Office of RGI (Registrar General of India) and Census Commissioner (2001, 2011)
Percentage of urbanisation	Office of RGI (Registrar General of India) and Census Commissioner (2001, 2011)
Log of NSDP per capita (Rs.)	Reserve Bank of India (RBI) Handbook (2004–05, 2011–12)
Index of health infrastructure	Rural Health Statistics, Health Management Information System (HMIS), 2011–12

Note NSDP Net state domestic product

which are considered as predictors of LEB in the previous literature. Data sources of various indicators are displayed in Box A.

3.2 Methods

3.2.1 Estimation of LEB

We have estimated LEB at the district level for all persons, males and females for the year 2001 and 2011 using the well-known Brass method and appropriate indirect estimation of IMR, child mortality rate (CMR) and corresponding LEB of different model life table parameters (Hill 2013). Thus, first, we estimated the IMR which has the estimates of corresponding LEB. For estimation of IMR, we need the average parity per woman which is estimated as:

$$P(i) = \mathrm{CEB}(i)/W(i)$$

where $\mathrm{CEB}(i)$ denotes the number of children ever born to women belonging to the age group i and $W(i)$ denotes the total number of women belonging to the age group i irrespective of their marital status (United Nations 1983). The proportion of children died for each age group of mothers is estimated by:

$$D(i) = \frac{\mathrm{CEB}(i) - \mathrm{CS}(i)}{\mathrm{CEB}(i)} = \frac{\mathrm{CD}(i)}{\mathrm{CEB}(i)},$$

where CS(i) denotes the number of surviving children reported by mothers belonging to the age group i and CD(i) denotes the number of children died reported by mothers belonging to the age group i. The multipliers $K(i)$'s are calculated according to Trussell's variant of the original Brass method. The simplified equation is:

$$K(i) = \frac{a(i) + b(i)P(1)}{P(2)} + \frac{c(i)P(2)}{P(3)},$$

where $a(i)$, $b(i)$ and $c(i)$ are the coefficients for the estimation of child mortality multipliers.

Finally,

$$q(x) = K(i) * D(i)$$

The proportions of children surviving to the date of the survey are the net result of the mortality conditions in the past rather than the mortality conditions prevalent on the date of survey. However, since mortality is not constant and changes over different time periods, it is important to identify the period to which Brass-type estimates most closely pertain. Following on the work of Feeney (1980), Coale and Trussell (1977) developed formulae for the estimation of the reference period, $t(x)$ (number of years prior to the survey), to which the values of $q(x)$ refer. The equations have the same format as those for the estimation of the adjustment factors $K(i)$ (Preston et al. 2000). The equation to estimate $t(x)$ is

$$t(x) = \propto (i) + \beta(i) * \frac{P(1)}{P(2)} + \gamma(i) * \frac{P(2)}{P(3)}$$

where $\propto (i)$, $\beta(i)$ and $\gamma(i)$ are the coefficients for estimation of $t(x)$.

3.2.2 Choice of Model Life Table and Standardisation

For India, the most suitable choice in the different families of model life tables is *South Asian model life table* (United Nation model life table) for developing countries which seems to be reasonably valid assumptions of fertility and mortality in the population under study. We have standardised LEB estimates derived from Census information to pro rata with sample registration system state average values of LEB for males and females separately for both the corresponding years.

3.3 Measures of Convergence

At second stage, we have used various neoclassical and cutting-edge convergence models to assess the progress in average *vis-a-vis* progress in health inequality

between districts of Uttar Pradesh by males and females. We have also performed panel data regression with random effect model to assess the determinants of convergence in LEB across the district of Uttar Pradesh.

3.3.1 Absolute β-Convergence

Barro (1991) and Barro and Sala-I-Martin (1992, 1997) have proposed the growth regression approach for measuring progress and named it as absolute β-convergence. Theoretically, application of β-convergence is possible when the gap between laggard and advanced nations or states shrinks, especially due to faster progress in laggard states. Empirically, β-convergence can be seen as a negative association between the growth rate of an indicator and its initial value. This model can be represented by the following equation:

$$\ln\left[\frac{Y_{i,t+k}}{Y_{i,t}}\right] = \alpha + \beta * \ln\left(y_{i,t}\right) + \varepsilon_{i,t}$$

where $\ln\left[\frac{Y_{i,t+k}}{Y_{i,t}}\right]$ is the mean annualised growth rate of the variable Y in the state i in the period $(t, t+k)$, $Y_{i,t}$ is the value in the initial time t and ε_{it} are the corresponding stochastic terms. However, in order to assess the recent progress in LEB we have measured the rate of convergence. The speed of convergence in LEB will help to predict the expected time to converge to homogenous state with higher levels of health status. The speed of convergence has been estimated through the following equation

$$s = -[\ln(1 + T\beta)/T]$$

where s is the speed of convergence and $T\beta$ is the β-convergence in time period T.

3.3.2 Sigma Convergence

While estimates of β-convergence measure depict the catching-up process of laggard states to advance states, sigma convergence is about whether states are converging towards each other regarding LEB over time (rather than to their steady-state levels). The sigma convergence can be measured through the following equation

$$\sigma_t > \sigma_{t+T}$$

where σ_t is the standard deviation (or assimilated measure) of the LEB levels at initial time and T stands for current time. If the parameter σ_{t+T} declines over time, it implies convergence.

3.3.3 Convergence Clubs: Kernel Density Plots

The convergence estimates through β and sigma measures have some caveats as both assume certain assumption of nature of the data, i.e. LEB for this study, whereas non-parametric measure does not assume any assumption about nature of the data except smoothness (Quah 1993; Wang 2004). Gaussian kernel density estimate is the most used technique for measuring convergence through non-parametric approach (Romer 1986; Strulik and Vollmer 2015). The general kernel estimator is defined by

$$\widehat{f(x)} = \frac{1}{nh}\sum_{i=1}^{n} K\left(\frac{x_i - x}{h}\right) = \frac{1}{nh}\sum_{i=1}^{n} K(Yi)$$

where $Y_i = h^{-1}(x_i - x)$, n is the number of observations in the sample, h is the window width (bandwidth) which is a function of the sample size and goes to zero as $n \rightarrow$ to ∞.

3.3.4 Convergence in Averages and Inequalities in LEB

Dispersion Measures of Mortality

Through this method, one can quantify the degree of dispersion in mortality experience (measured in terms of LEB) of a particular population existing at any given point of time. It was calculated as the average of the absolute difference in mortality experience, weighted by its population size, between each pair of the district. The decrease in dispersion measures of mortality (DMM) indicates that mortality among the districts is becoming homogenous (convergence), and an increase indicates heterogeneous growth over time and refers to a divergence in mortality. The DMM for life expectancy at birth is measured in years of life (Shkolnikov et al. 2003; Moser et al. 2005). The mathematical equation of DMM is as follows:

$$\text{DMM} = \frac{1}{2(W_Z)^2}\sum_{i}\sum_{J}\left(|M_i - M_j| * W_I * W_J\right)$$

where i, j are districts, and one $\leq i, j \leq 75$, Z is equal to 1 and M is the mortality rate. Further, W is the weights and can be expressed as $\sum_i W_i = \sum_j W_j = W_z$.

3.3.5 Gini Coefficient

To assess relative inequality, we have used Gini coefficients. The estimation of Gini in the case of LEB is equal to DMM divided by the average life expectancy of the districts (Shkolnikov et al. 2003).

$$G = \frac{\text{DMM}}{\overline{e_0^0}}, \text{ where } \overline{e_0^0} = \left[\sum_1 \text{Pi}\ e_0^i\right]$$

where

G	Gini index value,
DMM	Dispersion measures of mortality
$\overline{e_0^0}$	is average life expectancy at birth adjusted by the population proportion of the district $i \ldots i_n$.

3.3.6 Determinants of LEB

We have also estimated the determinants of LEB through panel data regression using random effect model. To make a decision among fixed or random effects, we run a *Hausman test* where the null hypothesis is that the preferred model is random effect versus the alternative, i.e. fixed effects (see Torres-Reyna 2007). It essentially tests whether the unique errors (μ_{it}) are correlated with the regressors; the null hypothesis is they are not the results of *Hausman test* suggested performing random effect model for panel data regression. The equation can show the random effect panel regression:

$$Y_{it} = \propto_{it} + \beta_i X_{it} + \mu_{it} + \varepsilon_{i,t}, \quad i = 1, \ldots, N,\ t = 1, \ldots, T,$$

where

$\propto_i$ $(i = 1, \ldots, n)$	is the unknown intercept for each entity (n entity-specific intercepts).
Y_{it}	is the dependent variable where i = entity and t = time.
X_{it}	represents one independent variable.
β_1	is the coefficient for that independent variable.
μ_{it}	is between entity error.
$\varepsilon_{i,t}$	is within entity error.

4 Empirical Findings

4.1 Levels and Trends of District LEB

The chapter estimates the LEB by sex of the individuals for all districts of Uttar Pradesh for the year 2001 and 2011. Also, we have analysed convergence in absolute and relative inequality of LEB among all population, females and males and its determinants for districts of Uttar Pradesh during the year 2001–2011. The results of Table 1 summarise the descriptive district-wise statistics of LEB for the years 2001 and 2011. The average of LEB for all persons among the districts had increased

Table 1 Summary statistics of LEB among the districts of Uttar Pradesh, 2001–2011

Gender	Years	Observations	Mean	SD	Minimum	Maximum	Range
Persons	2001	70	60.47	1.32	57.83	63.50	5.68
	2011	71	63.00	1.07	61.05	65.16	4.11
Male	2001	70	60.85	1.27	58.45	63.85	5.40
	2011	71	62.11	1.04	59.95	64.13	4.18
Female	2001	70	60.07	1.41	57.00	63.10	6.10
	2011	71	63.95	1.16	61.71	66.22	4.51

Source Authors' estimates based on Census 2001 and Census 2011 (Office of RGI 2001, 2011)
Note SD standard deviation

from 60.5 years in 2001 to 63.0 years in 2011. Similar trends were observed for males (60.9 years in 2001 to 62.1 years in 2011) and females (60.1 years in 2001 to 64.0 years in 2011) LEB over the years. Moreover, the range of average LEB suggested that the gap across districts had narrowed down during the study period irrespective of sex but at a slower pace.

Further, results showed that the growth of LEB for females (3.9 years) outpaced the growth of males (1.3 years) during the last one decade. The male–female gap in LEB which was 0.8 years in 2001 has reversed in the year 2011 and shows a female–male gap of 1.8 years. For the year 2001, the lowest LEB formulae were observed in Pilibhit (58.4 years) and Balrampur (58.6 years) districts, whereas in the females, the lowest LEB was observed for Balrampur (57.0 years) and Shravasti (57.8 years). Similarly, for the year 2011, the lowest LEB for males and females was observed in Barabanki (59.9 years) and Badaun (61.7 years), respectively. Overall, it is evident from Figs. 1 and 2 that the LEB was skewed towards the males in 2001 but reversed in 2011 in almost all the districts of Uttar Pradesh. Similarly, the cluster of districts with a low level of LEB, often categorised as eastern or north-eastern districts of Uttar Pradesh, showed a consistent pattern. Despite several government policies and programmes implemented in these districts, health status had not shown any significant improvement.

We have also measured the convergence in mortality inequalities over the decade. In order to do so, we have used DMM, average inter-district difference (AID) and Gini index, while DMM and AID measure absolute inequality and Gini measures relative inequality. Table 2 presents the estimates of DMM, AID and Gini indices in LEB among the districts of Uttar Pradesh during 2001–2011. The results reveal that the decline in DMM of males is slightly higher than their female counterparts. Similar trends were also observed for AID in LEB of males and females. However, the result of relative inequality measured through Gini index shows a higher decline in females as compared to males. Thus, the estimates of absolute and relative inequality in LEB of males and females showed a declining trend which means the districts are moving towards the steady state.

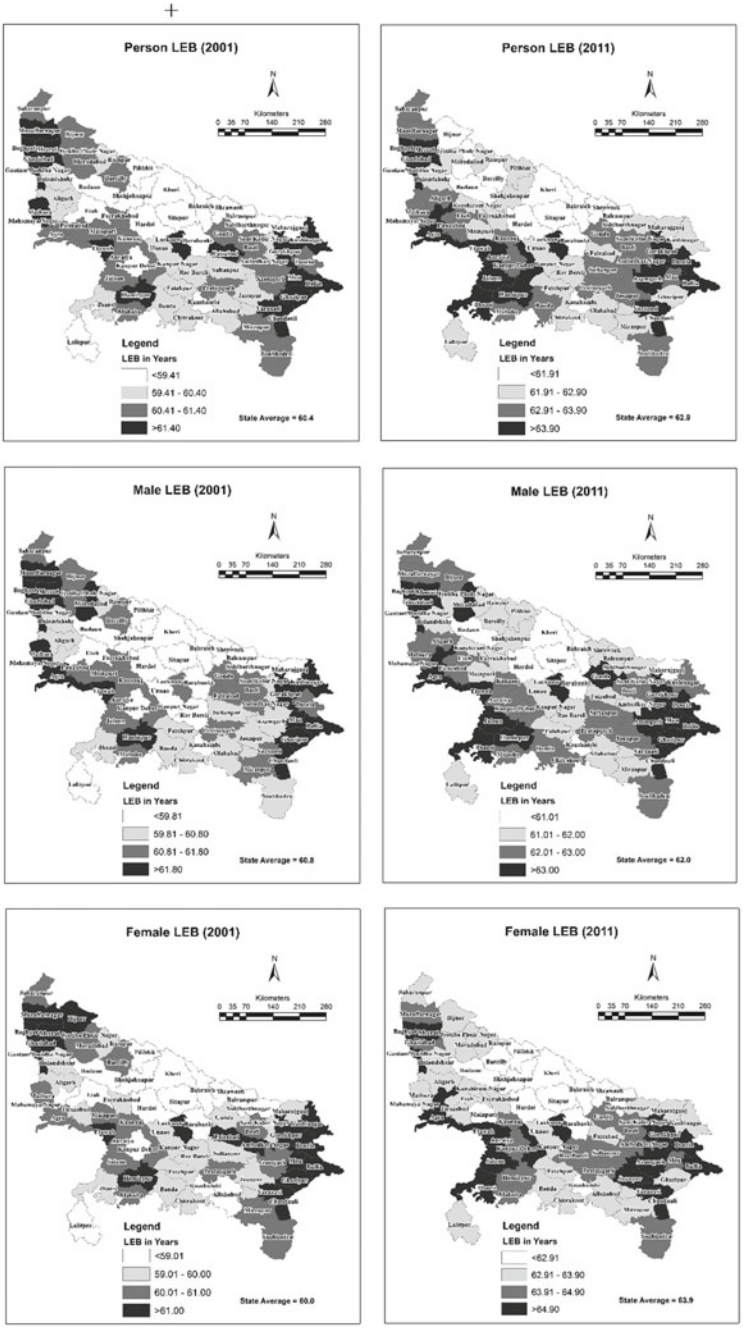

Fig. 1 Life expectancy at birth (LEB) for all persons, males and females in the districts of Uttar Pradesh during 2001 and 2011

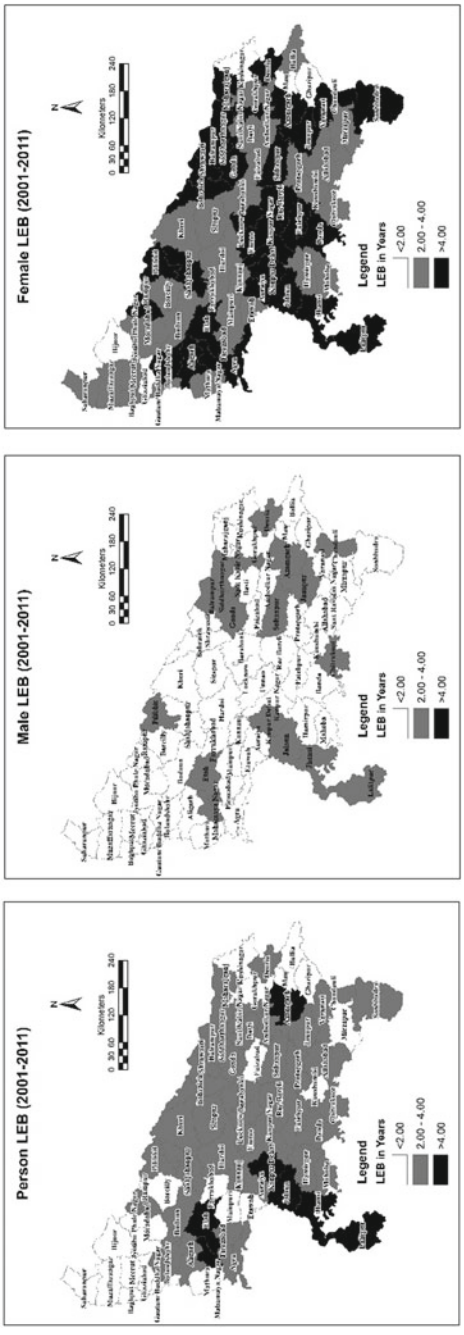

Fig. 2 Change in life expectancy at birth in all persons, male and females in the districts of Uttar Pradesh during 2001 and 2011

Table 2 Absolute and relative inequality measures of health status across the districts by gender, 2001–11

Inequality measures	Persons			Male			Female		
	2001	2011	Change	2001	2011	Change	2001	2011	Change
DMM	47.75	42.42	5.33	45.7	40.8	4.92	51.4	46.6	4.84
AID	23.88	21.21	2.67	22.9	20.4	2.46	25.7	23.3	2.42
Gini index	0.39	0.34	0.06	0.38	0.33	0.05	0.43	0.36	0.06

Source Authors' estimates based on Census 2001 and Census 2011 data (Office of RGI 2001, 2011)
Note DMM dispersion measures of mortality, AID average inter-district difference

4.2 Catching-up Process

The catching-up process is examined by plotting the change in LEB during 2001–2011 for districts of Uttar Pradesh by LEB levels in the initial period, 2001. The results reveal that LEB of males in the initial period and its change over the period showed a negative relationship that districts with a higher level of LEB registered comparatively lower growth as compared to their laggard districts with lower initial LEB levels. But, a considerable number of districts have also shown lower improvements with relatively lower levels of LEBs, while a few districts with higher levels of LEBs also have shown a better progress in it. Thus, here we interpret that although results suggest a catching-up process in LEB of males, females and all persons, the process is not very strong (Fig. 3).

4.3 Absolute β-Convergence

We have also assessed the convergence in averages of mortality rates. Convergence in mortality rates was measured based on LEB. The results of absolute β-convergence estimates showed statistically significant evidence of convergence in LEB of all persons (−0.089), males (−0.067) and females (−0.086) during the period 2001–2011. Table 3 shows that on an average, the LEB of all persons was converging by one unit per year towards the steady state across the districts. Moreover, the annual speed of convergence in LEB of males (0.69 years) is lower than that of females (0.90 years). Overall, the speed of convergence is very slow among both males and females. At this rate of convergence, the expected time for convergence based on the current levels of DMM was 45.5, 59.0 and 51.7 years for all persons, males and females, respectively.

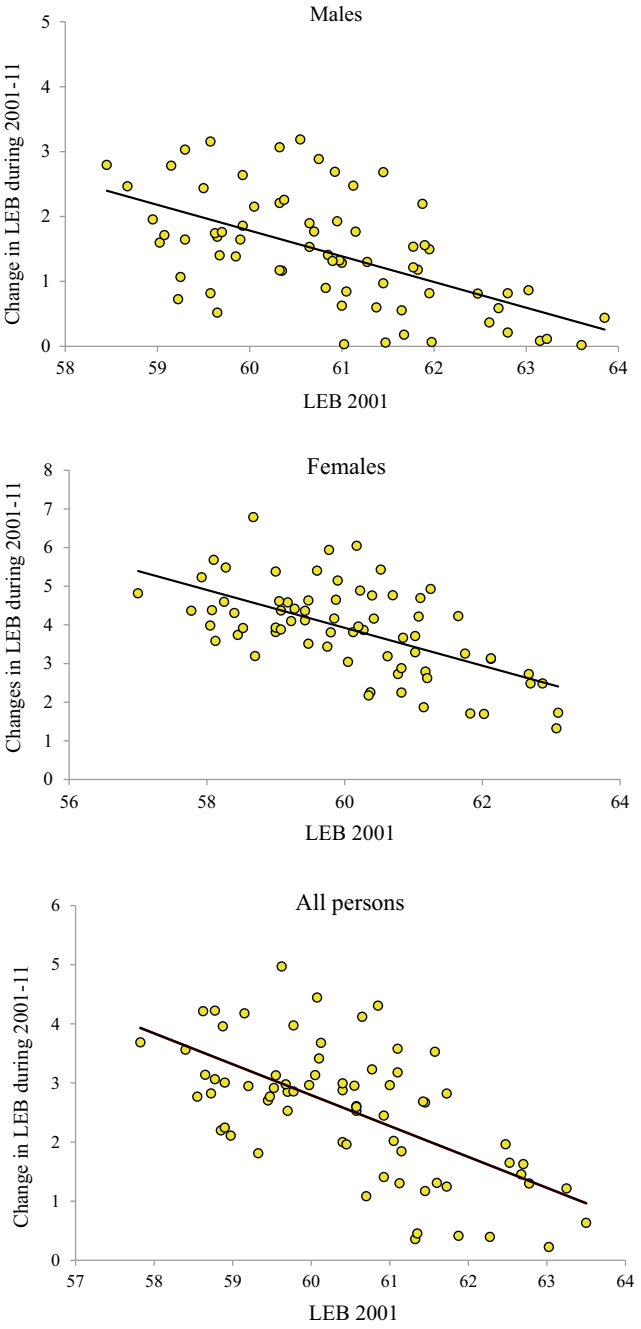

Fig. 3 Change in LEB during 1981–2011 for districts of Uttar Pradesh by LEB levels in the initial period, 2001, separately for males, females and all persons

Table 3 Absolute β-convergence estimates based on Barro regression model for LEB across the districts of Uttar Pradesh, 2001–2011

LEB convergence	Test of convergence (β-convergence)			
	Person	Male	Female	Male–female combined
β-coefficients (SE)	−0.08906*** (0.01248)	−0.06677*** (0.10873)	−0.08615*** (0.01223)	−0.11075*** (0.12562)
Constant	5.80053	4.2989	5.8032	7.1282
Number of observations	70	70	70	140
Degree of freedom	69	69	69	139
Adjusted R^2	0.4197	0.03473	0.4133	0.3557
Speed of convergence (annual)	0.932782	0.691036	0.900888	1.173769
Expected time for convergence in years (DMM)	45.5	59.0	51.7	36.1
Expected time for convergence in years (AID)	22.7	29.5	25.9	18.1

Source Authors' estimates based on Census 2001 and Census 2011 (Office of RGI 2001, 2011)
DMM and AID stand for dispersion measures of mortality and average inter-district difference, respectively
***$p < 0.01$
Note Districts: $n = 70$, df 69, standard error (SE) values in parenthesis for the beta coefficients at 95% confidence level

4.4 Sigma Convergence in LEB

Young et al. (2008) suggest that β-convergence is necessary but not a sufficient condition for sigma convergence. Therefore, we have examined sigma convergence based on a change in standard deviations of LEB over time for all persons, males and females across the districts of Uttar Pradesh (Table 4). The results for sigma convergence in LEB indicated a clear convergence in average LEB for males and females. The standard deviation in LEB of all persons declined from 1.32 years during 2001 to 1.07 years in 2011. Similarly, the standard deviation of LEB of males (0.22 years) and females (0.25 years) showed a moderate decline during the period of observation. Thus, results of the sigma convergence model are in collinearity with the findings of β-convergence. The parametric convergence metrics suggest that there is a convergence in LEB among the all persons, males and females across the districts of Uttar Pradesh, but its speed is very slow.

Table 4 Sigma convergence in gendered average LEB across the districts of Uttar Pradesh, 2001–2011

Sigma convergence			
Year	LEB all persons	LEB males	LEB females
2001	1.32	1.27	1.41
2011	1.07	1.05	1.16

Source Authors' estimates based on Census 2001 and Census 2011 (Office of RGI 2001, 2011)

4.5 Convergence Through Non-parametric Measures

Romer (1986), Bloom and Canning (2007) and Strulik and Vollmer (2015) have suggested testing convergence hypothesis using non-parametric measures, especially to detect the convergence clubs. Moreover, non-parametric convergence metrics do not make any assumption regarding the distribution of data. Therefore, they are powerful enough to detect minute dispersions. We have examined the convergence clubs through kernel density plot of LEB in males, females and all persons for the year 2001–2011. Figure 4 reveals in the case of LEB in males over the years 2001 and 2011, the presence of twin peaks in the distribution of LEB across the districts. The secondary peak has a minimum number of districts with highest LEB, whereas the first peak suggested a sufficiently large number of districts with a comparatively lower level of LEB. Similarly, the kernel plots in the case of LEB in females showed an emerging pattern of twin peaks for the year 2011. The overall distribution of LEB among the districts showed a rightward shift in case of female LEB as compared to males during 2001–2011. Districts with higher life expectancy levels emerged as separate convergence club suggested a noticeable divergence among districts by their levels of LEB in Uttar Pradesh over the years.

4.6 Determinants of Convergence

Table 5 presents the results from panel data regression showing socio-economic, demographic and supply-side factors such as health infrastructure as probable determinants of progress towards convergence in LEB across the districts of Uttar Pradesh, 2001–2011. The reduction of IMR ($\beta = -9.35, p < 0.01$) showed a significant negative association with the increase in LEB, meaning a decline in IMR raises the LEB, while literacy rate ($\beta = 0.01, p < 0.01$), per cent of children fully immunised ($\beta = 0.01, p < 0.01$) and score of health infrastructure ($\beta = 0.21, p < 0.05$) showed a significant positive effect on the improvement of LEB. However, a log of GDP per capita showed a positive but insignificant association with an increase in LEB. Probably, this pattern reflects the fact that the economic growth in the country is not inclusive in nature as the fruits are not being received by all. Overall, the results suggest that rise in IMR, education, healthcare infrastructure and health care along with

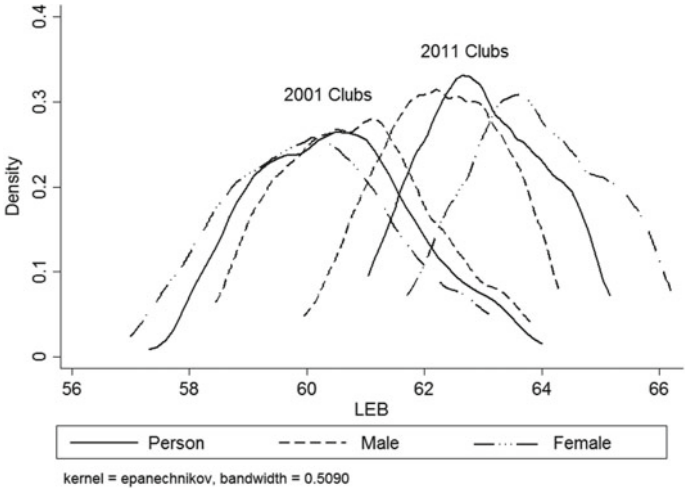

Fig. 4 Non-parametric test of convergence in health across the districts of Uttar Pradesh, 2001–2011

equitable distribution of fruits will help to raise the LEB levels across the districts of Uttar Pradesh.

5 Conclusion

The current exercise of assessment of convergence in progress of health status (measured in terms of LEB) across the districts of Uttar Pradesh during the last two decades has been the maiden effort to address inclusive growth in health status of the population in the state. Therefore, this is a timely attempt to fill the critical gap in the field of research on health policy and planning through addressing the concept of efficiency with equity in health progress in the state. We have applied various front-line methods for testing the convergence hypothesis for progress in the health status of both males and females at lowest possible administrative unit such as districts. Findings of this study propel numerous important conclusions. While the LEB trends suggest that although the number of districts with a higher level of LEB (above 63 years) has increased over the period, yet there was a huge variation in LEB transition across the districts in Uttar Pradesh. In particular, the gap between Eastern districts such as Balrampur, Bahraich, Barabanki, Gonda, Badaun and Western districts such as Ghaziabad, Moradabad, Meerut remains high despite substantial improvements in LEB among all the districts. This geographical gradient also holds true in gender-disaggregated LEB trends.

In general, although the study advances that the health status in the districts of Uttar Pradesh is converging, at a very slow pace, the conclusions differ in specific

Table 5 Results from panel data regression model (random effects)

Variables	β coefficients	Standard error	Confidence interval	
			Lower limit	Upper limit
IMR	−9.354***	0.222	−9.790	−8.919
TFR	0.078	0.070	−0.059	0.215
Population size	0.012	0.090	−0.164	0.189
Full immunisation	0.007***	0.003	−0.012	−0.002
Urban	0.003	0.003	−0.002	0.009
Literacy	0.014***	0.004	0.007	0.021
Log of GDP per capita	0.070	0.089	−0.245	0.104
Index of health Infrastructure	0.210**	0.104	0.006	0.414
Time dummy	0.112***	0.011	0.090	0.134
Constant	−121.062***	23.261	−166.65	−75.47
Number of observations	138			
R^2: Within	0.99			
R^2: Between	0.98			
R^2: Overall	0.98			
Wald Chi^2	7759.90***			

Source Authors' estimates based on Census 2001 and Census 2011 (Office of RGI 2001, 2011)
Standard error (SE) and upper and lower limits are at 95% confidence interval (CI)
*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$

to convergence metric used. For instance, inequality-based measures of convergence suggest that convergence process is underway regarding both absolute and relative inequalities in LEB across the districts, during 2001–2011. Similarly, the findings based on catching-up plots and absolute β-convergence and sigma convergence measures affirm convergence in LEB across the districts of Uttar Pradesh. The presence of a strong evidence of convergence clubs indicates that growth process is not inclusive and is skewed to few district clusters of the state. LEB growth process has favoured some districts compared to others. The estimation of time required for convergence in LEB across the districts based on the current speed of convergence suggests that it would take as long as 45 years to see absolute convergence at a steady state of equilibrium across the districts. But, previous evidence suggests that the stability of the convergence process is not guaranteed. Convergence can replace divergence at any stage of the convergence process based on setbacks in progress or dissimilar progress of states in health indicators. These divergent mortality trends in districts can also re-converge as disproportionate improvements among laggard and advanced districts (Dorius and Firebugh 2010; Smith et al. 2009; Moser et al. 2005; McMichael et al. 2004).

On the other hand, the findings also suggest apparent gender differentials in the pace of LEB progress and rate of convergence: a higher rate of convergence among

the female sex across the districts as compared to the males. Although the biological advantage of female sex had been historically offset through selective behaviour against females in developing countries in general and India in particular, however, over the time, through social, economic and political emancipation of females, the access to agencies through which females were claiming equal rights increased, being a catalyst to achieve the biological advantage in survival chances (WHO 2015). This connotation is well supported by the findings of this study in the context of Uttar Pradesh. Since the last one decade, females in the state are showing lower mortality, especially among children, adult ages and higher life expectancy as compared to their male counterparts. It is attributed to the reduction in maternal mortality ratio (MMR) and decreasing sex differentials in infant and child mortality (Office of RGI 2015). Thus, the findings also suggest that the highest contribution to an overall gain in life expectancy is contributed by a gain in female life expectancy. Similarly, findings suggest that decrease in infant mortality, progress in income level, improvement in literacy rate, full immunisation of children and health infrastructure would increase the health status across the geographical space in the state of Uttar Pradesh.

Moreover, achieving health goals of SDGs in Uttar Pradesh will not be possible unless speed and volume of the convergence in health status are achieved with inclusive growth process. The state should prioritise the agenda for reduction of IMR, a substantial increase in literacy rate and major investment in healthcare infrastructural availability and accessibility, universal access to immunisation services, especially in the laggard districts. The substantial contribution to IMR and female life expectancy in overall enhancement of life expectancy in the population of Uttar Pradesh suggests that improvement in maternal and child health, and reduction in maternal and infant mortality are the keys to future improvement in life expectancy of the state. Therefore, further enhancement of national and state programmes related to health and welfare of mother and children such as mother-baby package (MBP) services, saving newborn lives through improved management of birth asphyxia and essential newborn care (ENBC) services, nutritional programmes and reproductive and child health (RCH) programmes is required. Promoting outreaches of not only primary but also tertiary care treatment under national health mission (NHM) is also critical for enhancement of LEB. Prevention and treatment of communicable, non-communicable diseases, accidents, injury and falls through the installation of superior prevention and curative service delivery infrastructure and human resources are necessary for prolonging the life expectancy in a population (Blas and Kurup 2010; Whitehead et al. 2001). Also giving emphasis on laggard districts in these aspects will help to achieve convergence across the districts. In conclusion, convergence measures are important tools for timely monitoring of progress towards inclusiveness in a growth process. Convergence in averages of health status and its inequality not only reflects a sense of equity across the districts and between the sexes but also can be an effective summary measure for monitoring the progress in terms of absolute and relative distribution of health status.

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