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Mortality Transition in India: 1998-2017

Aalok R Chaurasia

Abstract

This paper analyses mortality transition India in terms of life expectancy at birth during 1998-2017. The analysis reveals considerable volatility in the increase in the life expectancy at birth in the country. There is considerable deceleration in the increase in the life expectancy at birth in the country because of the deceleration in the increase in female life expectancy at birth. Most of the increase in life expectancy at birth is attributed to the improvement in the person-years lived in the first five years of life. The recent deceleration in the increase in female life expectancy at birth may be attributed to the decrease in the person-years lived in the age group 40-65 years.

Introduction

The abridged life tables prepared by the Registrar General and Census Commissioner of India suggest that the life expectancy at birth (e_0) in India increased by more than 6 years from 62.9 years during 1998-2002 to around 69 years during 2013-17 (Government of India, 2019). The increase has more rapid in females (6.4 years) than in males (5.9 years). When compared with the United Nations model mortality improvement schedules (United Nations 2004), male mortality improvement in India has been somewhere between slow to medium model mortality improvement schedules female mortality improvement has been somewhere between medium to fast model mortality improvement schedules. Among states, e_0 ranged from more than 75 years in Kerala to 65 years in Uttar Pradesh during 2013-17. There are only six states, besides Kerala, where e_0 was more than 70 years. The gap in the highest and the lowest e_0 across states has, however, decreased from around 13.9 years during 1998-2002 to around 10.2 years during 2013-2017.

India was one of the signatories of The Programme of Action adopted at the 1994 International Conference on Population and Development at Cairo (United Nations, 1994). The Programme of Action envisaged that every country would take appropriate steps to increase e_0 to more than 70 years by the year 2005 and to more than 75 years by the year 2015. Viewed from this perspective, mortality improvement in India has fallen substantially short of what was committed way back in 1994. India's latest National Health Policy 2017 now aims at increasing e_0 to 70 years by the year 2025 (Government of India, 2017).

The life expectancy at birth is an indicator of population health (Wilmoth, 2000) and the most widely used summary measure of the survival experience of the population. The relationship between survival and e_0, although reciprocal, is more complicated (Pollard, 1982). Improvement in survival probability at different ages of the life has different impact on the improvement in e_0. The relevance of e_0, essentially, lies in the fact that the increase in the length of life of the people is one of the key health and development agenda throughout the world. Improvement in the health status of the people and reduction in mortality are widely recognised as the most proximate approaches of increasing the length of the life.

Despite the slow mortality transition and despite marked within country variation in longevity in India, there is virtually no study, to the best of our knowledge, that has analysed the temporal patterns and regional variations in e_0 in India in recent years. There have been many studies in the past that have analysed mortality transition in India (Chaurasia, 2010; Mari Bhat, 1987) but recent studies on mortality transition in India, especially, after 2000, are rare. Such an analysis is relevant as India announced a new population policy in 2000 (Government of India, 2000) and a new health policy in 2002 (Government of India, 2002). The National Rural Health Mission was launched in the year 2005 with a focus on establishing a fully functional, community-owned, decentralized health care delivery system (Government of India, 2005). In 2013, the National Urban Health Mission was launched (Government of India, 2013). The two Missions were clubbed into National Health Mission in 2013 which envisages achievement of universal access to equitable, affordable, and quality health care services that are accountable and responsive to health and family welfare needs of the people (Government of India, 2013). India has also recorded an unprecedented economic growth in the recent past. During 2001-2011, the country recorded an average annual growth rate of almost 7.7 per cent per year in the gross domestic product (Government of India, 2018). Although, economic growth in India slowed down after 2011, yet it remained amongst the highest in the world. It is expected that population and health related policy measures and rapid economic growth during 2000-2015 would have contributed to an accelerated improvement in the survival experience of Indian population and would have an impact on the health of the population of the country. It is in the above context, that this paper analyses temporal patterns and regional variations in the life expectancy at birth in India during 1998-2017.

The paper is organised as follows. The next section describes the data source. We have used abridged life tables based on India's official Sample Registration System. The third section outlines the methodology. We first analyse the trend in e_0 during 1998-2002 through 2013-2017 and then decompose the change in e_0 to the change in person-years lived in different ages. Results of the analysis of the trend in e_0 are presented in four. Section five analyses the contribution of the change in person-years lived in different ages to the change in e_0. Findings of the analysis are summarised and discussed in the last section of the paper.

Data Source

The analysis is based on the abridged life tables prepared by the Registrar General and Census Commissioner of India based on age specific death rates available through official Sample Registration System (SRS). SRS is a large-scale demographic sample survey based on the mechanism of a dual record system which was launched in 1964-65 to provide reliable estimates of fertility and mortality indicators. Since 1969-70, SRS covers the entire country (Government of India, 1971). Reporting of births and deaths in SRS has been found to be fairly reliable, although, there is some under-reporting (Government of India, 1983; Government of India, 1988; Mari Bhat, 2002; Mahapatra, 2010; 2017). Abridged life tables, based on SRS are available for the country and for states having least 10 million population. Five years average age-specific death rates are used for the construction of life tables to adjust for sampling fluctuations and to augment the sample size (Government of India, 2019) so that the average mortality experience of the population over five years period and it is assumed that the average mortality experience refers to the mid-year of the five-year period. Thus, abridged life table for the period 1998-2002 is assumed to reflect the mortality situation that prevailed in the year 2000. In situation where no death is reported under the system in an age-group, the age-specific death rate for that age group is imputed based on a geographic approach (Government of India, 2019). These abridged life tables are available for concurrent five-year periods since 1986-90 and are the only source to analyse temporal patterns of the life expectancy at birth in the country.

Methods

The analysis has been carried out in two parts. The first part of the analysis focusses on characterising the trend in e_0 while the second part dwells upon analysing the contribution of the change in person-years lived in different age groups to the change in e_0. To analyse the trend, we first identify the year(s) when the trend has changed. This is important as the trend in e_0 may be influenced by policies and programmes directed towards improving the health of the people and by improvements in the standard of living. The trend analysis is then carried out separately for different temporal segments in which the trend has remained unchanged. Different methods are available for identifying the year(s) when the trend has changed. These include permutation test (Kim et al, (2000), Bayesian Information Criterion (BIC) (Kim et al, 2009), BIC3 (Kim and Kim (2016) and Modified BIC (Zhang and Siegmund (2007). The permutation test is the gold standard but is computationally very intensive. BIC performs well to detect a change with a small effect size but has a tendency of over-estimating the number of joinpoints. The Modified BIC is the most conservative method, but it performs well to detect a change with a large effect size. The performance of BIC3 is comparable to that of the permutation test.

When there is a change in trend, the trend analysis may be carried out through joinpoint regression analysis. Let y_i denotes e_0 for the year t_i such that $t_1<t_2<\ldots<t_n$. Then the joinpoint regression model is defined as

$$\ln(y_i) = \alpha + \beta_1 t_1 + \beta_1 u_1 + \beta_2 u_2 + \cdots . + + \beta_j u_j + \varepsilon_i \qquad (1)$$

where

$$u_j = \begin{cases} (t_j - k_j), & if\ t_j > k_j \\ 0 & otherwise \end{cases}$$

and $k_1<k_2\ldots\ldots<k_j$ are the years when the trend has changed or joinpoints. Details of joinpoint regression are given elsewhere (Kim et al, 2000; Kim et al, 2004). Assuming that the trend is linear on a log scale in a temporal segment or between two joinpoints or

$$\ln(y_t) = \alpha_0 + \beta(t) \qquad (2)$$

then the annual per cent change (APC) in e_0 between two joinpoints or in a temporal segment is estimated as

$$APC = \frac{e_{0(t+1)} - e_{0t}}{e_{0t}} \times 100 = (e^{\beta} - 1) \times 100 \qquad (3)$$

The average annual per cent change (AAPC) during the entire reference period is then obtained as the weighted average of APCs in different temporal segments with weights equal to the length of different temporal segments. The AAPC is argued to be a better approach to describe the long-term trend when the trend changes over time in comparison to the commonly used approach in which a single regression line on a log scale is fitted for the entire reference period and the average annual per cent change is calculated from the slope of the regression line (Clegg et al, 2009). AAPC permits comparison of trend in different temporal segments.

Actual calculations are carried out using Joinpoint Regression Program (National Institute of Cancer, 2013). The software requires specification of minimum (0) and maximum number of joinpoints (>0) up to a maximum of 9 in advance. The programme starts with 0 or minimum number of joinpoints, which means a straight line fit on a log scale and tests whether more joinpoints must be added to the model to better describe the trend in the data. The statistical significance of the change in trend is tested based on a Monte Carlo permutation method (Kim et al, 2000). The number of joinpoint(s) are identified using the grid search method (Lerman, 1980) which allows a joinpoint to occur exactly at the year t. A grid is created for all possible positions of the joinpoint(s) or combination of joinpoint(s), the model is fitted for each possible position and that position is selected which minimises the sum of squared errors (SSE). In the present analysis, the minimum number of joinpoint(s) has been set to 0 while the maximum number of joinpoint(s) is set to 4.

Joinpoint regression analysis has frequently been used for analysing trend in mortality and morbidity from specific causes (Tyczynski and Berkel, 2005; Doucet, Rochette and Hamel, 2016; John and Hanke, 2015; Akinyede and Soyemi, 2016; Mogos et al, 2016; Chatenoud et al, 2015; Missikpode et al, 2015; Rea et al, 2017; Qiu et al, 2008; Puzo, Qin and Mehlum, 2016). It has also been used for estimating population parameters under changing population structure (Gillis and Edwards, 2019). It has also been used to analyse long-term trend in infant mortality and marital fertility in India (Chaurasia, 2020a; 2020b) and in understanding the rapid increase in life expectancy in Shanghai, China (Chen et al, 2018). Jointpoint regression analysis has also been used to analyse patterns and changes in life expectancy at birth in China during 1990-2016 (Chen et al, 2020).

The second part of the paper analyses the contribution of the change in person-years lived in different ages to the change in e_0. Let the radix of the life table is l_0 or there are l_0 persons at age 0. If there is no death, at any age, then the total number of person-years lived up to the age N will be $N*l_0$. If there is no death in the first year of life, then the survival probability in the first year of life, ${}_1p_0=1$, and the total number of person-years lived in the first year of life will be ${}_1L_0=l_0$. If ${}_1p_0<1$, then ${}_1L_0<l_0$ and person-years lost in the first year of life is

$$ {}_1D_0 = l_0 - {}_1L_0 \tag{4} $$

The persons years lost through all ages as the result of mortality in the first year of life, therefore, is given by

$$ D_1 = \sum_1^N {}_1D_0 = N * {}_1D_0 \tag{5} $$

Similarly, the person years lost in the second year of life is given by

$$ {}_1D_1 = {}_1L_0 - {}_1L_1 \tag{6} $$

and the number of person years lost through all ages as the result of the mortality in the second year of life is given by

$$ D_2 = \sum_2^N {}_1D_1 = (N-1) * {}_1D_1 \tag{7} $$

Total person-years of life lost due to mortality in different ages is, therefore

$$ {}_ND_0 = \sum_N D_i \tag{8} $$

The life expectancy at birth, e_0 may now be computed as

$$ e_0 = \frac{N*l_0 - {}_ND_0}{l_0} = N - \frac{{}_ND_0}{l_0} \tag{9} $$

The change in e_0 between two points in time, 1 and 2 may now be decomposed as

$$ e_0^2 - e_0^1 = \frac{{}_ND_0^1 - {}_ND_0^2}{l_0} = \frac{1}{l_0}\sum_N D_i^1 - D_i^2 \tag{10} $$

Temporal Patterns

Results of the joinpoint regression analysis of the trend in e_0 are presented in table 1. The joinpoint regression analysis suggests that the trend in e_0 in India changed three times during 2000 (1998-2000) through 2015 (2013-2017). The annual percent increase (APC) decreased considerably during 2002-2009 relative to 2000-2002; increased during 2009-2012 relative to 2002-2009 but again decreased during 2012-2015 relative to 2009-2012. As a result, e_0 increased, on average, by around 0.35 years per year during 2000-2002; by 0.32 years per year during 2002-2009; by 0.36 years per year during 2009-2012; and by only about 0.28 years per year during 2012-2015 (Table 1). If the increase in e_0 in the country, observed during 2000-2002, would have been sustained after 2002, the e_0 in India would have increased to more than 7.1 years by 2015. The deceleration in the increase in e_0 during 2002-2009 and again during 2012-2015, as reflected through APC, has resulted in a loss of more than two years in e_0 in the country during 2000-2015.

The increase in male e_0 has been different from that in female e_0. The trend in male e_0 changed two times during the period under reference but the trend in female e_0 changed three times. The increase in male e_0 accelerated during 2009-2015 but the increase in female e_0 decelerated considerably during 2011-2015. If the APC in female e_0 would have not decreased after 2002, the female e_0 would have increased to almost 73.9 years by 2015 which means that deceleration in the increase in female e_0 resulted in a loss of around 3.4 years in female e_0 during 2000-2015. Because of the deceleration in the increase in female e_0 during 2011-2015, the female-male gap in e_0 narrowed down substantially after 2011.

The increase in e_0 has also been comparatively faster in rural than in the urban areas of the country. The trend in both rural and urban e_0, however, changed three times, although the years of change in trend or the joinpoints have been different. The increase in urban e_0 has been slower than the increase in rural e_0 largely because the increase in urban e_0 almost stagnated during 2004-2007. The increase in e_0 decelerated in both rural and urban areas of the country during 2012-2015, although the deceleration has been more pronounced in the urban areas than in the rural areas. As a result of the stagnation in the increase in urban e_0, the urban-rural gap in e_0 was the lowest in 2007 (2005-2009).

Among different mutually exclusive population groups, the increase in e_0 has been the fastest in rural females but the slowest in urban females. The increase in e_0 accelerated substantially in rural females during 2009-2015 but decelerated considerably in urban females during 2012-2015 so that the urban-rural gap in female e_0 has narrowed down substantially. The trend in rural and urban male e_0 has, however, been more volatile so that the rural-urban gap in male e_0 has been the lowest in 2007 (2005-09). Table 1 also suggests that there has been substantial deceleration in the increase in female e_0 compared to the increase in male e_0 in recent years.

Table 1: Trend in e_0 in India and different population groups, 1998-2002 (2000) to 2013-2017 (2015).

<table>
<tr><th rowspan="2">Population groups</th><th rowspan="2">Total increase (years)</th><th rowspan="2">AAPC</th><th colspan="16">APC in different time-segments</th></tr>
<tr><th>2000</th><th>2001</th><th>2002</th><th>2003</th><th>2004</th><th>2005</th><th>2006</th><th>2007</th><th>2008</th><th>2009</th><th>2010</th><th>2011</th><th>2012</th><th>2013</th><th>2014</th><th>2015</th></tr>
<tr><td>Person</td><td>6.1</td><td>0.622*</td><td colspan="2">0.823*</td><td></td><td colspan="6">0.558*</td><td></td><td colspan="2">0.738*</td><td></td><td colspan="3">0.534*</td></tr>
<tr><td>Male</td><td>5.9</td><td>0.613*</td><td colspan="3">0.670*</td><td></td><td colspan="5">0.448*</td><td></td><td colspan="6">0.750*</td></tr>
<tr><td>Female</td><td>6.4</td><td>0.643*</td><td colspan="2">0.962*</td><td></td><td colspan="5">0.618*</td><td></td><td colspan="2">0.800*</td><td></td><td colspan="4">0.606*</td></tr>
<tr><td>Rural</td><td>6.1</td><td>0.631*</td><td colspan="2">0.884*</td><td></td><td colspan="5">0.573*</td><td></td><td colspan="3">0.696*</td><td></td><td colspan="3">0.491*</td></tr>
<tr><td>Rural male</td><td>6.6</td><td>0.601*</td><td colspan="4">0.653*</td><td></td><td colspan="4">0.460*</td><td></td><td colspan="6">0.683*</td></tr>
<tr><td>Rural female</td><td>4.8</td><td>0.662*</td><td colspan="2">1.002*</td><td></td><td colspan="9">0.717*</td><td></td><td colspan="3">0.256*</td></tr>
<tr><td>Urban</td><td>5.7</td><td>0.455*</td><td colspan="4">0.464*</td><td></td><td colspan="2">0.099</td><td></td><td colspan="4">0.705*</td><td></td><td colspan="3">0.385*</td></tr>
<tr><td>Urban male</td><td>5.1</td><td>0.498*</td><td colspan="3">0.592*</td><td></td><td colspan="3">0.100</td><td></td><td colspan="5">0.715*</td><td></td><td colspan="2">0.506*</td></tr>
<tr><td>Urban female</td><td>4.5</td><td>0.416*</td><td colspan="4">0.480*</td><td></td><td colspan="2">0.143</td><td></td><td colspan="3">0.716*</td><td></td><td colspan="4">0.256*</td></tr>
</table>

Source: Author

Remarks: * indicates that APC and AAPC are statistically different from zero. Dark shaded cells are jointpoints

Table 2: Trend in e_0 in selected states, 1998-2002 (circa 2000) through 2013-17 (circa 2015).

<table>
<tr><th rowspan="2">State</th><th rowspan="2">Net increase (years)</th><th rowspan="2">AAPC</th><th colspan="16">APC in different time-segments</th></tr>
<tr><th>2000</th><th>2001</th><th>2002</th><th>2003</th><th>2004</th><th>2005</th><th>2006</th><th>2007</th><th>2008</th><th>2009</th><th>2010</th><th>2011</th><th>2012</th><th>2013</th><th>2014</th><th>2015</th></tr>
<tr><td>Andhra Pradesh</td><td>6.3</td><td>0.645*</td><td colspan="2">0.987*</td><td></td><td colspan="2">0.495</td><td></td><td colspan="2">0.065</td><td></td><td colspan="5">1.029*</td><td></td><td>0.440</td></tr>
<tr><td>Assam</td><td>8.2</td><td>0.887*</td><td colspan="12">0.807*</td><td colspan="2"></td><td colspan="2">1.208*</td></tr>
<tr><td>Bihar</td><td>5.9</td><td>0.589*</td><td colspan="2">0.848*</td><td></td><td colspan="3">0.081</td><td></td><td colspan="4">1.015*</td><td></td><td colspan="4">0.436*</td></tr>
<tr><td>Gujarat</td><td>4.9</td><td>0.457*</td><td colspan="8">0.373*</td><td></td><td colspan="7">0.640*</td></tr>
<tr><td>Haryana</td><td>4.6</td><td>0.450*</td><td colspan="4">0.708*</td><td></td><td colspan="4">0.037</td><td></td><td colspan="4">0.725*</td><td></td><td>0.419*</td></tr>
<tr><td>Himachal Pradesh</td><td>4.3</td><td>0.416*</td><td colspan="2">0.811*</td><td></td><td colspan="6">0.124*</td><td></td><td colspan="6">0.625*</td></tr>
<tr><td>Jammu and Kashmir</td><td>8.2</td><td>0.843*</td><td colspan="4">1.554*</td><td></td><td colspan="3">0.159</td><td></td><td colspan="7">0.830*</td></tr>
<tr><td>Karnataka</td><td>4.2</td><td>0.417*</td><td colspan="4">0.567*</td><td></td><td colspan="2">0.129</td><td></td><td colspan="4">0.616*</td><td colspan="2"></td><td colspan="2">0.126*</td></tr>
<tr><td>Kerala</td><td>3.3</td><td>0.299*</td><td colspan="2">0.930*</td><td></td><td colspan="2">0.445*</td><td></td><td colspan="2">0.030</td><td></td><td colspan="5">0.240*</td><td></td><td>0.002</td></tr>
<tr><td>Madhya Pradesh</td><td>7.9</td><td>0.828*</td><td colspan="16">0.828*</td></tr>
<tr><td>Maharashtra</td><td>6.3</td><td>0.607*</td><td colspan="5">0.886*</td><td></td><td colspan="2">0.330</td><td></td><td colspan="3">0.648*</td><td colspan="2"></td><td colspan="2">0.366*</td></tr>
<tr><td>Odisha</td><td>9.3</td><td>0.990*</td><td colspan="2">1.080*</td><td></td><td colspan="5">0.712*</td><td></td><td colspan="2">1.020*</td><td></td><td colspan="4">1.342*</td></tr>
<tr><td>Punjab</td><td>5.2</td><td>0.511*</td><td colspan="3">0.835*</td><td></td><td colspan="4">0.128</td><td></td><td colspan="5">0.826*</td><td></td><td>0.204</td></tr>
<tr><td>Rajasthan</td><td>5.2</td><td>0.532*</td><td colspan="8">0.626*</td><td></td><td colspan="7">0.424*</td></tr>
<tr><td>Tamil Nadu</td><td>6.0</td><td>0.580*</td><td colspan="3">0.732*</td><td></td><td colspan="12">0.553*</td></tr>
<tr><td>Uttar Pradesh</td><td>5.3</td><td>0.567*</td><td colspan="12">0.599*</td><td colspan="2"></td><td colspan="2">0.439*</td></tr>
<tr><td>West Bengal</td><td>5.6</td><td>0.538*</td><td colspan="4">0.788*</td><td></td><td colspan="11">0.447*</td></tr>
</table>

Source: Author's calculations

Remarks: The shaded cell indicates joinpoint.

* Indicates APC or AAPC are statistically significantly different from zero.

Table 3: Trend in male e_0 in selected states, 1998-2002 (circa 2000) through 2013-17 (circa 2015).

<table>
<tr><th rowspan="2">Country/State</th><th rowspan="2">Net increase (years)</th><th rowspan="2">AAPC</th><th colspan="16">APC in different time-segments</th></tr>
<tr><th>2000</th><th>2001</th><th>2002</th><th>2003</th><th>2004</th><th>2005</th><th>2006</th><th>2007</th><th>2008</th><th>2009</th><th>2010</th><th>2011</th><th>2012</th><th>2013</th><th>2014</th><th>2015</th></tr>
<tr><td>Andhra Pradesh</td><td>7.0</td><td>0.749</td><td colspan="3">0.872*</td><td></td><td colspan="4">0.199</td><td></td><td colspan="7">1.090*</td></tr>
<tr><td>Assam</td><td>8.0</td><td>0.838</td><td colspan="11">0.668*</td><td></td><td colspan="4">1.309*</td></tr>
<tr><td>Bihar</td><td>5.8</td><td>0.545</td><td colspan="6">0.118</td><td></td><td colspan="9">0.831*</td></tr>
<tr><td>Gujarat</td><td>4.6</td><td>0.479</td><td colspan="7">0.320*</td><td></td><td colspan="8">0.619*</td></tr>
<tr><td>Haryana</td><td>3.2</td><td>0.282</td><td colspan="16">0.282*</td></tr>
<tr><td>Himachal Pradesh</td><td>3.2</td><td>0.287</td><td colspan="9">0.192*</td><td></td><td colspan="6">0.430*</td></tr>
<tr><td>Jammu and Kashmir</td><td>7.4</td><td>0.764</td><td colspan="4">1.596*</td><td></td><td colspan="11">0.463*</td></tr>
<tr><td>Karnataka</td><td>5.1</td><td>0.536</td><td colspan="4">0.690*</td><td></td><td colspan="3">0.165</td><td></td><td colspan="3">0.833*</td><td></td><td colspan="3">0.430*</td></tr>
<tr><td>Kerala</td><td>3.5</td><td>0.319</td><td colspan="2">0.933*</td><td></td><td colspan="2">0.348</td><td></td><td colspan="10">0.187*</td></tr>
<tr><td>Madhya Pradesh</td><td>6.7</td><td>0.706</td><td colspan="16">0.706*</td></tr>
<tr><td>Maharashtra</td><td>6.7</td><td>0.667</td><td colspan="5">0.884*</td><td></td><td colspan="2">0.314</td><td></td><td colspan="7">0.707*</td></tr>
<tr><td>Odisha</td><td>8.7</td><td>0.913</td><td colspan="16">0.913*</td></tr>
<tr><td>Punjab</td><td>5.0</td><td>0.526</td><td colspan="3">0.840*</td><td></td><td colspan="4">-0.101</td><td></td><td colspan="7">0.840*</td></tr>
<tr><td>Rajasthan</td><td>4.4</td><td>0.457</td><td colspan="7">0.606*</td><td></td><td colspan="8">0.328*</td></tr>
<tr><td>Tamil Nadu</td><td>5.7</td><td>0.570</td><td colspan="2">0.849*</td><td></td><td colspan="8">0.478*</td><td></td><td colspan="4">0.637*</td></tr>
<tr><td>Uttar Pradesh</td><td>4.4</td><td>0.476</td><td colspan="11">0.392*</td><td></td><td colspan="4">0.708*</td></tr>
<tr><td>West Bengal</td><td>6.1</td><td>0.599</td><td colspan="3">0.717*</td><td></td><td colspan="7">0.503*</td><td></td><td colspan="4">0.700*</td></tr>
</table>

Source: Author's calculations

Remarks: The shaded cell indicates the joinpoint.

* Indicates APC or AAPC are statistically significantly different from zero.

Table 4: Trend in female e_0 in selected states, 1998-2002 (circa 2000) through 2013-17 (circa 2015).

<table>
<tr><th rowspan="2">Country/State</th><th rowspan="2">Net increase (years)</th><th rowspan="2">AAPC</th><th colspan="16">APC in different time-segments</th></tr>
<tr><th>2000</th><th>2001</th><th>2002</th><th>2003</th><th>2004</th><th>2005</th><th>2006</th><th>2007</th><th>2008</th><th>2009</th><th>2010</th><th>2011</th><th>2012</th><th>2013</th><th>2014</th><th>2015</th></tr>
<tr><td>Andhra Pradesh</td><td>5.6</td><td>0.559</td><td colspan="3">1.043*</td><td></td><td colspan="4">0.119</td><td></td><td colspan="2">1.029*</td><td></td><td colspan="4">0.188</td></tr>
<tr><td>Assam</td><td>8.4</td><td>0.924</td><td colspan="16">0.924*</td></tr>
<tr><td>Bihar</td><td>6.1</td><td>0.614</td><td colspan="2">1.082*</td><td></td><td colspan="3">0.289*</td><td></td><td colspan="4">1.073*</td><td></td><td colspan="4">0.133</td></tr>
<tr><td>Gujarat</td><td>5.3</td><td>0.509</td><td colspan="2">0.642*</td><td></td><td colspan="5">0.358*</td><td></td><td colspan="4">0.722*</td><td></td><td colspan="2">0.298</td></tr>
<tr><td>Haryana</td><td>6.4</td><td>0.605</td><td colspan="2">1.396</td><td></td><td colspan="2">0.624</td><td></td><td colspan="2">0.063</td><td></td><td colspan="4">0.723*</td><td></td><td colspan="2">0.308</td></tr>
<tr><td>Himachal Pradesh</td><td>5.4</td><td>0.513</td><td colspan="2">1.158</td><td></td><td colspan="6">0.054</td><td></td><td colspan="6">0.836*</td></tr>
<tr><td>Jammu and Kashmir</td><td>9.4</td><td>0.883</td><td colspan="4">1.327*</td><td></td><td colspan="3">0.029</td><td></td><td colspan="4">1.366*</td><td></td><td colspan="2">0.506</td></tr>
<tr><td>Karnataka</td><td>3.1</td><td>0.302</td><td colspan="2">0.605*</td><td></td><td colspan="4">0.230*</td><td></td><td colspan="3">0.541*</td><td></td><td colspan="4">0.001</td></tr>
<tr><td>Kerala</td><td>2.9</td><td>0.286</td><td colspan="13">0.872*</td><td></td><td colspan="2">0.141*</td></tr>
<tr><td>Madhya Pradesh</td><td>9.3</td><td>0.968</td><td colspan="8">1.062*</td><td></td><td colspan="7">0.860*</td></tr>
<tr><td>Maharashtra</td><td>5.8</td><td>0.543</td><td colspan="6">0.828*</td><td></td><td colspan="6">0.464*</td><td></td><td colspan="2">-0.034</td></tr>
<tr><td>Odisha</td><td>10.0</td><td>1.046</td><td colspan="2">1.405*</td><td></td><td colspan="6">0.623*</td><td></td><td colspan="6">1.422*</td></tr>
<tr><td>Punjab</td><td>5.7</td><td>0.540</td><td colspan="3">0.950*</td><td></td><td colspan="4">0.424*</td><td></td><td colspan="4">0.716*</td><td></td><td colspan="2">-0.218</td></tr>
<tr><td>Rajasthan</td><td>6.0</td><td>0.592</td><td colspan="8">0.627*</td><td></td><td colspan="2">0.844*</td><td></td><td colspan="4">0.332*</td></tr>
<tr><td>Tamil Nadu</td><td>6.5</td><td>0.686</td><td colspan="16">0.686*</td></tr>
<tr><td>Uttar Pradesh</td><td>6.2</td><td>0.650</td><td colspan="11">0.838*</td><td></td><td colspan="4">0.135</td></tr>
<tr><td>West Bengal</td><td>5.2</td><td>0.487</td><td colspan="2">1.091*</td><td></td><td colspan="2">0.732*</td><td></td><td colspan="3">0.449*</td><td></td><td colspan="6">0.189*</td></tr>
</table>

Source: Author's calculations

Remarks: The shaded cell indicates the joinpoint.

* Indicates APC or AAPC are statistically significantly different from zero.

Table 5: Contribution of different age groups to the increase in e_0 in India between 2000(1998-2000) and 2015 (2013-2017).

Age	Combined			Rural			Urban		
Years	Person	Male	Female	Person	Male	Female	Person	Male	Female
0-1	1.72	1.77	1.61	1.72	1.75	1.63	1.22	1.38	1.01
1-4	1.86	1.70	2.10	2.08	1.90	2.35	0.89	0.83	0.99
5-9	0.70	0.58	0.82	0.76	0.63	0.89	0.41	0.34	0.47
10-14	0.30	0.26	0.33	0.33	0.29	0.37	0.15	0.13	0.17
15-19	0.21	0.18	0.25	0.24	0.20	0.29	0.10	0.09	0.12
20-24	0.29	0.21	0.37	0.33	0.24	0.44	0.14	0.11	0.18
25-29	0.31	0.24	0.38	0.33	0.26	0.41	0.22	0.17	0.27
30-34	0.26	0.24	0.29	0.25	0.22	0.29	0.24	0.26	0.21
35-39	0.21	0.20	0.22	0.20	0.18	0.22	0.19	0.23	0.14
40-44	0.15	0.17	0.14	0.12	0.13	0.11	0.18	0.20	0.15
45-49	0.13	0.13	0.13	0.09	0.09	0.09	0.18	0.20	0.15
50-54	0.11	0.18	0.04	0.03	0.12	-0.06	0.24	0.27	0.18
55-59	0.13	0.19	0.05	0.01	0.07	-0.07	0.34	0.38	0.26
60-64	0.20	0.24	0.17	0.10	0.10	0.10	0.39	0.47	0.30
65-69	0.29	0.38	0.21	0.21	0.30	0.15	0.45	0.56	0.36
70-74	0.13	0.11	0.15	0.10	0.08	0.13	0.20	0.19	0.22
75-79	-0.10	-0.16	-0.03	-0.09	-0.15	-0.03	-0.09	-0.19	0.02
80-84	-0.35	-0.38	-0.33	-0.36	-0.37	-0.34	-0.29	-0.31	-0.26
85+	-0.40	-0.36	-0.44	-0.42	-0.38	-0.46	-0.29	-0.21	-0.40
Increase in e_0	6.15	5.89	6.44	6.05	5.65	6.50	4.85	5.10	4.53

Source: Author's calculations.

Table 6: Contribution of different age groups to the increase in e_0 in states between 2000(1998-2000) and 2015 (2013-2017).

Age	AP	AS	BI	GU	HA	HP	JA	KA	KE	MP	MS	OD	PU	RA	TN	UP	WB
0-1	1.90	1.87	1.57	1.09	1.78	1.47	0.93	2.06	0.07	2.14	2.05	2.52	2.17	1.73	1.76	1.08	1.76
1-4	1.30	2.18	1.89	1.41	1.85	0.84	0.85	1.41	0.15	3.19	0.99	2.68	1.29	2.46	0.85	2.51	1.22
5-9	0.36	0.90	0.93	0.61	0.57	0.19	2.08	0.37	0.41	0.80	0.30	0.60	0.35	0.72	0.26	1.06	0.48
10-14	0.23	0.54	0.48	0.19	0.14	0.09	1.76	0.11	0.33	0.31	0.16	0.32	0.11	0.20	0.12	0.39	0.23
15-19	0.26	0.36	0.35	0.11	0.09	0.08	0.05	0.13	0.05	0.20	0.18	0.32	0.06	0.14	0.20	0.27	0.17
20-24	0.33	0.49	0.38	0.18	0.25	0.15	0.08	0.20	0.05	0.29	0.19	0.45	0.10	0.21	0.37	0.44	0.21
25-29	0.30	0.46	0.41	0.24	0.31	0.18	0.23	0.21	0.07	0.23	0.22	0.35	0.23	0.26	0.34	0.49	0.18
30-34	0.29	0.34	0.35	0.27	0.14	0.24	0.15	0.22	0.12	0.18	0.28	0.24	0.24	0.19	0.26	0.34	0.13
35-39	0.22	0.27	0.28	0.18	0.12	0.09	0.11	0.17	0.14	0.18	0.23	0.31	0.13	0.06	0.18	0.24	0.15
40-44	0.11	0.28	0.21	0.14	0.07	0.07	0.02	0.07	0.15	0.24	0.22	0.27	0.04	-0.01	0.19	0.07	0.12
45-49	0.10	0.39	0.31	0.19	-0.02	0.07	-0.07	0.09	0.14	0.19	0.28	0.14	-0.05	-0.03	0.13	-0.06	0.17
50-54	0.20	0.32	0.35	0.01	0.13	-0.01	0.12	0.22	0.12	0.17	0.19	0.18	-0.06	-0.16	0.11	-0.26	0.17
55-59	0.30	0.39	0.16	-0.11	0.14	-0.01	0.29	0.17	0.17	0.21	0.14	0.40	0.12	-0.21	0.35	-0.41	0.26
60-64	0.37	0.44	0.29	0.11	-0.33	0.19	0.27	-0.01	0.35	0.21	0.38	0.44	0.13	-0.07	0.50	-0.21	0.47
65-69	0.30	0.16	0.47	0.36	-0.48	0.48	0.37	0.07	0.37	0.33	0.50	0.16	0.01	0.11	0.51	0.12	0.50
70-74	0.15	-0.07	-0.18	0.18	-0.21	0.25	0.42	-0.09	0.34	0.07	0.48	0.11	0.12	0.13	0.35	0.13	0.19
75-79	-0.08	-0.25	-0.52	-0.04	-0.02	-0.09	0.12	-0.11	0.34	-0.31	0.22	-0.19	0.16	-0.07	0.08	-0.02	-0.13
80-84	-0.26	-0.47	-0.83	-0.17	-0.02	-0.13	-0.08	-0.41	-0.02	-0.46	-0.35	-0.29	-0.01	-0.22	-0.28	-0.36	-0.35
85+	-0.06	-0.36	-0.96	-0.11	0.05	0.10	0.49	-0.62	-0.03	-0.29	-0.45	0.20	0.11	-0.26	-0.18	-0.52	-0.29
Increase in e_0	6.31	8.24	5.93	4.85	4.59	4.25	8.18	4.26	3.32	7.90	6.24	9.21	5.26	5.18	6.08	5.29	5.63

Source: Author's calculations.

Table 7: Contribution of different age groups to the increase in e_0 in India in different time segments of the period 2000-2015 identified through joinpoint regression analysis.

Age	Time-segment				
	2000-02	2002-09	2009-12	2012-15	2000-15
0-1	0.10	0.89	0.45	0.28	1.72
1-4	0.26	0.87	0.41	0.32	1.86
5-9	0.14	0.25	0.15	0.16	0.70
10-14	0.06	0.12	0.06	0.05	0.30
15-19	0.03	0.09	0.05	0.05	0.21
20-24	0.05	0.09	0.06	0.09	0.29
25-29	0.05	0.11	0.05	0.10	0.31
30-34	0.03	0.10	0.06	0.07	0.26
35-39	0.03	0.06	0.07	0.04	0.21
40-44	0.04	0.04	0.04	0.03	0.15
45-49	0.03	0.03	0.03	0.04	0.13
50-54	0.06	0.05	0.00	0.00	0.11
55-59	0.09	0.16	-0.03	-0.08	0.13
60-64	0.07	0.12	0.04	-0.02	0.20
65-69	0.06	0.01	0.10	0.11	0.29
70-74	0.03	-0.11	0.09	0.11	0.13
75-79	-0.03	-0.15	0.05	0.03	-0.10
80-84	-0.05	-0.11	-0.09	-0.10	-0.35
85+	-0.01	-0.08	-0.14	-0.16	-0.40
Increase in e_0	1.04	2.52	1.46	1.12	6.15

Source: Author's calculations.

The trend in e_0 has varied across the states in terms of both volatility and magnitude of change (Table 2). In Andhra Pradesh and Kerala, the trend in e_0 changed four times whereas Madhya Pradesh is the only state where there has been no change in the trend during 2000-2015 or e_0 increased linearly on a log scale during the period under reference. In majority of the states, however, the trend in e_0 changed three times during the period under reference reflecting the volatility in the trend. The increase in e_0 has been the fastest in Odisha but the slowest in Kerala. Odisha is the only state where female e_0 increased by more than nine years during 2000-2015 or by more than 0.5 years per year, on average. Kerala, on the other hand, is the only state where e_0 increased by less than four years or by just 0.2 years per year. Inter-state variance in e_0, however, decreased over time which indicates sigma-convergence in e_0 across states. There are seven states where APC has not been found to be statistically significantly different from zero during at least one time-segment of the period under reference which suggests that the increase in e_0 stagnated during these time segments. In Andhra Pradesh, the increase in e_0 stagnated in three of the five time-segments. In Kerala and Punjab, increase in e_0 stagnated in two time-segments while it stagnated in one time segment in Bihar, Haryana, Jammu and Kashmir and Maharashtra.

Table 8: Contribution of different age groups to the increase in male e_0 in India in different time segments of the period 2000-2015 identified through joinpoint regression analysis.

Age	Time-segment			
	2000-2004	2004-2009	2009-2015	2000-2015
0-1	0.20	0.81	0.76	1.77
1-4	0.30	0.76	0.64	1.70
5-9	0.11	0.21	0.26	0.58
10-14	0.04	0.11	0.11	0.26
15-19	0.03	0.07	0.08	0.18
20-24	0.05	0.03	0.13	0.21
25-29	0.06	0.03	0.15	0.24
30-34	0.04	0.04	0.16	0.24
35-39	0.05	0.00	0.16	0.20
40-44	0.05	-0.03	0.15	0.17
45-49	0.05	-0.04	0.12	0.13
50-54	0.08	-0.01	0.12	0.18
55-59	0.13	0.08	-0.02	0.19
60-64	0.13	0.04	0.06	0.24
65-69	0.08	-0.01	0.31	0.38
70-74	-0.01	-0.10	0.22	0.11
75-79	-0.06	-0.11	0.01	-0.16
80-84	-0.08	-0.06	-0.24	-0.38
85+	0.08	-0.17	-0.27	-0.36
Increase in e_0	1.34	1.64	2.91	5.89

Source: Author's calculations.

Across different states and different time segments, APC was the fastest in Jammu and Kashmir during 2000-2004 but the slowest in Kerala during 2013-2015. In most states of the country, the increase in e_0 decelerated during the later years or the period 2000-15 as compared to earlier years of the period 2000-2015, with the exception of only two states - Assam and Odisha. The trend in e_0 in Kerala, the state with the highest e_0 in the country throughout the period under reference is typical. currently and in the past has been the most remarkable with the increase in e_0 stagnating during the period 2013-2015.

The deceleration in the increase in e_0 has particularly been marked in female e_0. Odisha is the only state where increase in female e_0 did not decelerate during the period under reference whereas in Maharashtra and Punjab, female e_0 appears to have decreased in recent years. By comparison, there is no state where APC in male e_0 has been negative in recent years. By contrast, male e_0 decreased in only Punjab during 2003-2008. In many states, increase in male e_0 accelerated in recent years compared to that in the past. In all states, the volatility in the trend has also been found to be less in male e_0 compared to females. There is no state where number of joinpoints in male e_0 is four and, in three states, there is no joinpoint indicating a linear trend on a log scale. By comparison, number of joinpoints in female e_0 has been four in one state and three in seven states. There is only one state where there is no joinpoint in the trend in female e_0.

Table 9: Contribution of different age groups (years) to the increase in female e_0 in India in different time segments of the period 2000-2015 identified through joinpoint regression analysis.

Age	Time-segment				
	2000-2002	2002-2008	2008-2011	2011-2015	2000-2015
0-1	0.07	0.78	0.37	0.39	1.61
1-4	0.30	0.81	0.42	0.56	2.10
5-9	0.18	0.21	0.17	0.25	0.82
10-14	0.08	0.11	0.08	0.06	0.33
15-19	0.03	0.09	0.06	0.07	0.25
20-24	0.05	0.13	0.06	0.13	0.37
25-29	0.07	0.14	0.06	0.11	0.38
30-34	0.04	0.12	0.06	0.07	0.29
35-39	0.03	0.08	0.08	0.03	0.22
40-44	0.04	0.11	0.00	-0.02	0.14
45-49	0.04	0.06	0.04	-0.01	0.13
50-54	0.07	0.03	0.07	-0.13	0.04
55-59	0.09	0.18	0.00	-0.23	0.05
60-64	0.06	0.11	0.06	-0.07	0.17
65-69	0.07	0.01	0.01	0.11	0.21
70-74	0.07	-0.11	0.03	0.17	0.15
75-79	-0.01	-0.16	0.03	0.10	-0.03
80-84	-0.05	-0.12	-0.04	-0.12	-0.33
85+	0.04	-0.02	0.00	-0.46	-0.44
Increase in e_0	1.28	2.58	1.58	1.00	6.44

Source: Author's calculations.

Decomposition of the Increase in e_0

The increase in e_0 in India was around 6.1 years between 1998-2002 and 2013-2017. The increase in the person-years lived in the first year of life accounted for an increase of around 1.72 years in e_0 while increase in person-years lived in 1-5 years of life accounted for an increase of 1.86 years so that increase in person-years lived in the first five years of life accounted for an increase of 3.58 years or more than 58 per cent of the increase in e_0. Increase in person-years lived in 15-60 years of age accounted for an increase of 1.8 years or 30 per cent increase in e_0. Increase in person-years lived in 60-

75 years of age accounted for an increase of around 0.62 years or 10 per cent increase in e_0 but the decrease in the person-years lived in the age group 75 years and above resulted in a decrease of around 0.85 years or 14 per cent decrease in e_0. The average annual gain in e_0 was the highest during 2009-2012 but the lowest during 2012-2015 because the person-years lived in the age group 50-65 years decreased during 2012-2015 compared to 2009-2012. Another reason behind low average annual gain in e_0 during 2012-2015 appears to be very slow increase in the survival probability in the first five years of life leading to only a marginal increase in the person-years lived in this age group.

The relative contribution of the change in age-specific survival probabilities to the change in e_0 has been different in different states of the country. In most of the states, however, the increase in e_0 has primarily been attributed to the improvement in person-years lived in the first five years of life. Notable exceptions to this general pattern are Jammu and Kashmir and Kerala. Similarly, decrease in person-years lived in the age group 75 years and above has accounted for the decrease in e_0 in most of the states. There are only four states - Haryana, Jammu and Kashmir, Kerala, and Punjab - where person-years lived in the age group 75 years and above increased during the period under reference and, therefore, contributed to the increase in e_0. In Haryana, person-years lived in the age group 60-75 years decreased in 2015 compared to 2000. Similarly, person years lived in the age group 40-65 years decreased in Rajasthan and person-years lived in the age group 45-65 years decreased in Utter Pradesh during the period under reference and, therefore, decelerated the increase in e_0.

The relative contribution of the change in person-years lived in different age groups to the change in e_0 has been different in females as compared to males. Almost 80 per cent of the increase in the female e_0 is attributed to the increase in person-years lived in the first 15 years of life. This proportion is only 70 per cent in males. By contrast, increase in person-years lived in the age group 60-75 years accounted for an increase of 0.73 years in male e_0 but only 0.53 years in female e_0. On the other hand, decrease in person-years lived in the age group 75 years and above accounted for a decrease of 0.81 years in female e_0 but 0.90 years in male e_0. Similarly, increase in person-years lived in the first five years of life accounted for almost two-third increase in e_0 in the rural areas of the country but only around 43 per cent in the urban areas. Increase in person-years lived in the age group 1-5 years of life accounted for more than 34 per cent of the increase in rural e_0 but only around 18 per cent increase in urban e_0.

Discussions and Conclusions

The present analysis reveals volatile trends in e_0 in India and in its different population groups and 17 states between 1998-2002 and 2013-2015.There has been a deceleration in the increase in the later years compared to the earlier years of the period 2000-2015 which is quite marked in females. The deceleration in the increase in

e_0 during the period under reference is estimated to have costed more than 2 years in the gain in e_0. The increase in e_0 has also decelerated in most states of the country leading to retarded increase in e_0. The reason for the observed deceleration in the increase in e_0 has been the deceleration in the increase in female e_0 as the increase in male e_0 has accelerated during this period. The deceleration in the increase in female e_0 is estimated to have costed more than 3 years in the gain in female e_0 and has resulted in narrowing the gender gap in e_0.

The analysis also reveals that the increase in urban e_0 has stagnated during 2003-2007 and this stagnation has primarily been responsible for relatively slower increase in urban e_0 as compared to the increase in rural e_0. Unlike the urban areas, there has been no stagnation in the increase in e_0 in the rural areas of the country. Because of the stagnation in the increase in urban e_0, the urban-rural gap in e_0 was the narrowest during 2007 (2005-2009). The urban-rural gap in e_0 narrowed down again in the recent past because of the increase in urban e_0 decelerated again. The deceleration in the increase in urban e_0 has not been confined to a particular sex but is evident in both sexes.

The increase in e_0 in the country has largely been the result of the improvement in the survival probability in the first five years of life. However, the contribution of the improvement in the survival probability in the first five years has varied in different time segments as identified through the joinpoint regression analysis. In recent years, contribution of the improvement in the survival probability in the first five years of life to the increase in e_0 has decreased substantially. On the other hand, the number of person-years lived in the age group 75 years and above has decreased during the period under reference which contributed to the decrease in e_0. Although, survival probability increased in the age group 75-80 and 80-80 years, yet improvement in the survival probability in these age groups has not been large enough to ensure a decrease in the number of deaths so that the number of person-years lived in these age groups decreased leading to decrease in e_0.

The deceleration in the increase in female e_0 in the country in recent years is a matter of concern from the perspective of population health. The decrease in person-years lived in the age group 40-65 years appears to be responsible for the deceleration in the increase in female e_0 in the country. Although, the probability of death in females of this age group has decreased during 2000-2015, yet the decrease in the probability of death has not been sufficient enough to ensure the decrease in the number of deaths and hence increase in person-years lived in this age group. To ensure that improvement in survival probability results in the increase in person-years lived and increase in e_0, it is imperative that the improvement in survival probability is large enough to ensure an increase in person-years lived in the age group.

Reasons for volatile trends and deceleration in the increase in e_0, especially in females in India are not known at present. To accelerate the increase in e_0, it appears imperative to increase the investment in the health of the people. The current investment in health does not appear to be adequate to accelerate the pace of the increase in e_0 which remains slow by international standards. India has not been able to achieve the goal of an e_0 of 75 years by the year 2015 set at the 1994 International Conference on Population and Development. The National Health Policy 2017 has scaled down the goal of e_0 to 70 years by the year 2025 which will be achieved even without any acceleration in the current rate of increase in e_0.

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Demographic Factors Affecting Unfunded Pensions

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Abstract

Population aging affects more and more countries. An important aspect of population aging is the role of public pension systems to ensure that retired workers have adequate pension to support themselves. There are many types of pension systems. This paper examines the type found in most countries, the unfunded pension system, also known as pay-as-you go old-age insurance. This paper examines the demography of the unfunded pension system for birth cohorts in the United States using U.S. census data and simulations from population projections. The paper analyses the implicit rate of return for birth cohorts over time. Results show that cohorts born during the baby boom years, 1946 to 1967, and earlier years show a positive return. However, cohorts born after 2000 have returns that are negative. Declines in pay-as-you-go old-age insurance returns are typical for unfunded pensions as they mature, and negative returns are usual for populations when the birth rate decreases under fixed economic conditions. The return of unfunded pensions can be kept positive by greatly increasing fertility, a demographic change that is unlikely in the United States and many countries that are experiencing population aging. The conclusions of this paper for the United States are broadly applicable to other countries with unfunded pension systems that are experiencing or have experienced a transition from high fertility to replacement or sub-replacement fertility.

Introduction

Unfunded or pay-as-you-go pension systems pay out to current beneficiaries based on current contributions (Auerbach and Lee, 2011; Bloom and Canning, 2004). Such systems are heavily dependent on the ratio of persons in the beneficiary ages to those in the contributing ages (Ludwig and Reiter, 2010). If fertility is relatively high and mortality is comparatively low, the population will be young and rapidly growing and the ratio of beneficiaries to contributors will be low so that the scheme will seem inexpensive and reasonable (Lee, 2003). An unfunded system will also appear to be inexpensive in a rapidly expanding economy. If the population and the economy are stationary, then, an unfunded scheme is more expensive. But the threat of a stationary population (a population with replacement-level fertility and zero population growth) is only part of the reason for concern with unfunded pension schemes (MacKellar, 2000; Thøgersen, 1998).

There is a worse condition than a stationary population that is an immediate concern. In the United States, large birth cohorts of late 1940s, 1950s, and early 1960s began to retire in the second decade of the twentieth-first century, and the number of contributors to the pension systems are smaller because of low fertility since 1970s (Börsch-Supan, 2004; Brooks, 2002 Modigliani, Ceprini, and Muralidhar, 1999). Among larger high-income countries, previous replacement fertility in France, United Kingdom, and the United States have decreased to sub-replacement levels with total fertility rates ranging from 1.7 to 1.9 children per woman (United Nations, 2020). Population is decreasing in more than a dozen countries at present, and the ratio of persons in working ages to older ages is falling below that existing in stationary populations. This worse-than-stationary population ratio will persist as the post-war baby boom passes through retirement ages.

Although the numbers presented in this paper are for the United States, the general demographic outcome will apply for any low-fertility population that previously experienced higher fertility. The lessons about unfunded pension systems, for example, will help to understand better the evolving situation in several Asian populations experiencing fertility decline. Based on U.N. Population Division (2020) analysis, current average total fertility rate of 1.7, 2.2 and 2.4 for East Asia, Southeast Asia, and South Asia respectively, are projected to decrease to replacement or sub-replacement levels ranging from 1.7, 2.0, and 2.1 in 2030. Lower future fertility in more populous countries of Bangladesh, China, India, Indonesia, and Japan and in many countries with smaller populations will lead to unfunded pension outcomes similar to those described in this paper.

The effect of economic growth on unfunded pensions is similar to that of population growth. An increase or decrease of one percent economic growth will have the same effect (Geanakoplos, Magill, and Quinzii, 1999; Krueger and Ludwig, 2007). But there is an important difference between them. An economy can have much higher and lower rate of growth than a population. For modern industrialized countries, annual population growth rate typically varies between negative and positive one percent. Economic growth has been more rapid than population growth in recent decades and has exceeded population growth in all but a few years (Mankiw and Weil, 1989; Poterba, 2004). If economic growth is moderate or slow, then the demographic situation can have an important influence on unfunded pensions.

The purpose of this paper is to describe the effect of demographic factors on unfunded pensions. We ignore economic factors, such as economic growth, that influence unfunded pensions. Rather, demographic factors are considered as the sole source of change on unfunded pensions over the lifetime for successive birth cohorts. For consideration of major factors affecting the U.S. public pension system, see the U.S. Social Security Administration's (2020) recent annual report that offers forecasts of the contributions and payments for future decades. Rather than forecasts over time, the simulations in this paper describe net transfers between generations over entire lifetime. Unfunded pension schemes are too often viewed in cross-sectional terms based on the current calendar year (Barr and Diamond, 2008; Diamond and Orszag, 2005; Lindbeck and Persson, 2003). Such a short-term view does not offer an adequate description of the demography of these schemes (Samuelson, 1958). Long-term stability depends to some extent on a degree of equity between generations, and this requires analysis of birth cohorts over several generations.

This paper asks whether a population that is growing faster or slower influences unfunded pensions for successive generations. If there is higher or lower fertility, or higher or lower mortality, what difference does it make? If there is more or less immigration, what effect does that have? This paper updates an earlier publication by Keyfitz (1985) with two contributions: (1) estimates of the implicit rate of return for unfunded pensions for the 1830-34 to 2040-44 U.S. birth cohorts and (2) simulations of the effect of fertility, mortality, and immigration based on more recent data. This paper owes its conceptual foundation to Keyfitz's (1985) paper.

Unfunded Pensions

Measure of Return

There are several possible measures for the comparison of costs and benefits of an unfunded pension scheme (Fenge and Werding, 2003). Total contributions to the scheme for an individual could be a comparison to total benefits to obtain the absolute profit or loss for that person. Or the same comparison could be made for a birth cohort of persons. The ratio of benefits to costs to a person offers another measure, indicating how many dollars a person receives in return for each dollar contributed.

The measure used in this paper is the implicit rate of return, which is calculated as the rate of interest that makes contributions equal to benefits when both are discounted back to birth (see Knell, 2010a; Knell 2010b; and Knell, 2013 for extensive discussion of economic aspects of implicit rate of return). This is the way that most private funded pensions are evaluated, and it is a common measure for bonds, real estate, and other investments. The implicit rate of return offers a reasonable comparison of different rules, such as beginning a pension at age 60, 65, or 70 years, for example, or for different situations, such as high or low fertility, or high or low net immigration.

To assess the return of an unfunded pension scheme, the characteristics of the operation need to be described. Suppose each worker is promised a fixed sum, say \$10,000, for each year the worker is alive after age β (say, 65 years), and in return, during ages between α and β (say, 20 to 64 years) the worker is to bear equal share each year of the cost of providing the same benefit to the old people who are alive. In essence, this is the way in which most unfunded pension schemes are conceived, which is called a *defined benefit scheme* because workers are promised a specific benefit when they retire. In practice, not all workers contribute to an unfunded pension and the benefit is not equal to the wage but usually replaces only a fraction of it. These differences are disregarded in calculations here and are described for conceptual clarity. If only 60 percent of a salary is replaced, then this part is related to the contribution, and all the following calculations are applicable. The tables below compare various conditions, maintained for long time periods, for a conventional fixed pension of, say, \$10,000 per year.

Suppose an individual goes through their working life making contributions to the support of old people alive each year. Each calendar year's contribution is taken to be equal to the ratio of old people to working people of that year. In this approach, this is the cost to the payer as they pass through working life of that \$10,000 per year expected during retirement. Stated formally, the number of beneficiaries in year t is

$$\int_{\beta}^{\omega} p(x,t)dx$$

where β is the age of retirement, ω is the highest age that anyone lives, and *p*(x,t)dx is the number of persons in the population between age x and x+dx at time t. The number of contributors in the year t is

$$\int_{\alpha}^{\beta} p(x,t)dx$$

where α is the age of starting work and β is the age of retirement. For such a defined benefit scheme, the premium paid each year by everyone between α and β is the ratio of the number of beneficiaries to the number of contributors. The ratio for the premium at time *t* is

$$Prem(t) = \int_{\beta}^{\omega} p(x,t)dx / \int_{\alpha}^{\beta} p(x,t)dx$$

The equation is to be solved for *r*, the implicit rate of return, consists of the expected payment of Prem(t) against the expected benefit of unity per year, or

$$\int_{\beta}^{\omega} e^{-rx}\, l(x)dx = \int_{\alpha}^{\beta} e^{-rx}\, l(x) Prem(c + x - 20)dx \qquad (1)$$

where *c* is the calendar year when the cohort starts working (assumed here to be 20 years). Call the left-hand side A and the right-hand side B, and we then need to find a value of *r* in which A=B. The implicit rate of return is quickly computed by functional iteration. Calculate the discounted benefit (A) and the discounted payment (B), with both discounted to birth for calculation convenience, using an initial trial value for the rate of return. In practice, convergence is reached to six significant digits in five or fewer iterations.

Results would not be identical with an opposite approach that is less conventional: fix the contributions at, say, \$10,000 per year and divide the total proceeds among those who are drawing on the pension scheme, which is called a *defined contribution scheme* because workers make a specific contribution and receive a variable amount after retirement which depends upon what workers have contributed. Both the pattern and the inequalities between birth cohorts would be quite different in the defined benefit and the defined contribution schemes. This paper devotes attention to a defined benefit scheme, which is the conventional public pension scheme found in the United States and in most countries. The last section of the paper includes brief discussion of differences with a defined contribution pension scheme that holds the contributions constant.

For a defined contribution scheme, the contribution received each year by everyone aged β to ω is the ratio of the number of contributors to the number of beneficiaries, where the benefits at time t is

$$Ben(t) = \int_{\alpha}^{\beta} p(x,t)dx \Big/ \int_{\beta}^{\omega} p(x,t)dx$$

The equation to be solved for the implicit rate of return is

$$\int_{\alpha}^{\beta} e^{-rx}\, l(x)dx = \int_{\beta}^{\omega} e^{-rx}\, l(x)Ben(f + x - 65)dx \qquad (2)$$

where f is the year when the cohort is 65 years old. Equation (2) is also solved by functional iteration.

Trends in the Rate of Return

We calculate the implicit rate of return for 1830-34 to 2040-44 birth cohorts for the U.S. population. This requires age data from 1850 (when the 1830 birth cohort reached 20 years of age) to 2130 (when the 2040 birth cohort reaches the end of life). Age data are from two sources: (1) tabulations of microdata samples from U.S. censuses from 1850 to 2010, which are interpolated for birth cohorts for the five-year periods between decennial censuses and (2) U.S. Census Bureau (2017) population projections for 2017 to 2060. For projections for 2060 to 2130, this paper makes separate population projections if mortality, fertility, and net immigration prevailing in 2060 continues unchanged until 2130.

The implicit rate of return based on these age data is shown as the solid green line, labelled "demographic *r*", in Figure 1 for 1830-34 to 2040-44 birth cohorts. The annual rate of return is 2.09 percent for the 1830-34 birth cohort, when relatively high fertility produced a young age structure. Steady fertility declines in subsequent years results in an increasingly older population, which declines the implicit rate of return to 0.95 percent for the 1920 birth cohort, below zero (-0.05 percent) for the 1995-99 birth cohort and continuing with negative rates of return for subsequent birth cohorts.

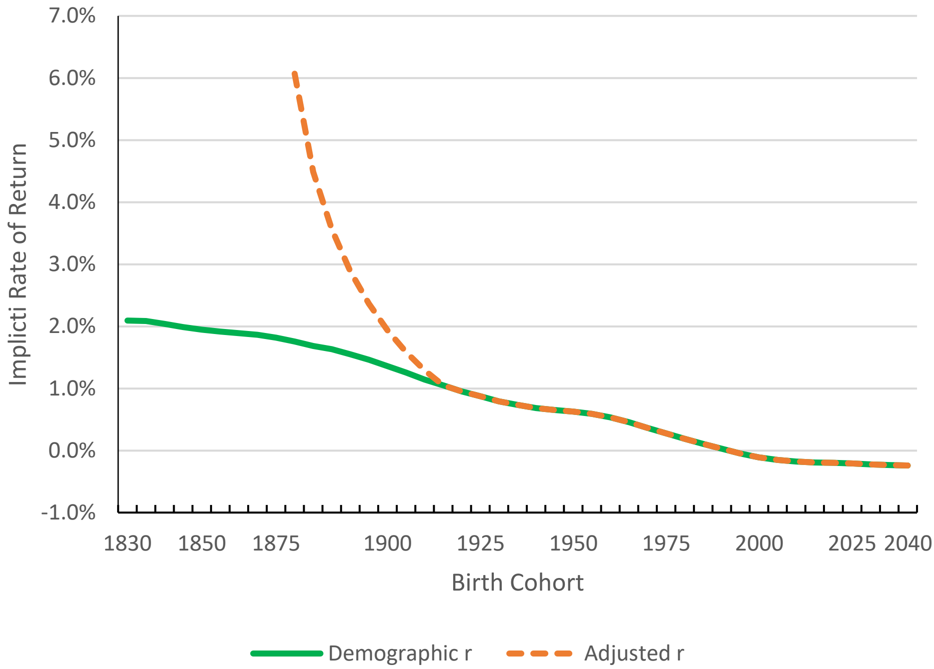

Figure 1: Trend in the rate of return, 1830-2040.
Source: Author

The trend in the rate of return can be modified (called the "adjusted *r*") to illustrate the fact that the U.S. public pension system began in 1935, with contributors beginning in the second half of the 1930s but offering benefits to all elderly persons (shown as the dotted orange line in Figure 1). This meant that birth cohorts born before 1875 received benefits having not made contributions prior to 1935. The 1875-79 birth cohort began to receive benefits at age 65 in 1940 having made contributions only for the previous five years. The 1875-79 birth cohort obtained an implicit annual rate of return of 6.1 percent. Earlier birth cohorts (born before 1875) received an infinite rate of return because they did not make contributions. The 1920-24 birth cohort is the first birth cohort that made contributions throughout their young adult years and had the same implicit "demographic" and "adjusted" rates of return.

Figure 2 displays the implicit rate of return for the baby boom and subsequent generations for 1945-49 to 2040-44 birth cohorts. The important point is that there is a positive rate of return for the 1945 to 1969 birth cohorts, those born during the baby boom. The subsequent generation – those born during 1970 to 2000 – have a declining rate of return that becomes negative for those born after 1990. Births occurring after 2000 have decreasingly negative returns.

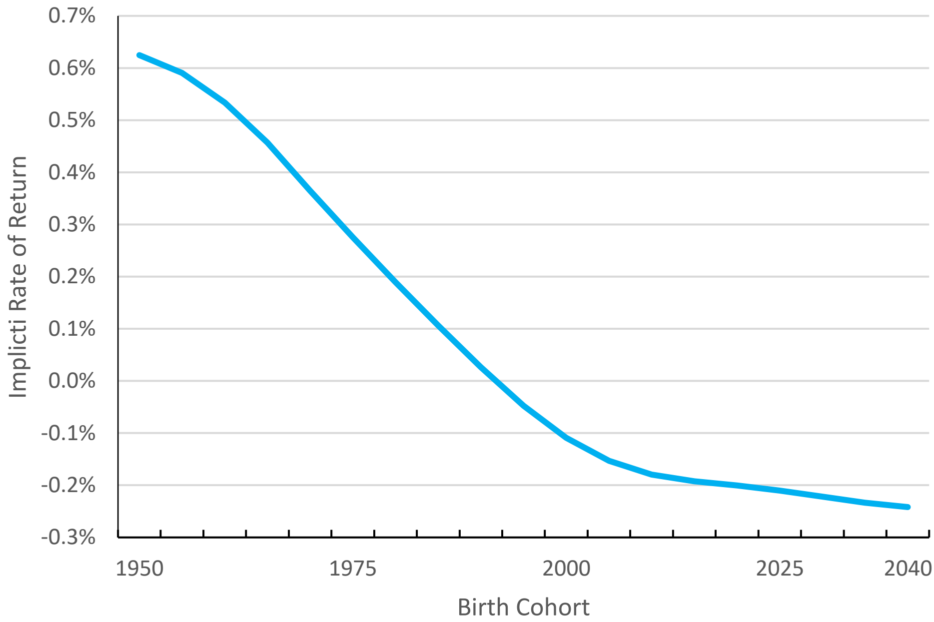

Figure 2: Implicit rate of return for baby boom and subsequent generations 1945-2044
Source: Author

The next section describes simulations that examine the effects of variations in fertility, mortality, and immigration on the implicit rate of return for the 1990-1994 to 2080-84 birth cohorts.

Simulation

Simulation for the effect of fertility, mortality, and immigration on the implicit rate of return uses projections from 2010 to 2170. Simulation starts with 2010 U.S. population, by age and sex, with results reported for both sexes combined. The population is projected 160 years into the future, up to 2170, with varying assumptions about fertility, mortality, and net immigration. Initially, fertility, mortality, and immigration are fixed to provide baseline comparisons for other simulations. For the baseline, total fertility rate is held constant at 2.00, life expectancy at birth is 76.4 years for males and 81.2 years for females, and net immigration of 1,000,000 per year, with age and sex distribution of immigrants during 2010-2015. We can judge result of these assumptions by examining the effect of higher or lower fertility, mortality, and net immigration respectively. As described below, we can use different combinations of assumed fertility, mortality, and net immigration to describe how demographic factors affect the rate of return for unfunded pensions.

Table 1: Population projection for United States, 2010 to 2170
(Population in 1,000s for both sexes combined)

Age	Year								
	2010	2030	2050	2070	2090	2110	2130	2050	2170
All	308746	357296	383718	404251	421872	430399	447478	455995	464275
0-4	20201	21663	22814	23784	24785	25763	26705	27623	28516
5- 9	20349	22052	23019	24002	25032	26009	26471	26922	27360
10-14	20677	22187	22972	24049	25087	26059	26525	26980	27420
15-19	22040	22060	22930	24103	25108	26083	26555	27012	27455
20-24	21586	21765	23216	24360	25322	26317	26792	27250	27696
25-29	21102	22050	23736	24693	25666	26685	27159	27619	28067
30-34	19962	22655	24144	24917	25978	27001	27472	27935	28385
35-39	20180	24091	24111	24964	26115	27102	27573	28039	28491
40-44	20891	23328	23503	24919	26037	26976	27455	27923	28374
45-49	22709	22216	23131	24764	25691	26633	27122	27585	28034
50-54	22298	20324	22890	24310	25048	26061	26546	27001	27448
55-59	19665	19735	23376	23396	24192	25265	25727	26174	26617
60-64	16818	19517	21709	21867	23144	24152	24581	25025	25458
65-69	12435	20012	19582	20362	21762	22558	22973	23408	23821
70-74	9278	18145	16566	18596	19726	20313	20734	21140	21520
75-79	7318	14127	14169	16706	16723	17282	17687	18034	18371
80-84	5743	9786	11319	12552	12641	13366	13686	13956	14234
85+	5493	11583	20530	21907	23814	25074	25714	26370	27007

Note: The population projection applies 2010 age-specific mortality rates for males and females, 2010 age- specific fertility rates, and annual immigration of 1,000,000 persons distributed by age and sex like recently arrived foreign-born persons in the 2015 American Community Survey.
Source: Author

The initial baseline projection shows a population of 394.1 million by 2060, compared to a figure of 420.3 million in the 2017 medium-level projection published by the U.S. Census Bureau (2018) and a figure of 412.4 million in the 2019 medium-variant projection of United Nations (2019). The differences are mainly due to fertility, mortality, and immigration being fixed in the baseline simulation, while the U.S. Census and United Nations projections assume mortality improvement, rising net immigration, and slight decline in total fertility rate.

Fertility

Based on U.S. fertility data by age, we use the following age-specific fertility rates per 1,000 women of reproductive age: 74.5 for 15-19, 107.3 for 20-24, 100.6 for 25-29, 74.5 for 30-34, 37.2 for 35-39, and 6.0 for 40-44 age groups – which corresponds to a total fertility rate of 2.00. We examine rates for five fractions 0.50, 0.75, 1.00, 1.25, and 1.50 times these age-specific fertility rates, which correspond to total fertility rates of 1.00, 1.50, 2.00, 2.50, and 3.00 respectively.

Mortality

We create life tables for different levels of life expectancy at birth (e_0) and life expectancy at age 65 (e_{65}) using Brass relational life table model. We use 2008 U.S. life tables (Arias, 2012) as the standard for creating other life tables, where the number surviving to age x, called l_x^s, is referred to as the standard life table below.

The baseline model for simulation uses an e_0 of 78.8 years for both sexes combined, the e_0 of U.S. population in 2010. Life tables calculated based on a fraction of 2010 death rates imply an e_0 of 85.3 years; for a 0.50 fraction, 82.0 years; for a 0.75 fraction, 76.5 years for a 1.25 fraction; and 74.3 years for a 1.50 fraction. We create four life tables with e_0 ranging from -4.5 and -2.2 years to +3.2 and +6.5 years around the life table with e_0 of 78.8 years. These life tables are created by varying only the intercept value of the two-parameter Brass model life table, which raises or lowers survival at all ages relative to the standard life table but does not alter the slope of the standard life table. The e_0 for males and females and corresponding intercept values used in the Brass life tables are given in table 2.

Table 2: Intercept values of Brass life tables

Fraction of 2010 Age-specific Death Rates	e_0 for Both Sexes Combined	Males		Females	
		e_0	intercept	e_0	intercept
0.50	85.3	82.9	+0.20	87.7	+0.24
0.75	82.0	79.6	+0.08	84.4	+0.10
1.00	78.8	76.4	-0.04	81.2	-0.04
1.25	76.5	74.2	-0.24	79.0	-0.26
1.50	74.3	71.9	-0.46	76.7	-0.52

Source: Author

For the study of variations in life expectancy at age 65, we use the same five life tables discussed above for mortality after age 65, holding mortality below age 65 at the same level used for a life table with the medium level of $e_0 = 78.8$.

Immigration

The number of net immigrants is set 1.0 million per year in the baseline. The simulations range from 0.50, to 0.75, 1.25, and 1.50 times 1.0 million – or 500,000, 750,000, 1,250,000, and 1,500,000 per year respectively. A zero-immigration assumption is also introduced to examine stationary and stable populations. The U.S. Census Bureau has collected census-type data in recent years through American Community Survey. We use data from this survey to obtain age and sex information on recently arrived immigrants.

Demographic Effects

Variation in Fertility

The column (3) of Table 3 – labelled 1.00 for the fraction of 2010 age-specific fertility rates, which implies a total fertility rate of 2.00 – shows the rate of return if birth and death rates are the same as in 2010 and the annual net immigration is 1.00 million. The 1990-1994 birth cohort will have a 0 percent rate of return in their contributions. This is a birth cohort that will contribute to the pension scheme between 2010 and 2055. Later birth cohorts up to the latter part of the 21st century will have progressively larger negative returns.

The baby boom explains these negative returns. Larger cohorts share payments for the old among more people, so individuals pay less than if the cohort is small. If contributors receive a given subsequent pension regardless of their numbers (that is, if the tax rates are subsequently raised proportionally as the number of payers decreases), then larger cohorts gain and smaller cohorts suffer.

Table 3: Rate of return on unfunded pension contributions for successive birth cohorts, for five levels of fertility.

Birth cohort	Fraction of 2010 age-specific fertility rates				
	0.50	0.75	1.00	1.25	1.50
	Rate of return (percent)				
	(1)	(2)	(3)	(4)	(5)
1990-1994	-0.24	-0.17	0.00	-0.05	-0.03
2000-2004	-0.48	-0.33	-0.14	-0.11	-0.02
2010-2014	-0.72	-0.44	-0.21	-0.06	0.09
2020-2024	-0.88	-0.52	-0.23	0.01	0.21
2030-2034	-0.98	-0.58	-0.25	0.05	0.29
2040-2044	-1.02	-0.61	-0.26	0.07	0.35
2050-2054	-1.01	-0.61	-0.27	0.08	0.37
2060-2064	-0.95	-0.60	-0.27	0.07	0.36
2070-2074	-0.90	-0.59	-0.27	0.07	0.36
2080-2084	-0.88	-0.59	-0.28	0.07	0.36
Implied TFR	1.00	1.50	2.00	2.50	3.00

Source: Author

Other columns of Table 3 show the effect of lower or higher birth rates relative to that prevailed in 2010. If future birth rate decreases to half of the birth rate in 2010, then the negative annual rates of return increase to over 1 percent (column 1) by 2040-44. The increase in the negative rate of return will be less if future birth rate decreases to 0.75 times the birth rate in 2010. On the other hand, a 25 percent rise in the birth rate, which implies a total fertility rate of 2.50 and an annual rate of natural increase of about 0.5 percent, would provide all 2020-2024 and later birth cohorts with positive rate of return (column 4). A 50 percent increase in the birth rate, which implies a total fertility rate of 3.0 will lead to an increase in the annual rate of natural increase of slightly over 1 percent. This would lead to the rate of return of more than 0.3 percent for 2010-2014 cohorts (column 5).

Variation in Mortality

In contrast to the noticeable effect of variation in fertility, variation in mortality makes less of a difference. Table 4 shows negative returns for all birth cohorts for all levels of mortality, except for death rates that are one-half 2010 levels (implying a life expectancy at birth of 73.8 years, or 5.0 years less than the 2010 level). The 2040-2044 cohort would have a return of -0.01 percent if mortality is one-half of 2010 level, and -0.59 percent if mortality is 50 percent higher than~~t~~ 2010 level. The differences in mortality underlying these results are very large: the former corresponds to an expectation of life at birth of 85.3 years, and the latter to only 74.3 years. Recent annual life expectancy gains have averaged 1.9 per decade, and a reduction in mortality by one-half roughly corresponds to mortality improvements that might be expected over the next 35 years. One might be puzzled that such large differences in mortality rates have relatively smaller effects. In fact, mortality changes/differences produce offsetting effects: the contributor who suffers because their elders live longer also benefits themselves by drawing a pension for a longer period.

Table 4. Rate of return on unfunded pension contributions for successive birth cohorts for five levels of mortality, United States, fixed pension

Birth cohort	Fraction of 2010 age-specific death rates				
	0.50	0.75	1.00	1.25	1.50
	Rate of return (percent)				
	(1)	(2)	(3)	(4)	(5)
1990-1994	0.16	0.08	0.00	-0.12	-0.25
2000-2004	0.06	-0.04	-0.14	-0.29	-0.45
2010-2014	0.02	-0.10	-0.21	-0.38	-0.57
2020-2024	0.01	-0.11	-0.23	-0.42	-0.63
2030-2034	0.00	-0.12	-0.25	-0.45	-0.67
2040-2044	-0.01	-0.14	-0.26	-0.47	-0.70
2050-2054	-0.01	-0.14	-0.27	-0.47	-0.71
2060-2064	-0.01	-0.14	-0.27	-0.48	-0.72
2070-2074	-0.01	-0.14	-0.27	-0.48	-0.73
2080-2084	-0.01	-0.15	-0.28	-0.49	-0.74
Implied e_0	85.3	82.0	78.8	76.5	74.3

Source: Author

One might also be surprised that these differences are all in a consistent direction: returns are better when mortality is lower. While more favourable mortality increases the cost to those currently paying from the moment when mortality improves, it also increases even more the total return that they will eventually receive. Moreover, lower mortality, other conditions being equal, creates more rapid population growth which helps unfunded pension programs.

What about mortality at the oldest ages, supposing that mortality at ages under 65 years does not change? One may think that mortality changes only for the old population would make a great difference. As shown in Table 5, however, in old age mortality alone are less influential than variation in mortality at all ages. The difference between an expectation of life at age 65 of 22.9 years and of 16.9 (the difference between the first and last columns of Table 5) leads to rate of return ranging from -0.10 to -0.65 percent for the 2080-2084 birth cohort and even less for earlier cohorts.

These results suggest that enabling people to live longer does not make unfunded pension schemes greatly worse. Rather, a much greater problem is a declining birth rate. If people live longer after age 65, it means that contributors will need to pay more, but they will be eventually compensated by obtaining more when they become old.

Table 5: Rate of return on unfunded pension contributions for successive birth cohorts, for five levels of mortality above 65 years of age, U.S. population, fixed pension

Birth cohort	Fraction of 2010 age-specific death rates at age 65 and above				
	0.50	0.75	1.00	1.25	1.50
	Rate of return (percent)				
	(1)	(2)	(3)	(4)	(5)
1990-1994	0.12	0.06	0.00	-0.09	-0.20
2000-2004	0.00	-0.07	-0.14	-0.26	-0.39
2010-2014	-0.05	-0.13	-0.21	-0.34	-0.50
2020-2024	-0.07	-0.15	-0.23	-0.37	-0.55
2030-2034	-0.08	-0.16	-0.25	-0.40	-0.59
2040-2044	-0.09	-0.17	-0.26	-0.42	-0.62
2050-2054	-0.09	-0.18	-0.27	-0.42	-0.63
2060-2064	-0.10	-0.18	-0.27	-0.43	-0.64
2070-2074	-0.10	-0.18	-0.27	-0.43	-0.65
2080-2084	-0.10	-0.18	-0.28	-0.44	-0.65
Implied e_{65}	22.9	20.8	19.0	18.0	16.9

Source: Author

Variation in Net Immigration

Net immigration also makes only a small difference to rate of return (Table 6). With annual net immigration of 0.5 million (one-half of the baseline level), the rate of return to the 1990-1994 cohort are -0.13 percent, compared to -0.07 if there were 1.5 million net immigrants, or four times the base level. The effect is not strong enough that, by itself, would recommend fewer or more immigrants. The effects of immigration, when viewed over a lifetime, are modest because immigrants not only contribute over their working years but also subsequently draw benefits when they are old. Increased immigration has only a temporary benefit for the initial years after arrival, while the longer-term generational effect on returns is modest. Differences in the effect of immigration diminish slightly for later birth cohorts, with modest differences in the rate of return for the 2080-84 birth cohort.

Further Comparisons of Fertility and Immigration

Table 7 shows the same range of net immigration as in Table 6 but calculates the rate of return based on a fixed absolute number of 4.2 million annual births instead of using fixed age-specific birth rates. This produces immediate birth stationarity, in comparison to a stable age distribution that would be obtained by fixed age-specific birth rates only after the cohorts who were born before the commencement of fixed rates have died. The effect of a fixed number of births is obvious. For all immigration assumptions except zero immigration, the effects become increasingly negative. With heavy immigration of 1.5 million (shown in column (5)), along with fixed annual births of 4.2 million, the annual rate of return eventually stabilizes at –0.39 percent. If there were modest immigration of 0.5 million, the annual rate of return stabilizes at -0.34 percent and as shown in the first column, assumption of zero net immigration implies a long-term rate of return of 0 percent.

Table 6: Rate of return on unfunded pension contributions for successive birth cohorts, for five levels of immigration, U.S. population, fixed pension

Birth cohort	Fraction of 1,000,000 immigrants per year				
	0.50	0.75	1.00	1.25	1.50
	Rate of return (percent)				
	(1)	(2)	(3)	(4)	(5)
1990-1994	-0.13	-0.12	0.00	-0.09	-0.07
2000-2004	-0.25	-0.23	-0.14	-0.19	-0.18
2010-2014	-0.27	-0.25	-0.21	-0.21	-0.20
2020-2024	-0.27	-0.25	-0.23	-0.22	-0.20
2030-2034	-0.27	-0.26	-0.25	-0.23	-0.21
2040-2044	-0.28	-0.26	-0.26	-0.24	-0.22
2050-2054	-0.28	-0.26	-0.27	-0.24	-0.23
2060-2064	-0.28	-0.26	-0.27	-0.24	-0.23
2070-2074	-0.28	-0.26	-0.27	-0.24	-0.23
2080-2084	-0.28	-0.26	-0.28	-0.24	-0.23
Immigration (000)	500	750	1,000	1,250	1,500

Source: Author

Table 8 is similar to Table 7, but it varies the number of births rather than the number of immigrants. Comparing Tables 8 and 7 shows how much difference is due to the effect of births. Initially, the effect of births is greater than immigration for earlier birth cohorts. After the rate of return stabilizes, however, there is only a modest difference in the rate of return for either births or immigration.

Table 7: Rate of return on unfunded pension contributions for successive birth cohorts, for five levels of immigration and births fixed at 4.2 million per year, 2010 U.S. population, fixed pension.

Birth Cohort	Fraction of 1,000,000 Immigrants per Year				
	0.50	0.75	1.00	1.25	1.50
	Rate of return (percent)				
	(1)	(2)	(3)	(4)	(5)
1990-1994	-0.03	-0.02	0.00	0.02	0.03
2000-2004	-0.18	-0.16	-0.15	-0.13	-0.11
2010-2014	-0.26	-0.24	-0.23	-0.21	-0.19
2020-2024	-0.28	-0.27	-0.26	-0.25	-0.24
2030-2034	-0.30	-0.30	-0.30	-0.29	-0.29
2040-2044	-0.32	-0.32	-0.33	-0.33	-0.33
2050-2054	-0.32	-0.33	-0.34	-0.35	-0.36
2060-2064	-0.33	-0.34	-0.36	-0.37	-0.38
2070-2074	-0.33	-0.35	-0.36	-0.38	-0.39
2080-2084	-0.34	-0.35	-0.37	-0.38	-0.39
Immigration (1,000s)	500	750	1,000	1,250	1,500

Source: Author

Table 8: Rate of return on unfunded pension contributions for successive birth cohorts, for five levels of births with immigration of 1000000 persons per year, U.S. population, fixed pension

Birth Cohort	Thousands of Annual Births				
	3,200	3,700	4,200	4,700	5,200
	Rate of return (percent)				
	(1)	(2)	(3)	(4)	(5)
1990-1994	-0.04	-0.02	0.00	0.02	0.03
2000-2004	-0.23	-0.18	-0.15	-0.11	-0.08
2010-2014	-0.36	-0.29	-0.23	-0.17	-0.11
2020-2024	-0.45	-0.35	-0.26	-0.18	-0.11
2030-2034	-0.50	-0.39	-0.30	-0.21	-0.13
2040-2044	-0.51	-0.41	-0.33	-0.25	-0.18
2050-2054	-0.49	-0.41	-0.34	-0.28	-0.23
2060-2064	-0.45	-0.40	-0.36	-0.32	-0.29
2070-2074	-0.42	-0.39	-0.36	-0.34	-0.33
2080-2084	-0.40	-0.38	-0.37	-0.35	-0.34

Source: Author

Stationary and Stable Populations

Column (1) of Table 8 – with 500,000 net immigrants, the 2010 life table, and 4.2 million births each year – has special interest because it almost produces a stationary population. If mortality rates and replacement-level fertility is fixed and immigration is zero then it leads to a stationary population, the exchange feature of a pay-as-you-go pension scheme becomes clearer because there is no way for it to be either negative or positive in the long run – assuming only demographic factors. Thus, the rate of return stabilizes (as expected) at a level close to zero for a stationary population.

Table 9 shows the effect of stationarity in its pure form. It presents results for zero immigration, 2010 mortality, and different levels of a fixed annual number of births that lead ultimately to stationary population. As stationarity implies, the rate of return ultimately becomes zero irrespective of the level of fertility, starting with the cohort of 2050-2054, which is the first cohort to enter the pension scheme after the last unstable cohort passes through retirement.

Table 9: Rate of return on unfunded pension contributions for successive birth cohorts, for five levels of births, with zero immigration that leads to a stationary population, 2010 U.S. population, fixed pension

Birth Cohort	Thousands of Annual Births				
	3,200	3,700	4,200	4,700	5,200
	Rate of return (percent)				
	(1)	(2)	(3)	(4)	(5)
1990-1994	-0.12	-0.09	-0.07	-0.05	-0.03
2000-2004	-0.10	-0.08	-0.06	-0.04	-0.03
2010-2014	-0.08	-0.07	-0.05	-0.03	-0.02
2020-2024	-0.05	-0.04	-0.03	-0.02	-0.01
2030-2034	-0.03	-0.03	-0.02	-0.01	-0.01
2040-2044	-0.02	-0.01	-0.01	-0.01	0.00
2050-2054	0.00	0.00	0.00	0.00	0.00
2060-2064	0.00	0.00	0.00	0.00	0.00
2070-2074	0.00	0.00	0.00	0.00	0.00
2080-2084	0.00	0.00	0.00	0.00	0.00
Ultimate stationary population size (million)	258.8	299.0	339.2	379.4	419.6

Source: Author

Table 10 repeats in its zero percent column the column (3) of Table 9. Table 10 shows calculations based on the assumption that absolute number of births increases exponentially, ranging from annual rate of -2 and -1 percent to +1 and +2 percent. This is a quick way to generate a stable population from an arbitrary initial age distribution. In Table 10, the annual rate of change in births is reproduced in the rate of interest by participants in the scheme after 85 years, when the initial birth cohort has passed away. After about 85 years, the implicit rate of return is the same as the assumed annual rate of change in the number of births.

The general proposition regarding Table 10 is that a population increasing at *r* percent per year and arraying its pensions on a pay-as-you-go basis, will return to its participants an effective rate of real interest of *r* percent. Table 9 shows results for $r=0$ and table 10 illustrates results for a range of values of *r*. The formal statement for the expression for the premium of a scheme at rate of interest *r* is

$$\int_{\beta}^{\omega} e^{-rx} l(x) dx \Big/ \int_{\alpha}^{\beta} e^{-rx} l(x) dx$$

and this is identical to the ratio of the population over age β to that from α to β if the stable growth rate is *r*, as noted earlier in equation (1).

The results in Table 10 provide an explanation for the decrease in the rate of return shown in Figure 1. Higher fertility levels associated with a growing population produce higher rates of return. As fertility decreased in the U.S. population, population growth declined and the rates of return diminished. With relatively low fertility and moderate immigration, the implicit rates of return will remain negative.

Table 10: Rate of return on unfunded pension contributions for successive birth cohorts, with number of births Increasing from 4.2 million in 2010 at five different rates, with zero immigration that leads to stable populations, U.S. population, fixed pension

Birth Cohort	Annual increase (percent) in births from 4.2 million in 2010				
	-2	-1	0	+1	+2
	Rate of return (percent)				
	(1)	(2)	(3)	(4)	(5)
1990-1994	-0.09	-0.08	-0.07	-0.06	-0.05
2000-2004	-0.47	-0.34	-0.06	-0.03	-0.02
2010-2014	-0.71	-0.48	-0.05	0.01	0.03
2020-2024	-0.95	-0.58	-0.03	0.14	0.28
2030-2034	-1.23	-0.69	-0.02	0.34	0.68
2040-2044	-1.51	-0.80	-0.01	0.56	1.11
2050-2054	-1.74	-0.89	0.00	0.77	1.54
2060-2064	-1.89	-0.96	0.00	0.92	1.83
2070-2074	-1.97	-0.99	0.00	0.98	1.96
2080-2084	-2.00	-1.00	0.00	1.00	2.00

Source: Author

Discussion and Conclusion

This paper uses the metric of implicit rate of interest to study unfunded pensions under various demographic conditions. We make no attempt to examine the effect of economic growth. A growing economy helps a pension scheme as much as does a growing population. In the calculations here, we take people rather than the goods and services supplied to people, as our unit for study, and calculations are limited to demographic factors. The proper interpretation for these results is that they represent pure demographic effects, which would be superimposed on economic growth.

This study analyses effects of fertility, mortality, and immigration on the returns of an unfunded pension scheme. It illustrates the marked extent to which future fertility is more likely to be important for the rate of return that individuals will realise on their premiums than either mortality or immigration. There are several topics of interest that are not discussed in this paper. Two other effects that are worth studying are variation in labour force participation and age at retirement. This paper focusses solely on given benefits, which is the most common form of pay-as-you-go pension schemes. It would be useful to examine a fixed contribution approach in future research.

We also note a basic point concerning the equity between generations. Pay-as-you-go schemes not only redistribute income over a cohort's lifetime but also, in most cases by design, from better-off to the poor people. They also redistribute it – sometimes in a less equitable fashion – between generations. Keyfitz (1980) presents a cogent demographic critique of unfunded pension systems based on intergenerational equity issues, as well as recommending better public pension alternatives. In a fixed benefit scheme, income is redistributed from the members of smaller cohorts to the members of larger cohorts. In a fixed contribution scheme, the redistribution goes in the opposite direction. With either type of scheme, some cohorts will experience negative rates of return on their contributions.

Under the fixed benefit scheme that exists in the United States, most of those born before 2000 are likely to experience positive rates of return, as calculated from a purely demographic basis, but cohorts born after 2000 will probably experience negative rates. The rise of premium needed as the baby boom birth cohorts enter retirement ages, together with the prospect of negative returns, will put considerable additional stress on the public pension scheme. The present underlying challenges of such schemes, however, are not necessarily from demographic factors alone but also from the fact that the public unrealistically expects the relatively high returns to continue without change and the lack of political will to make/bring changes in existing public pension systems.

For developing countries such as India, the general implications of this paper are similar to those of the United States - pay-as-you-go unfunded pension schemes have inherent equity issues because the size of birth cohorts vary over time. Unlike the United States, however, where public pension covers most residents and has been in place for more than 85 years, public pension systems in many developing countries do not often cover all residents and are either new or, in some countries, do not yet exist. This means that changes to the public pension systems in developing countries may not involve such massive changes, as are required for reforms in U.S. public pension system. Keyfitz (1980) provides a useful discussion of public policy options for reforming unfunded pension systems. Although, Keyfitz (1980) focuses on the U.S. system, his discussion considers options for reform that are relevant for the study of unfunded public pension systems in developing countries.

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Duration of Post-partum Amenorrhoea: A Model-based Approach

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Abstract

This paper develops a model to examine the distribution of the duration of post-partum amenorrhoea based on extreme value distributions. The applicability of the model is examined using data from India's National Family Health Survey 2005-06.

Introduction

Every woman, following the childbirth, goes through a temporary period of infecundability which is referred to as the period of post-partum amenorrhoea (PPA). During this period, the woman does not ovulate and, therefore, is not susceptible to conception. The duration of PPA period is a significant determinant of birth interval in societies in the absence of the practice of contraception and, therefore, influences the level of fertility. There are many factors that determine the duration of PPA. The main determinant is breastfeeding. The duration and the nature of breastfeeding is directly related to the duration of PPA (Perez et al, 1971; 1972; Srinivasan et al, 1989; Nath et al, 1993; Singh et al, 1994). The duration of PPA is also influenced by weaning and the death of child which results in either reduction in the frequency or stopping of breastfeeding. The nutritional and health status of the woman also influences the duration of PPA. Under nutrition affects woman's reproductive health and causes a delay in resuming the menstrual cycles. An undernourished woman produces reduced quantity of breast milk and, therefore, the child suckles more intensely and frequently to get adequate milk which results in increasing the inhibition of ovulatory hormones (Jones, 1989; Jones, 1990). Because of these and many other factors, the duration of PPA varies widely across women. There are studies to suggest that the distribution of the duration of PPA is bimodal with the first mode at around 3-4 months and the second mode at around 12-14 months in a developing country like India depending upon the duration of breastfeeding. When the breastfeeding is not initiated or when breastfeeding is stopped because of the death of the child, the duration of PPA is short. However, prolonged breastfeeding results in extended duration of PPA. Cleland et al (1984) have shown that, in the developing countries, the duration of PPA has a strong impact on the level of fertility. The length of PPA is, therefore, one of the proximate determinants of fertility (Bongaarts, 1978).

In India, breastfeeding is nearly universal. Therefore, the duration of PPA is quite long (Ramchandran, 1987; Srinivasan et al, 1989; Nath et al, 1993; Singh et al, 1994). In rural areas, it is one of the important factors in deciding the birth interval. The relationship between the duration of PPA and the duration of breastfeeding has been extensively studied (Habicht et al, 1984; Singh and Singh, 1989; Singh et al, 1990; Nath et al, 1994; Singh et al, 1994; Mukharjee et al, 1994; Singh et al, 1999).These studies suggest that the relationship between the duration of breastfeeding and the duration of PPA is not direct because the duration of PPA is also influenced by many other factors (Frisch, 1978; Huffman et al, 1987).

The information related to the duration of PPA is usually collected through household surveys like National Family Health Survey (NFHS) in India or Demographic and Health Survey (DHS) in other countries of the world. There are studies to suggest that data regarding the duration of PPA available through these surveys are generally of poor quality as women do not remember the exact time of the return of menstruation after their last birth. Moreover, information about the duration of PPA is recorded in completed months so that it is found that these data suffer from age heaping usually at months 3,6,9 and 12 (Singh et al, 1994). The duration of PPA, however, is a continuous variable. At the same time, substantial variation in the duration of PPA has been observed among populations despite nearly universal breastfeeding pattern (Singh et al, 1999).

In view of the limitations of household survey-based approach of establishing the distribution of the duration of PPA in contemporary populations, model-based approaches have been evolved to estimate the duration of PPA in the context of fertility-related research. Efforts, in this direction, have been made by Barrette (1969), Lesthaeghe and Page (1980) and Potter and Kobrin's (1981). Barrette has used modified Pascal distribution; Lesthaeghe and Page have used logit model while Potter and Kobrin have used mixed geometric negative binomial model to characterise the distribution of the duration or length of PPA. Ford and Kim (1987) have used a mixture of two extreme value distributions to model the distribution of the duration of PPA in the presence of censored cases. The applicability of these models has generally been examined through data obtained from prospective studies. In all these studies, the duration of PPA is treated as a discrete variable.

In the present paper, we model the distribution of the duration of PPA under the assumption that the duration of PPA is a continuous variable. Moreover, we test the applicability of the model based on the retrospective data available from a large-scale household survey. The paper is organized as follows. The next section of the paper describes the model that characterises the bimodal nature of the distribution of the duration of PPA. Section three of the paper describes the source of data that has been used to apply the model. We have used the data available from India's National Family Health Survey 2005-06. Results of fitting the model to the real time data are presented in the fourth section of the paper. The last section of the paper discusses the nature of the distribution of the duration of PPA in India and its policy and programme implications.

The Model

We have used type I extreme value distribution or Gumbel distribution (Jhonson and Kotz, 1970) to model the duration of PPA in the present study. The Gumbel distribution, named after the pioneer German mathematician Emil J. Gumbel (1891-1966), has been extensively used in various fields including hydrology for modelling extreme events. Nath and Talukdar (1992) have used type I extreme value model to describe the pattern of woman age at marriage in a traditional society in India in which women marry at an early age and where all births occur within the institution of marriage. Singh and Dixit (2017) have used this distribution for modelling age at first birth. The distribution and density function of the extreme value distribution can be given as follows

$$F(x) = \exp\left(-\exp\left(-\frac{(x-M)}{\theta}\right)\right) \tag{1}$$

$$f(x) = \frac{1}{\theta}\exp\left(-\frac{x-M}{\theta} - \exp\left(-\frac{(x-M)}{\theta}\right)\right) \tag{2}$$

In the above model M is the mode and is termed as the location parameter while θ is the scale parameter. The model used here incorporates both unimodal and bimodal behaviour of the distribution of the duration of PPA by using a mixing parameter α, which ranges between 0 and 1. The mixture distribution can be written as

$$f(x) = \alpha f_1(x) + (1-\alpha) f_2(x) \tag{3}$$

where $f_1(x)$ is the first extreme value distribution and $f_2(x)$ is the second extreme value distribution. The desired density function is now given by

$$\begin{aligned} f(x)_m = {} & \frac{\alpha}{\theta_1}\exp\left(-\frac{(x-M_1)}{\theta_1} - \exp\left(-\frac{(x-M_1)}{\theta_1}\right)\right) \\ & + \frac{\left((1-\alpha)\right)}{\theta_2}\exp\left(-\frac{(x-M_2)}{\theta_2} - \exp\left(-\frac{(x-M_2)}{\theta_2}\right)\right) \end{aligned} \tag{4}$$

and the mixture distribution can be expressed as:

$$F(x)_m = \alpha\exp\left(-\exp\left(-\frac{x-M_1}{\theta_1}\right)\right) + (1-\alpha)\exp\left(-\exp\left(-\frac{x-M_2}{\theta_2}\right)\right) \tag{5}$$

The mixing parameter α of the model reflects the proportion of those women with short duration PPA so that 1-α reflects the proportion of women with prolonged duration of PPA. The mean and variance of women having short duration PPA and mean and variance of women having long duration PPA can be described by the set of parameters (M_1, θ_1) and (M_2, θ_2).The relationship between mode (M) and mean (μ) of type I extreme value distribution can be described as:

$\mu = M + \theta\gamma$

Where γ, approximately equal to 0.5772, is known as the Euler-Mascheroni constant (Singh and Dixit, 2017). Since M and $\theta$are positive, mean (μ) of the distribution is always more than the mode (M) which means that the distribution of the duration of PPA is always positively skewed.

The model has five parameters which need to be estimated. We have used non-linear minimisation procedure to estimate the parameters of the model. This procedure minimises the following quantity:

$$SS_F = \sum_x \left(S_x - \left(1 - F(x)\right)\right)^2 \tag{6}$$

where S_x is the life table survival function, while $F(x)$ is the distribution function of the mixture model. The proposed model can also incorporate censored data (Ford and Kim, 1987), but we consider here complete observations only.

Application

We apply the above model to the data available from India's National Family Health Survey-3 (NFHS-3) 2005-06for five states – Kerala, Andhra Pradesh, Maharashtra, Uttar Pradesh, and West Bengal (Government of India, 2007). The data pertain to the duration of PPA reported by ever-married women aged 15-49 years at their last but one birth. Any missing or conflicting data have been excluded from the analysis. An exploratory data analysis was carried out to identify and exclude outliers and extreme values in the data before fitting the model.

Table 1: Summary statistics of the distribution of the duration of PPA in five states.

State	Percentage of women with duration of PPA (months) less than				Mean	Median	SD
	3	6	9	12			
Kerala	53.0	76.2	89.3	95.8	4.88	3.00	3.86
Andhra Pradesh	43.5	73.8	87.2	97.2	5.17	4.00	3.66
Maharashtra	40.3	62.1	74.0	94.4	5.14	5.00	4.50
Uttar Pradesh	50.6	65.7	73.4	93.8	5.28	3.00	5.04
West Bengal	53.4	73.3	81.2	94.2	5.16	3.00	4.56

Source: Authors' calculation

Table 1 gives the distribution of the ever-married women by the duration of PPA in five states. The mean duration of PPA is higher than the median duration of PPA in all the five states which indicates that the distribution of the duration of PPA in all states is positively skewed. Among different states, the mean duration of PPA is estimated to be the longest in Uttar Pradesh, but the shortest in Kerala. However, the median duration of PPA is estimated to be the longest in Maharashtra. Table 1 also suggests that in all states, less than 5 per cent ever-married women had a PPA of at least 12 months. In all state, majority of the ever-married women had at the most 3 months of PPA. This proportion was around 53 per cent in West Bengal and Kerala but only about 40 per cent in Maharashtra. Kerala is the only state where the distribution of the duration of PPA is found to be unimodal. In rest of the states, the distribution of the duration of PPA is found to be bimodal.

Table 2 gives estimates of the parameters of the model for the five states. In states where the distribution of the duration of PPA is bimodal, the second mode, as revealed by parametersM_2, is around 8-10 months. The mean duration of PPA, estimated based on the model, is found to be the close approximation of the mean duration of PPA obtained directly from the data. This suggests that the model fits the observed distribution of the duration of PPA very well. In fact, the difference between the observed mean duration of PPA and the mean duration of PPA estimated from the model is found to be statistically insignificant in all the five states.

Table 2: Estimates of the parameters of the model

PPA Pattern	States	Parameters					Duration of PPA	
		M_1	θ_1	M_2	θ_2	α	Mean	SD
Unimodal	Kerala	2.65	4.04	-	-	-	4.98	5.18
Bimodal	Andhra Pradesh	2.15	1.80	7.82	3.88	0.71	5.18	3.08
	Maharashtra	1.39	1.29	7.66	4.03	0.65	4.88	2.88
	Uttar Pradesh	0.35	1.79	10.34	2.69	0.66	4.96	2.69
	West Bengal	0.58	2.60	8.92	5.45	0.66	5.48	4.58

Source: Authors' calculation

It may also be seen from table 2 that the first mode of the distribution of the duration of PPA is the lowest in Uttar Pradesh and very low in West Bengal. This implies that the duration of PPA in a substantial proportion of women in these states is too short to have a regulating effect on fertility.

Empirical and fitted distribution of the duration of PPA five states are given in figures 1 through 5. In Kerala, the distribution has single mode at around 3 months and a mean duration of around 5 months. The distribution is positively skewed. In Andhra Pradesh, on the other hand, the distribution is bimodal with estimated modes at around 2 and 8 months but the distribution remains positively skewed (Figure 2).

Figure 3 shows the distribution of the duration of PPA in Maharashtra. There are also two modes in the distribution at around 1and 8 months respectively. The estimated mean duration of PPA is more than 5 months. In Uttar Pradesh, the first mode of the distribution of the duration of PPA is at 0.35 months only so that the mean duration PPA is very low despite the second mode at more than 10 months. The median duration of PPA in the state is 3 months.

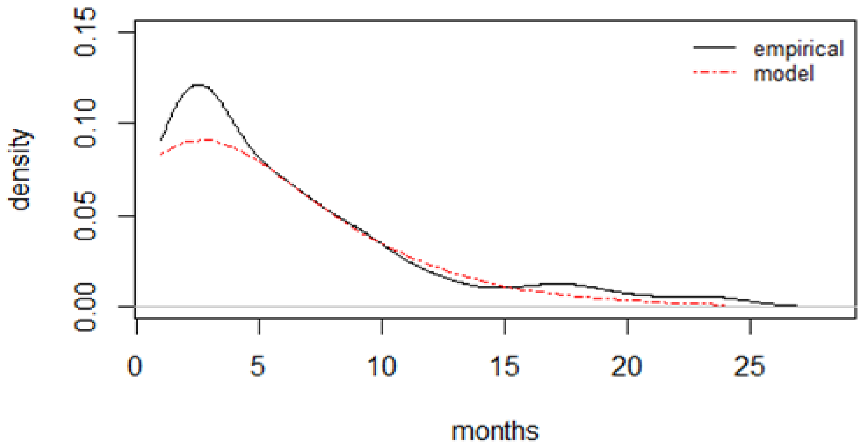

Figure 3: Empirical density and model estimates for Kerala
Source: Authors

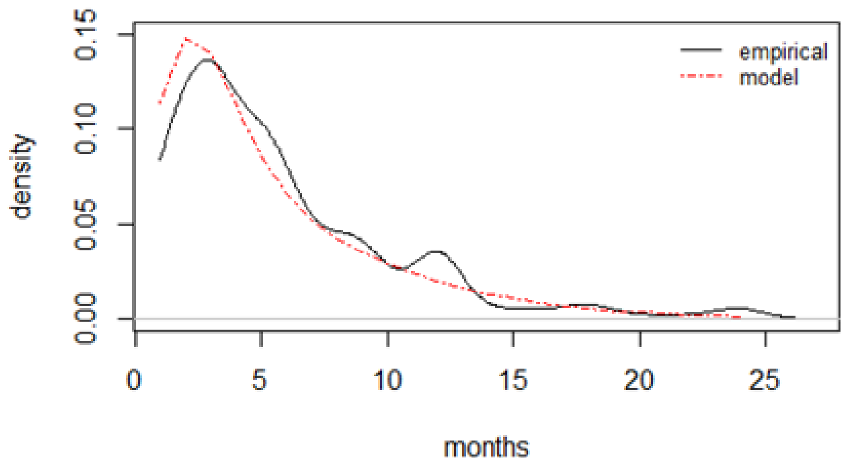

Figure 2: Empirical density and model estimates for Andhra Pradesh
Source: Authors

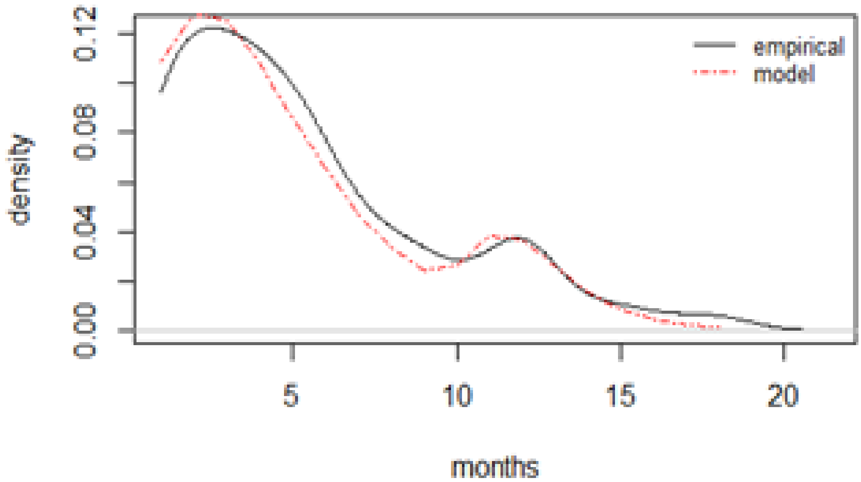

Figure 3: Empirical density and model estimates for Maharashtra
Source: Authors

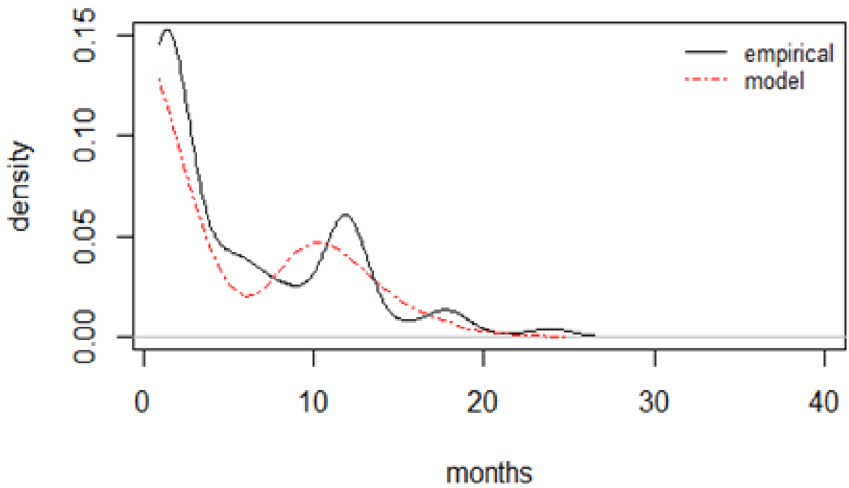

Figure 4: Empirical density and model estimates for Uttar Pradesh
Source: Authors

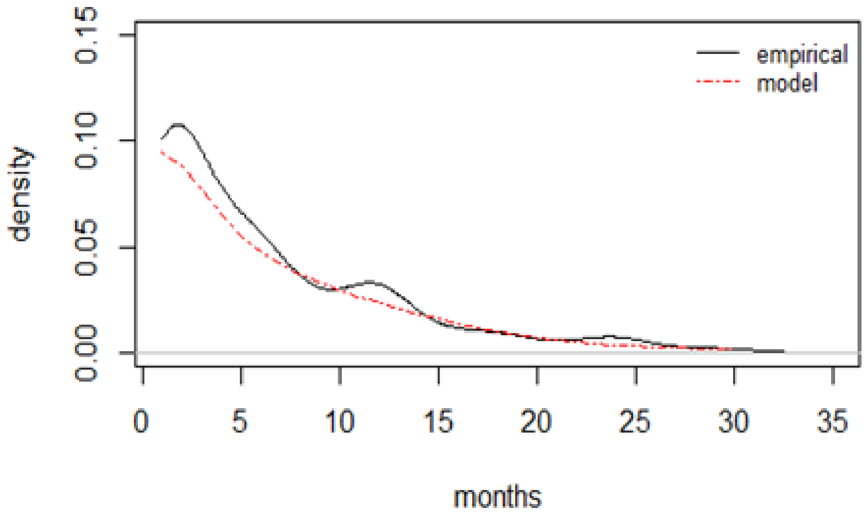

Figure 5: Empirical density and model estimates for West Bengal
Source: Authors

The fitting of the model reveals interesting differences in the distribution of the duration of PPA across five states. First, the distribution is unimodal in Kerala but bimodal in the remaining four states. Second, the first model value is the highest in Kerala but the lowest in Uttar Pradesh. Third, the second modal value of the distribution is the highest in Uttar Pradesh among the four states but the lowest in Maharashtra. These variations in the parameters of the model across the five states suggest that factors influencing the duration of PPA are essentially different in different states. For example, women in four states other than Kerala can be divided into two groups, one having short duration PPA and the other having long duration PPA. It would be interesting to explore the distinguishing characteristics of the two groups of women. Similarly, it would be illustrating to examine the fertility impact of the duration of PPA in women belonging to two groups.

Conclusion

This study has attempted to fit a mixture of two extreme value distributions to model the distribution of the duration of PPA in selected states of India as the available evidence suggests that the distribution of the duration of PPA may be unimodal as well as bimodal. Our modelling exercise confirms that the distribution of the duration of PPA in most of the states of India is bimodal with the only exception of Kerala where this distribution is unimodal. The paper also reveals that in majority of women, the duration of PPA is short which means that the impact of PPA on fertility is not substantial, although there are women in all states having long duration PPA. The paper suggests the need of analysing the distinguishing characteristics of women having short duration PPA and women having long duration PPA in different states of the country.

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Discussing Population Concepts: Overpopulation is a Necessary Word and an Inconvenient Truth

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Abstract

In science, in the media, and in international communication by organizations such as the United Nations, the term 'overpopulation' is rarely used. Here, we argue that it is an accurate description of our current reality, well backed up by scientific evidence. While the threshold defining human overpopulation will always be contested, overpopulation unequivocally exists where 1) people are displacing wild species so thoroughly, either locally or globally, that they are helping create a global mass extinction event; and where 2) people are so thoroughly degrading ecosystems that provide essential environmental services, that future human generations are likely to have a hard time living decent lives. These conditions exist today in most countries in the world, and in the whole world. Humanity's inability to recognise the role population growth has played in creating our environmental problems and the role population decrease could play in helping us solve them is a tremendous brake on environmental progress. While reducing excessive populations is not a panacea, it is necessary to create ecologically sustainable societies. We, therefore, recommend use of the concept of overpopulation in scientific publications and in public outreach.

Background

People who work to draw attention to the risks of excessive human populations and to promote family planning to curtail population growth, are often warned not to use the word overpopulation (Gardner, 2014). In one sense, overpopulation just describes humanity's present project: the process of increasing human numbers globally to the detriment of wildlife, our common climate, food security, green urban spaces, and more (Foreman and Carroll, 2014; Crist et al, 2017). But the word can be construed as misanthropic, perhaps not as bad as Thanos in the film *Avenger's: Endgame* (Abegão, 2019), but still somehow hinting at a desire to eliminate surplus people by unethical means. This, of course, is a misrepresentation, but it happens repeatedly. Should we self-censor to be a smaller target for criticism or should we present our honest view that humanity is already overpopulated, and that by denying it we turn our backs on the best options for averting humanitarian and ecological crises?

Science and a Definition

The word 'overpopulation' can be applied to any species which exceeds the carrying capacity of its habitat. For a while, the species might continue to uphold its numbers, but only by running down its 'natural capital', consuming the critical resources faster than they can regenerate and disrupting the balance that sustains each year's bounty. Ultimately, the degraded habitat will no longer support such numbers and the population collapses locally. But people are clever in modifying environments to support more people. They can use technology to get more goods and services from the same resources. People can also gather and trade resources over vast distances – a major difference compared to other species. This has led to lengthy discussions about the question "How many people can the Earth support?" (Cohen, 1995). The answer depends upon value judgements, such as what quality of life we want people to have and how much we value preserving wild places where other species can thrive (Wilson, 2017). They also depend upon what technologies we might conceivably draw upon in the future. Maximum and optimum population sizes are likely to differ substantially (Lianos and Pseiridis, 2016; Derer 2018a; Tucker, 2019).

All of this creates a large grey area, with room for disagreement about what constitutes overpopulation. The Global Footprint Network (GFN), for example, defines "overshoot" by contrasting a national population's overall consumption with its country's total biocapacity (www.footprintnetwork.org). This definition assumes perfect substitutability between different biocapacities, and an entitlement for humans to consume it all (a country could be sustainable, according to the GFN's criteria, even if it had no national parks and exterminated all its native wildlife). But even such selfish calculations, grounded on human species only, imply that we would need 1.75 planet Earths to sustain our current behaviours. In theory, humanity could retreat from this excess purely by consuming less and improving technology, without stemming population growth. In practice, that is unlikely, much more costly, and achieves less human wellbeing than addressing both population growth and per person impacts simultaneously. The GFN's footprint calculator, however, emphasises per capita footprints while de-emphasising numbers of "feet". Users of this approach can avoid thinking about population matters.

There are limits beyond which human overpopulation becomes undeniable. We suggest the following definition of overpopulation, grounded straightforwardly in the environmental ethics - overpopulation exists where 1) people are displacing wild species so thoroughly, either locally, regionally, or globally, that they are helping create a global mass extinction event; and 2) people are so thoroughly degrading ecosystems that provide essential environmental services, that future human generations are likely to have hard times living decent lives (Staples and Cafaro, 2012, The Overpopulation Project, 2020). This definition recognises that this planet is not inhabited by humans alone. We share it with perhaps 10 million other species or may be more, and we do not want to live under too crowded conditions. We want to live well, we want our grandchildren to live well, and we want them and *their* grandchildren to live well in a biologically rich world (Dodson, 2019). According to this definition, whole world and most of the nations are overpopulated, and getting more overpopulated with each passing year. Fortunately, not all areas of the planet Earth are overpopulated and in places that are, we could reduce our numbers to restore and protect ecosystems. But, to motivate action to do so, we must be able to name/acknowledge overpopulation as a problem. We must use this word.

An Uncomfortable Concept

Why are so many people uncomfortable talking about overpopulation? There are many reasons, two of which seem especially important. First, some people deny overpopulation exists, referring to recent progress in human well-being around the world (Götmark, 2018). Second, the term may cause communication problems, if not explained well. Some colleagues and conservationists, both in rich low-fertility countries and poor high-fertility countries, feel it gives the wrong impression about whose interests are being pursued.

Regarding the first point, we do not deny that the average living conditions for many people around the world have improved in recent decades (Roser, 2020). However, this observation distracts from the more salient fact that, on several criteria, suffering and deprivation have increased in absolute numbers. Undernourishment, for instance, persists and has even increased compared to 60 or 70 years ago (Marsh, 2017; FAO 2019). Moreover, future improvements in peoples' lives are commonly taken for granted, despite the United Nation's forecast that we face another 80 years or more of substantial global population increase, while environmental capital, from groundwater reserves to climate stability, is being run down already (Drechsel et al, 2001; UNEP, 2012; Vaughan, 2019). It may be pointed out that food (Le Page, 2020) and freshwater (D'Odorici et al, 2018; Götmark, 2019) cannot increase indefinitely as human population grows. Many will argue that Malthus was proven wrong in the 19th century (Wikipedia, 2020), Paul Ehrlich in the 20th century (Climate One, 2018) and smart *Homo sapiens* will once again solve new problems through clever management or new technology in the 21st century - more people, more brains to solve problems.

This is a common response from political and intellectual elites whose privilege has allowed them to do well and feel confident about the future. However, people heading to work on crowded buses, low-paid workers fighting flooded labour markets, or poor farmers worried about droughts or subdividing their properties among their numerous children, usually have more negative and realistic views about population growth (Dodson, 2019). This contrast can be seen when people respond to newspaper reports or opinion pieces focused on solving environmental problems through technical solutions. People often recognise population growth or overpopulation as the missing piece and express scepticism about solutions that ignore population growth.

Those who have any interest in wildlife are even less inclined to argue away overpopulation, since they are aware of current clear negative trends for wild species and populations. One study of mammal population trends for the period 1900-2015 concludes, of the 177 mammals for which we have detailed data, all have lost 30 percent or more of their geographic ranges and more than 40 percent of the species have experienced severe population decline, and more than 80 percent range shrinkage (Ceballos et al, 2017). Another recent study has concluded that North American wild bird abundance decreased by 30 percent during the last 50 years, an astonishingly rapid rate of population loss (Pennisi et al, 2019). Human overpopulation has obviously contributed to these negative effects.

The second issue is that, in some circles, such as in discussions regarding international development aid, the word overpopulation increasingly seems to have become a taboo over the last two or three decades (Bognar, 2019). Among our colleagues in Africa, use of this word can create negative responses, despite our sharing of similar views on the negative effects of population growth and on the needed solutions, such as greater financial support for family planning. For example, an African colleague protested that attributing social and environmental problems to overpopulation "… *ignores issues of inequities within and across countries which is at the heart of the poor state of human conditions we see in different parts of the world today. It is NOT overpopulation that is sending millions of children to bed hungry each night. It is not overpopulation that is responsible for the massive ecological devastation in Africa today*."

There is a lot to unpack in these words, but implicit is the idea that citing overpopulation means denying the inequities of colonial legacies and modern exploitation. Even worse, persons citing overpopulation wish to impose some sort of penalty on poor, high-fertility countries, rather than identifying a crucial area in which they need help. We are all raised on stories where adversity is characterised by villains and heroes, so it may be hard to grasp that naming is not blaming. Yet, it is incorrect to argue that population growth has played no role in driving deforestation, overgrazing, soil degradation and loss of species in Africa, not to mention shrinking land holdings, burgeoning urban slums and insufficient access to food, infrastructure, and services (Campbell et al, 2007; Graves et al, 2019). Knowing the fact that crowded labour markets lead to low wages and exploitative working conditions, can it really be argued that population growth plays no role in driving economic inequality?

It is a fact that no country other than petro-states has achieved middle-income status without first reducing its birth rate substantially through voluntary family planning, and countries which did so, regardless of their colonial legacy, have seen substantial improvements (O'Sullivan, 2013). By denying overpopulation and the problems generated by continued rapid population growth, our colleague's commendable desire to address economic equity could contribute to worsening it. Such denial also ignores the fact that limiting future population growth is likely to be an important factor in preserving spectacular wildlife heritages of African nations (Bradshaw and Di Minin, 2019).

A Balanced View and a Recommendation

Pointing all this out does not mean arguing against greater economic equity between nations, fairer trade relations, or increased foreign aid—all are needed. It also does not mean acquiescing in overconsumption by wealthy people or pretending that overpopulation is only an issue in the developing world. But as Clark (2016) notes, "Valid arguments about injustice and economic equity should not do double duty as forms of population denialism."

It is important to acknowledge that overpopulation exists in many rich countries with too high rates of consumption as well as in many poor countries with too high fertility rates. Every effort should be made to reduce high consumption rates as well as high birth rates. In combination, these two measures would create a much better future for people on the planet. From this perspective, the fact that some rich nations have aging, and declining populations is good news (Götmark et al, 2018). Each nation, each political leader, each citizen, can contribute to creating sustainable societies by addressing both consumption and population issues, and their interconnections. Avoiding overpopulation is important in creating societies that sustain good human lives and maintain the existence of other species. Many futurists acknowledge the threat but claim that the problem is fixing itself (Randers 2012, Rosling et al, 2018). This belief is part of the mythology through which population growth and overpopulation have been rendered taboo, particularly since the mid-1990s. Sadly, as a consequence of this complacency, family planning efforts were neglected, and many countries have seen fertility declines stall or reverse (Bongaarts, 2008). The United Nations' prediction of peak world population has consequently been revised upward from 9 to 11 billion people since 2000 (O'Sullivan, 2016). The partnership "Family Planning 2020" was launched in 2012 to revitalise languishing family planning efforts and has helped many women in many countries receive contraception (Cahill et al, 2018). But it has fallen well short of its targets, due to weak political will in both donor and recipient countries (Family Planning 2020, 2019) and the number of women with an unmet need for contraception continues to rise (Kantorová et al, 2020), while family planning receives only 1 percent of international aid (Potts and Graves, 2019).

It seems that the campaign to disavow overpopulation and refocus birth control efforts exclusively on women's reproductive health and rights has not served women's rights well. Equally, it has impeded environmental protection. The Convention on Biological Diversity's Aichi targets systemically neglect of population growth as a driver of biodiversity loss (Driscoll et al, 2018). Integrated assessment models (IAMs) using the IPCC's 'shared socioeconomic pathway' (SSP) scenarios have found that the feasibility of achieving less than two degrees warming depends on extremely rapid fertility decline in Africa but fail to include measures to achieve that decline (O'Sullivan, 2017). An area of forest equal to the size of Germany can be saved from conversion to crops by accelerating fertility decline in Africa (Searchinger et al, 2018).

We ignore overpopulation at our peril. Yet, in recent decades, many environmental scientists and environmental advocacy organizations have done just that (Porritt, 2014; Foreman and Carroll, 2014; Derer, 2018b). The word 'overpopulation' is rare in titles or abstracts of articles in the fields of demography, ecology, food science, or sustainability in general. This neglect and denial have made it much harder to deliver the reproductive freedom that millions of people in high-fertility countries want, and consequently undermine their own conservation aims. Still, the fight to address overpopulation continues. We recommend that the concept be used widely in scientific analyses as well as in public outreach, especially in media discussions about environmental issues.

In a promising sign, the "World Scientists' Warning to Humanity: A Second Notice" (Ripple et al, 2017) has attracted endorsement from 15,364 scientists for an agenda which includes "further reducing fertility rates by ensuring that women and men have access to education and voluntary family-planning services, especially where such resources are still lacking." The organisation formed to advance the agenda, ScientistsWarning.org, organised a well-attended seminar on overpopulation at the most recent annual United Nations Climate Change Summit (COP 25) in Madrid in December 2019 (Scientists' Warning, 2019). The event eloquently argued that overpopulation was a major threat to climate stabilization and there were effective, just, and practical solutions to help us deal with it (Cafaro, 2012). The self-righteous refusal to name the problem can only deepen the environmental and social crises we face. Having come so close to the brink of cascading disasters (Cafaro and Crist, 2012), we can no longer afford to pander to misguided political correctness.

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Poverty Hotspots in Rural India: Evidence from 2011 Population Census

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Abstract

The present paper focusses on the geographical concentration of poverty across villages in India with the objective of identifying poverty hotspots in rural India. The paper follows an assets-based approach of identifying poor households in villages and to classify a village as poverty hotspot if the proportion of poor households in the village is at least 40 per cent. Our analysis suggests that around 20 per cent villages in the country are poverty hotspots in the sense that at least 40 per cent households in these villages were not having any of the seven household assets for which information was collected at the 2011 population census. The paper also applies data mining techniques to identify the defining characteristics of villages classified as poverty hotspots explores their geo-political distribution. The analysis reveals that poverty hotspots in rural India are characterised by small size of the village, low literacy rate, high fertility, and high proportion of Scheduled Tribes in the village. More than 73 per poverty hotspots in India are located in only eight states of the country. A focus on poverty hotspots in rural India through targeted interventions can contribute to alleviating poverty in the country.

Introduction

Concern for eradicating poverty and improving the quality of life of the people in India have been a pertinent development agenda in India right since independence. A concomitant feature of this concern has been measurement of poverty. The commonly used definition of poverty is the exclusion from ordinary living patterns, customs, and activities due to lack of resources (Townsend 1979). Following this definition, the official approach of measuring poverty in India is based on comparing household consumption expenditure with a cut-off/threshold consumption expenditure commonly known as the poverty line (Government of India, 2013). All households having consumption expenditure less than the poverty line are classified as poor households and the proportion of these households is a measure of the prevalence of poverty. This approach assumes household consumption as the best possible proxy measure of well-being (Ruggeri et al, 2003).

Consumption based approach of measuring poverty has many limitations. First, it provides very limited information about the reason of poverty and the material situation of the poor, which is likely to change over time (Carter, 2014). This approach usually accounts for 'current income' and not wealth (e.g., savings or other liquid assets), debt, or access to credit that may be used to obtain goods and services. Goods may also be obtained without income, savings, or credit. They may be acquired as gift, exchanged via barter, received as free services or public goods from the government (Ringen, 1988). Households may also meet their basic needs through accumulated wealth or credit or through other markets. Consumption-based measures, therefore, are likely to misrepresent households' ability to meet their basic needs. The living conditions of a household are not shaped by current consumption alone and the household may experience different living standards for reasons not explained by current consumption (Beverly, 1999; Edin and Lein, 1997; Mayer and Jencks, 1989, 1993; Rector et al, 1999). Consumption-based approach is based on self-reported consumption data collected from a sample of households. Consumption-based measures of poverty are also insufficient to characterise and analyse well-being because these measures relate to means to achieve ultimate ends rather than the ends in themselves (Hulme and McKay, 2005).

An alternative approach that has been suggested to address limitations of the consumption-based approach to measure poverty is the asset poverty. Asset poverty is defined as the inability of a household to access wealth resources to provide for its basic needs. Basic needs refer to minimum standards for consumption and acceptable needs (Jolly, 1976). It is argued to be a more complete understanding of what it really means to be living in poverty. Assets that a household possesses, or to which, it has access or command, can be related to household consumption in the sense that the latter may be conceptualised as returns to these assets. In this view, household consumption reflects the assets that household commands and the returns and it is able to earn on these assets. Assets may also be important to households in their own right. Having a sufficient level of household assets also offers security. Households having assets can insure themselves against shocks and gain easier access to credit. Assets also capture long term dynamics of household economics much better than the consumption or income at one or two points in time. Household assets, in principle, can be considered in a range of different dimensions of the capital including the social capital. The assets-based approach is also associated with the concept of poverty in a more intuitive way than the simple income or consumption-based concept of poverty. Similarly, deprivation of household assets is a better measure of the 'persistence' of ill-being as households without a specific set of assets, are directly linked to the standard of living.

The objective of this paper is to identify poverty hotspots in rural India in the context of asset poverty. Poverty hotspots are defined as those villages where the proportion of households having none of a specified set of assets is more than a pre-determined cut-off value. The paper also applies data mining techniques to explore the distinguishing features of poverty hotspots in rural India.

The paper is organised as follows. The next section explains the methodology adopted for identifying poverty hotspots. Section three describes the data source. The paper is based on the house level primary census abstract of the 2011 population census. The fourth section of the paper identifies poverty hotspots and analyses their distribution across the country. The fifth section of the paper applies data mining techniques to identify distinguishing characteristics of poverty hotspots. The last section of the paper summarises main findings of the analysis and discusses its policy and programme implications in the context of poverty eradication.

Methodology

Asset-based Poverty Measurement

We measure poverty in terms of the proportion of households in a village which do not have any of a specified set of household assets or the proportion of asset-less households. The specified set of household assets consists of seven household items – radio or transistor; television, black and white or colour; telephone, landline, mobile or both; computer, with or without internet; bicycle, scooter or motorcycle or moped or any other two-wheeler; and jeep or car or any other four-wheeler. We classify a village as the poverty hotspot if at least 40 per cent of the households in the village are asset-less households. The cut-off limit of the proportion of asset-less household is dynamic in the same way as the poverty line based on consumption expenditure changes with time. Our approach of characterizing household poverty is related to the concept of fuzzy poverty which conceptualizes the state of poverty in the form of "fuzzy sets" to which all members of the population belong but to a varying degree (Cerioli and Zani, 1990; Cheli and Lemmi, 1995; Betti and Verma, 2008; Betti, Mangiavacchi, Piccoli, 2017).

Characterisation of Poverty Hotspots

We apply classification modelling approach to identify distinguishing characteristics of poverty hotspots (Tan, Steinbach, Kumar, 2006; Han, Kamber, Pei, 2012). This approach involves classifying villages based on the proportion of asset-less households as the classification variable and selected village characteristics as predictor variables. The village characteristics used in the present paper included: 1) proportion of population aged 0-6 years; 2) proportion of the population aged 7 years and above who is illiterate, cannot read and write with understanding; 3) gender balance in the village measured in terms of the proportion of females in the village; 4) proportion of Scheduled Castes; and 5) proportion of Scheduled Tribes. The classification and regression tree (CRT) method (Breiman et al, 1984) was used for classification modelling. CRT is a non-parametric method that divides villages into mutually exclusive groups or clusters so that within group homogeneity with respect to the classification variable is maximised. It recursively partitions villages so that the partition can be represented as a decision tree (Loh, 2011). When the classification variable takes finite number of unordered values, the method generates classification tree. When the classification variable is either a continuous variable or an ordered discrete variable, regression tree is generated. Villages are sorted according to the classification variable into mutually exclusive groups based on that predictor variable which causes the most effective split based on a similarity measure. The process is repeated until either the perfect similarity is achieved, or the stopping criterion is met (Ambalavanan et al, 2006; Lemon et al, 2003). A group in which all villages have the same value of the classification or the dependent variable – the proportion of asset-less households – is termed as "pure." If a group is not found "pure", then the impurity within the group can be measured through a number of impurity measures. We have used the Gini coefficient of impurity in the present analysis. We have used the Statistical Package for Social Sciences (SPSS) for classifying villages and for identifying the distinguishing characteristics of poverty hotspots. Since the classification variable in the present analysis – the proportion of asset-less households in the village – is a continuous variable, the regression tree was generated.

Data

Information about the availability of seven household assets - radio or transistor; television, black and white or colour; telephone, landline, mobile or both; computer, with or without internet; bicycle, scooter or motorcycle or moped or any other two-wheeler; and jeep or car or any other four-wheeler – is available from the 2011 population census. The house level primary census abstract (HLPCA) provides the information about the proportion of households, which were having none of the above seven household assets in every village in the rural areas and municipal ward in the urban areas of the country. The present analysis is confined to rural area only. Poverty in the village is measured in terms of the proportion of asset-less households – households having none of the seven household assets. Therefore, the higher the proportion of asset-less households, the higher is the prevalence of poverty in the village.

In addition to HLPCA, the present analysis also uses the data available from the primary census abstract (PCA) of 2011 population census. The PCA provides data related to selected defining characteristics of the village population including gender composition, social class structure, level of literacy or, equivalently, extent of illiteracy, work participation rate and broad age composition of the population. These defining characteristics of the village population have been used to characterise poverty hotspots (villages) through the application of data mining technique.

There were 640,867 villages in the country at the time of 2011 population census according to the Registrar General and Census Commissioner of India. Out of these villages, 43,330 villages were found to be uninhabited at the time of 2011 population census. The present analysis is, however, limited to 597,478 villages as which were having at least one household at the time of 2011 population census. Total number of households in these villages varied from 1 household to 15,595 households, which shows that villages in India vary widely in terms of household size.

Asset-less Households in India

According to the 2011 population census, there were 168,563,192 households in the 597,478 villages of the country, out of which 38,438,675 or 22.8 per cent households were not having any of the seven household assets so that these villages are identified as poverty hotspots. According to the estimates prepared by the Government of India based on the consumption data available through the National Sample Survey, the proportion of population living below the poverty line in rural India was 25.7 per cent in 2011-12 (Government of India, 2013). Recognising that average household size of a poor household is relatively larger than that of a non-poor household, the proportion of asset-less households is a very close approximation of the prevalence of poverty estimated by the Government of India based on consumption data.

The proportion of asset-less households in a village is found to be inversely related to the number of households in the village. In villages with less than 50 households, the proportion of asset-less households is found to be almost 28 per cent, whereas, in villages with at least 1000 households, the proportion of asset-less households is found to be just around 20 per cent. This implies that poverty in rural India is essentially concentrated in small villages which are usually located in the remote areas (Table 1).

Table 1: Assetless households in villages of India by village size

Village size (Number of households)	Total number of villages	Number of households	Asset-less households	Household Poverty (percent)
<50	101933	2583045	719332	27.85
50-100	95644	7175196	1817615	25.33
100-200	142998	20948603	5165591	24.65
200-600	193599	66144400	15694822	23.73
600-1000	39034	29623104	6609116	22.31
≥ 1000	24128	42088844	8432149	20.03
All	597336	168563192	38438625	22.80

Source: 2011 population census.

The proportion of asset-less households are not uniformly distributed across the country. There are four states/Union Territories – Meghalaya, Dadra and Nagar Haveli, Nagaland, and Madhya Pradesh – where more than 40 per cent of the households were found to be having none of the seven specified assets at the 2011 population census with the highest proportion in Meghalaya. Poverty appears to be quite pervasive in Arunachal Pradesh, Mizoram, and Tripura also. In these states, more than one third of the households were found to be having none of the seven specified assets. North-eastern states and other hilly states are found to be relatively poorer than their counterparts. On the other hand, in 11 states/Union Territories, the proportion of assetless household is found to be less than 10 per cent with the Union Territory of Chandigarh having the lowest proportion. In Haryana, Uttar Pradesh, and West Bengal also, the proportion of asset-less households has been found to be quite low (Table 2 and Figure 1).

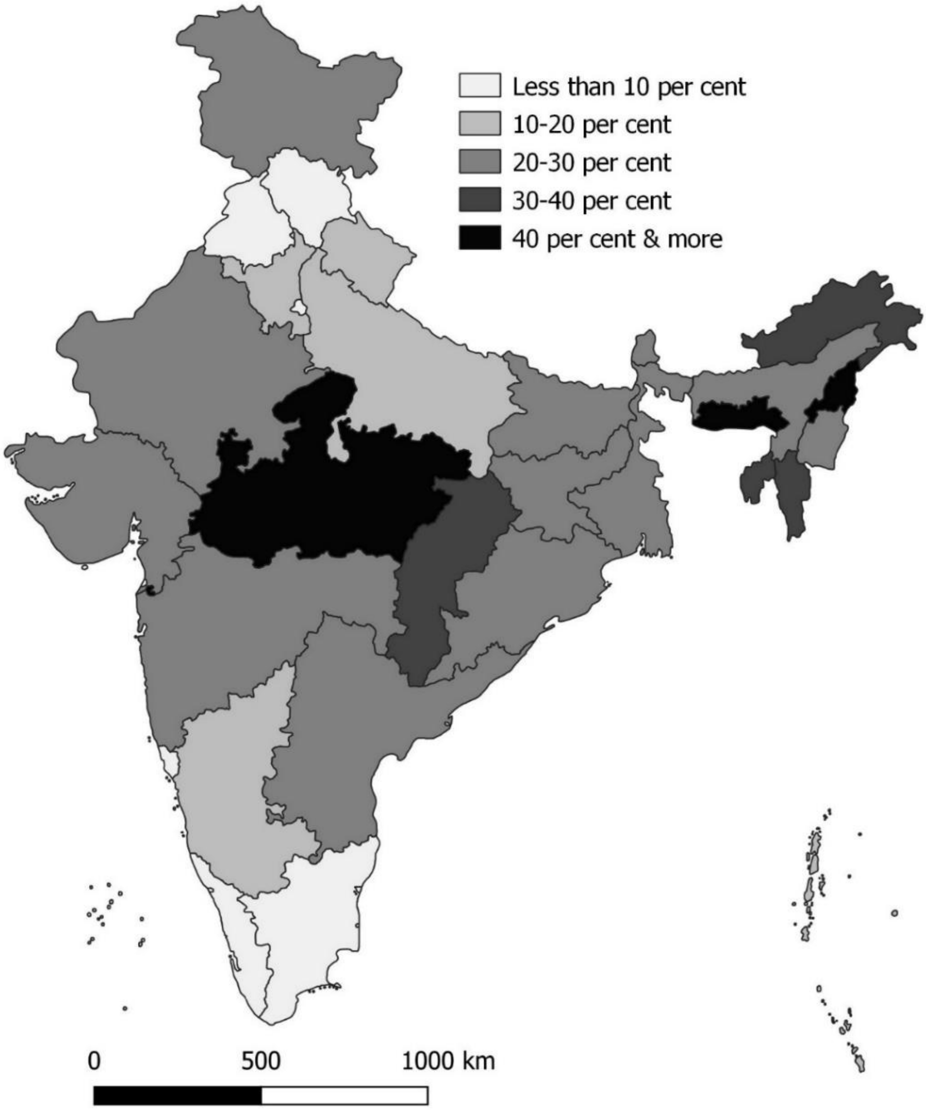

Figure 1: Proportion (per cent) of assetless households in states/Union Territories.
Source: Authors

Table 2: Assetless households in states/Union Territories, 2011.

State/Union Territory	Total number of households	Asset-less households		Rural population below poverty line 2011-12*
		Number	Proportion (percent)	
Jammu & Kashmir	1553433	341184	21.96	11.54
Himachal Pradesh	1312510	125658	9.57	8.48
Punjab	3358113	172844	5.15	7.66
Chandigarh	7140	206	2.89	1.64
Uttarakhand	1425086	252660	17.73	11.62
Haryana	3043756	361731	11.88	11.64
Delhi	79574	3985	5.01	12.92
Rajasthan	9494903	2423364	25.52	16.05
Uttar Pradesh	25684729	3115260	12.13	30.40
Bihar	16862940	4513741	26.77	34.06
Sikkim	93288	22169	23.76	9.85
Arunachal Pradesh	200210	75978	37.95	38.98
Nagaland	277491	113952	41.07	19.93
Manipur	338109	76019	22.48	38.80
Mizoram	105812	34914	33.00	35.43
Tripura	616582	212269	34.43	16.53
Meghalaya	430573	184375	42.82	12.53
Assam	5420877	1416316	26.13	33.89
West Bengal	13813165	3924150	28.41	22.52
Jharkhand	4729369	1164100	24.61	40.84
Odisha	8089987	2278556	28.17	35.69
Chhattisgarh	4365568	1361107	31.18	44.61
Madhya Pradesh	11080278	4449859	40.16	35.74
Gujarat	6773558	1865364	27.54	21.54
Daman and Diu	12744	1034	8.11	0
Dadra & Nagar Haveli	36094	15259	42.28	62.59
Maharashtra	13213680	3900852	29.52	24.22
Andhra Pradesh	14234387	3561474	25.02	10.96
Karnataka	7946657	1576370	19.84	24.53
Goa	128208	9551	7.45	6.81
Lakshadweep	2710	85	3.13	0
Kerala	4149641	253597	6.11	9.14
Tamil Nadu	9528495	614773	6.45	15.83
Puducherry	95018	9166	9.65	17.06
Andaman & Nicobar Islands	58507	6701	11.45	1.57

Source: Calculated by authors based on the data available through 2011 population census.
*Estimates prepared by the Planning Commission of India (Government of India, 2013)

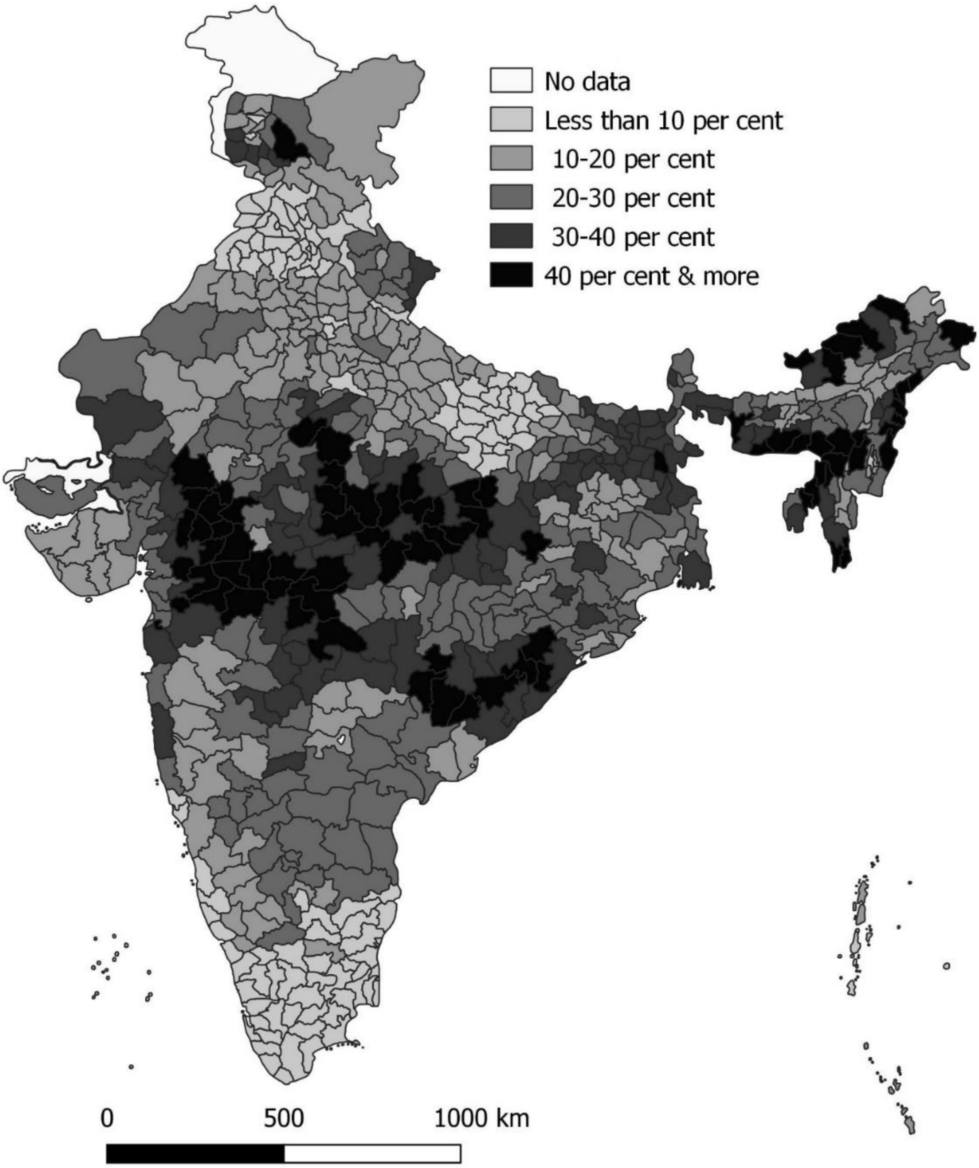

Figure 2: Proportion (per cent) of assetless households in districts of India.
Source: Authors

Variation in the proportion of asset-less households is even wider at sub-district level (Table 3). In 868 (14.8 per cent) sub-districts, at least 40 per cent of the households were asset-less and, therefore, are poverty hotspots sub-districts. In

Migging sub-district of Upper Siang district of Arunachal Pradesh, virtually all households were asset-less. In sub-districts Parsi-Parlo of Kurung Kumey and Payum of West Siang districts of Arunachal Pradesh, more than 90 per cent households were asset-less. On the other hand, there was no asset-less household in sub-district Preet Vihar in East Delhi district of the National Capital Territory of Delhi and in sub-district Kochilaput in Lingraj district of Odisha.

Poverty Hotspots in Rural India

There are 118,690 (19.9 per cent) villages where more than 40 per cent households were asset-less at the 2011 population census. These villages are the poverty hotspots in rural India. More than 42 per cent of these villages (poverty hotspots) are located in only three states – Madhya Pradesh (20.4 per cent); Odisha (11.43 per cent) and Maharashtra (10.58 per cent). In addition, more than 30 per cent of these villages, are located in five states – Rajasthan (7.3 per cent); Bihar (6.4 per cent); West Bengal (5.7 per cent); Andhra Pradesh (5.7 per cent); and Jharkhand (5.6 per cent). This means that more than 73 per cent of the poverty hotspots in rural India are located in only eight states. On the contrary, in the Union Territories of Daman and Diu, Lakshadweep and Puducherry, there was no poverty hotspot in the rural areas (Table 4).

Table 3: Distribution of districts and sub-districts by the proportion of assetless households.

Proportion of assetless households (Per cent)	Districts		Sub-districts		Villages	
	Number	Per cent	Number	Per cent	Number	Per cent
< 10	122	19.3	716	12.2	171469	29.2
10-20	166	26.3	1527	26.0	138671	23.3
20-30	155	24.6	1729	29.4	98636	16.6
30-40	104	16.5	1038	17.7	65812	11.0
≥40	84	13.3	868	14.8	118690	19.9
All	631	100.0	5878	100.0	595978	100.0
No data	9				1559	

Source: Calculated by authors based on 2011 population census.

The concentration of rural poverty hotspots varies across states/Union Territories of the country. In six states/Union Territories - Dadra and Nagar Haveli, Meghalaya, Arunachal Pradesh, Nagaland, Madhya Pradesh, and Tripura - more than 40 per cent villages are poverty hotspots whereas in 13 states/Union Territories of the country, less than 10 per cent villages are poverty hotspots. Almost one third of these villages are located in Uttar Pradesh, while around 27 per cent are located in Tamil Nadu; Himachal Pradesh; Punjab; and Rajasthan. Moreover, in 5,256 (0.9 per cent) villages, all households were asset-less whereas in 30,716 (5.2 per cent) villages, there was no asset-less household.

Distinguishing Characteristics of Poverty Hotspots

We have used the classification modelling approach to examine how proportion of asset-less households in a village is related to selected village level characteristics. The classification and regression tree (CRT) method (Breiman et al, 1984) was used for the purpose. CRT is a nonparametric method that divides villages into mutually exclusive groups or clusters so that within group homogeneity with respect to the classification or the dependent variable is maximized. This method recursively partitions the data space so that the partition can be represented in the form of a decision tree (Loh, 2011). Villages are sorted according to the classification variable – proportion of asset-less households in the village - into mutually exclusive groups based on that predictor variable which causes the most effective split on the basis of the similarity measure. The process is repeated until either the perfect similarity within the group is achieved, or the pre-decided stopping criterion is met (Ambalavanan et al, 2006; Lemon et al, 2003). A group in which all villages have the same value of classification, or the dependent variable - the proportion of asset-less households in the village - is termed as "pure." If a group is not "pure", impurity within the group can be measured through several impurity measures. We have used the Gini coefficient of impurity. The Statistical Package for Social Sciences (SPSS) has been used for classification modelling.

The classification modelling exercise was limited to only those 529,129 villages of the country which had at least 10 households at the 2011 population census. Villages having less than 10 households and villages having no household were excluded from the analysis. Results of the classification modelling exercise are presented in table 5 while the associated classification tree is depicted in figure 3. The exercise suggests that 529,129 villages of the country can be grouped into 10 mutually exclusive groups or clusters (Terminal nodes) of villages and the characteristics of villages belonging to different clusters are different and the mean proportion of asset-less households in different clusters is also different. The proportion of asset-less households, on average, is found to be the highest in 16,210 (3.1 per cent) villages of the country where Scheduled Tribes constitute more than 94.3 per cent of the village population and where illiteracy rate is 48 per cent and more (Node 14). The average of the proportion of asset-less households in villages of this cluster is 57.6 per cent with a standard deviation of 0.28. Next, there are 17,109 (3.2 per cent) villages where Scheduled Tribes constitute 30.6-94.3 percent of the village population, and the illiteracy rate is 48 per cent and more (Node 13). The average of the proportion of asset-less households in the villages of this cluster is 44.9 per cent with a standard deviation of 0.24. The third cluster comprises of those villages where Scheduled Tribes constitute at least 30.6 per cent of village population, illiteracy rate is less than 48 per cent and proportion of the population aged 0-6 years is at least 16.4 per cent (Node 12). There are 24,884 (4.7 per cent) villages in this cluster and the average of the proportion of asset-less households in the villages of this cluster is estimated to be 40.2 per cent with a standard deviation of 0.25. Most of the poverty hotspots (villages) in rural India are located in these three clusters

Table 4: Rural poverty hotspots (villages) across states/Union Territories of India.

State/Union Territory	Total number of villages	Number of poverty hotspots	Proportion of poverty hotspots in the country (Per cent)	Proportion of poverty hotspots within the state (Per cent)
Jammu & Kashmir	6321	907	0.76	14.35
Himachal Pradesh	17844	570	0.48	3.19
Punjab	12152	23	0.02	0.19
Chandigarh	5	0	0.00	0.00
Uttarakhand	15685	2531	2.13	16.14
Haryana	6636	103	0.09	1.55
Delhi	101	2	0.00	1.98
Rajasthan	43180	8715	7.34	20.18
Uttar Pradesh	97654	1928	1.62	1.97
Bihar	39009	7607	6.41	19.50
Sikkim	425	61	0.05	14.35
Arunachal Pradesh	5220	2705	2.28	51.82
Nagaland	1399	660	0.56	47.18
Manipur	2353	858	0.72	36.46
Mizoram	703	274	0.23	38.98
Tripura	862	363	0.31	42.11
Meghalaya	6454	3430	2.89	53.15
Assam	25345	5057	4.26	19.95
West Bengal	37140	6773	5.71	18.24
Jharkhand	29423	6627	5.58	22.52
Odisha	47607	13570	11.43	28.50
Chhattisgarh	19434	5491	4.63	28.25
Madhya Pradesh	51847	24225	20.41	46.72
Gujarat	17819	4513	3.80	25.33
Daman and Diu	19	0	0.00	0.00
Dadra and Nagar Haveli	65	36	0.03	55.38
Maharashtra	40862	12552	10.58	30.72
Andhra Pradesh	26264	6737	5.68	25.65
Karnataka	27343	2257	1.90	8.25
Goa	320	5	0.00	1.56
Lakshadweep	5	0	0.00	0.00
Kerala	1017	2	0.00	0.20
Tamil Nadu	15006	44	0.04	0.29
Puducherry	90	0	0.00	0.00
Andaman and Nicobar Islands	369	64	0.05	17.34
India	595978	118690	100.00	19.92

Source: Calculated by authors based on 2011 population census.

Table 5: The classification table.

Node	Village characteristics			Proportion of households without assets		N	Remarks
	Proportion Scheduled Tribes	Proportion illiterate	Proportion 0-6 years	Mean	SD		
0	All	All	All	0.242	0.202	529129	
1	≤0.306			0.203	0.167	417207	
2	>0.306			0.387	0.253	111921	
3	≤0.306	≤0.389		0.181	0.153	312482	
4	≤0.306	>0.389		0.268	0.188	104725	
5	>0.306	≤0.480		0.335	0.227	78602	
6	>0.306	>0.480		0.510	0.288	33319	
7	0	≤0.389		0.155	0.148	184398	
8	>0 ≤0.306	≤0.389		0.217	0.152	128083	
9	≤0.306	>0.389 ≤0.497		0.246	0.171	70513	Terminal
10	≤0.306	>0.497		0.315	0.211	34212	Terminal
11	>0.306	≤0.480	≤0.164	0.304	0.209	53738	Terminal
12	>0.306	≤0.480	>0.164	0.402	0.248	24884	Terminal
13	>0.306 ≤0.943	>0.480		0.449	0.240	17109	Terminal
14	>0.943	>0.480		0.576	0.260	16210	Terminal
15	0	≤0.389	≤0.172	0.147	0.142	156410	Terminal
16	0	≤0.389	>0.172	0.201	0.171	27989	Terminal
17	>0 ≤0.081	≤0.389		0.201	0.146	86906	Terminal
18	>0.081≤0.306	≤0.389		0.250	0.159	41177	Terminal

Source: Authors

On the other hand, the proportion of asset-less households, on average, is found to be the lowest in 156,410 (29.8 per cent) villages of the country where there is no Scheduled Tribes population, illiteracy rate is less than 39 per cent and the proportion of the population aged 0-6 years in the village is less than or equal to 17.2 per cent (Node 15). The average of the proportion of asset-less households in the villages of this cluster is found to be 14.7 per cent with a standard deviation of 0.14. The proportion of asset-less households has also been found to be low, on average, in those villages where Scheduled Tribes population is less than 10 per cent and illiteracy is low, although proportion of the population aged 0-6 years in these village is relatively high. The classification modelling exercise thus suggests that hotspots of poverty in rural India can be traced in terms of three village level characteristics - proportion of Scheduled Tribes population, level of illiteracy or, equivalently, level of literacy and the proportion of the child population – population below 7 years of age – in the village. The proportion of child population, it may be pointed out, reflects the level of fertility in the village, although in a crude sense. Table 6 presents defining characteristics of the households in villages of different clusters identified.

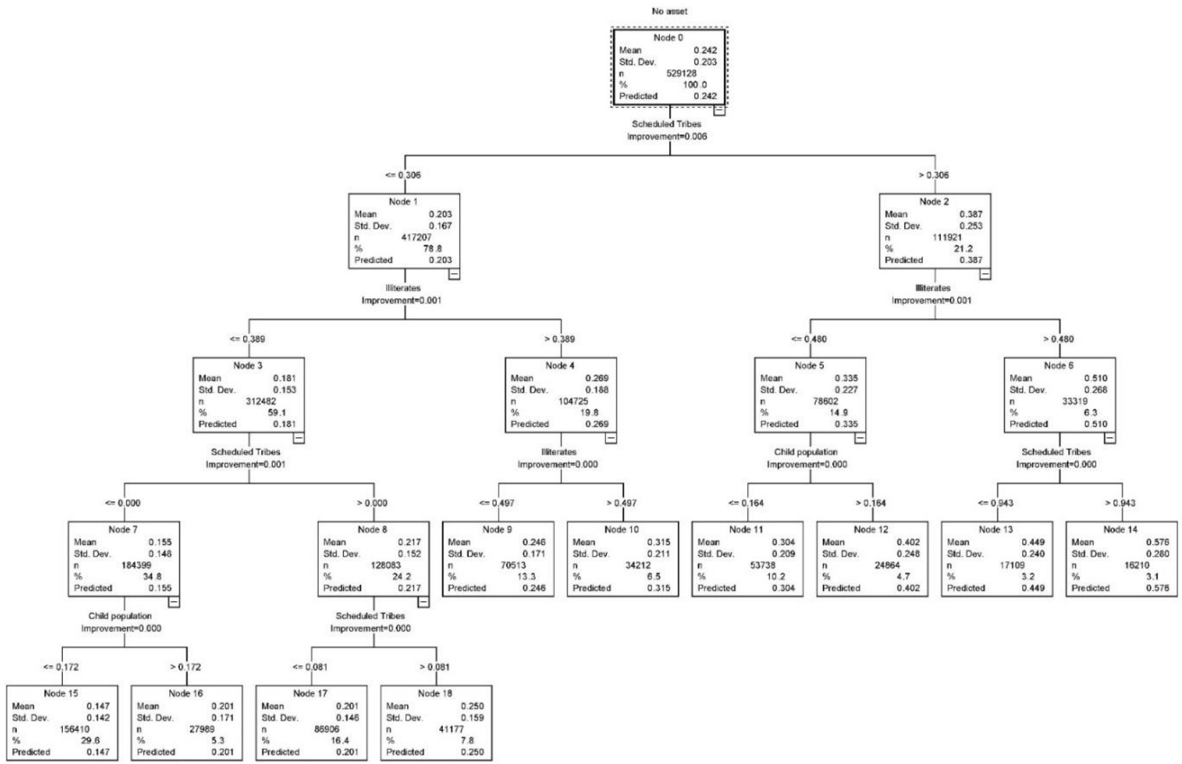

Figure 3: The classification tree.
Source: Authors

Table 6: Distinguishing characteristics of different clusters of villages.

Node	Number of villages	Total households	Assetless households		Average household size	Population 0-6 years (Per cent)	Scheduled Castes (Per cent)	Scheduled Tribes (Per cent)	Literates (Percent)
			Number	Per cent					
15	156410	39857799	5847599	14.67	5.12	13.08	23.11	0.00	74.08
17	86906	46669856	8761959	18.77	4.69	12.80	19.89	1.81	75.62
16	27989	6563659	1379113	21.01	5.86	18.91	19.67	0.00	68.10
18	41177	14063693	3525452	25.07	4.58	12.85	17.06	16.60	74.27
9	70513	25999288	6578059	25.30	5.07	16.41	19.94	2.76	56.49
11	53738	11242409	3477008	30.93	4.62	12.92	7.73	62.73	69.44
10	34212	10704636	3314451	30.96	5.28	18.75	16.72	2.39	43.40
12	24884	4084972	1711059	41.89	5.10	18.87	5.42	73.84	63.37
13	17109	3520730	1550121	44.03	4.76	17.81	8.08	66.47	42.99
14	16210	2051770	1233295	60.11	5.14	19.44	0.45	98.53	37.69
All	529128	164758812	37378116	22.69	4.94	14.51	18.61	10.95	67.82

Source: Authors

Conclusions and Policy Implications

This paper has identified poverty hotspots in rural areas in terms of these villages where at least 40 per cent households are asset-less households. Data available through 2011 population census suggest that there are almost one fifth villages in the country are poverty hotspots. Moreover, more than 40 per cent of these poverty hotspots are located in only three states – Madhya Pradesh, Odisha, and Maharashtra. Among different states/Union Territories, there is high concentration of poverty hotspots in north-eastern states and in Madhya Pradesh. The analysis also suggests that main determinants of household poverty in rural India are social class composition of the population, extent of literacy and the level of fertility. This means that efforts to reduce poverty in the rural areas of the country should focus on villages which are dominated by Scheduled Tribes population with an attempt to increase literacy and reduce fertility.

Findings of the present study are comparable with estimates prepared by the Government of India (Government of India, 2013). However, official estimates are inherently restricted up to state/Union Territory level only, because of data limitations. They contribute little to enhance our understanding about the extent of poverty below the state/Union Territory level. Although, the present study is based on the data available through the 2011 population census, yet it provides intriguing insights about the household poverty and poverty hotspots (villages) in rural India. To the best of our knowledge, this is the first pan-India study that has identified poverty hotspots and their distinguishing characteristics in rural India. The findings of the present study have important policy implications for poverty eradication. It is obvious that increasing individual income or consumption, alone, may not be adequate enough to reduce household poverty until these efforts are effectively backed up by efforts directed towards universalising education and reducing fertility. The analysis also suggests that poverty hotspots identified should have a targeted policy interventions for an accelerated reduction in poverty in rural India. It is also clear that poverty alleviation interventions must be integrated with interventions directed toward promoting education and reducing fertility.

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Risk Factors of Infertility in Bangladesh: A Poisson Regression Analysis

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Abstract

This study attempts to identify risk factors of infertility among women in Bangladesh. Based on the data available through Bangladesh Demographic and Health Survey (BDHS) 2014, the study observes that 12.7 percent married women in Bangladesh are infertile. Infertility is found to be associated with Women's age, age at marriage, education, BMI, division, religion, mass media, regular menstruation and genital diseases are found to be significant risk factors for infertility in the country.

Introduction

In the global perspective, efforts to improve community health have great success in improving maternal and child health during the past decade, partly due to the focus on reproductive health (Cousens et al, 2011). However, infertility has often been neglected in these efforts even though, it is a critical component of reproductive health (Cui, 2010). The inability to conceive affects both men and women equally across the globe. Infertility can lead to distress and depression, as well as discrimination and ostracism (Singh and Shukla, 2015).

Infertility has recently emerged as a challenge for the health sector. Accurate profile of the prevalence, distribution, and trend in infertility is important for shaping evidence-based interventions and policies to reduce the burden of this neglected disability. However, scarcity of population-based studies and inconsistent definition of infertility are the main challenges in generating global estimates of the prevalence of infertility (Gurunath et al, 2010; Ombelet et al, 2008). Infertile couples are reported to have psychological anguish, down heartedness, and low self-assurance (Chachamovich, 2010). In many cultures, social consequences of infertility compound the individual impact. Infertility has been found to be a major factor in divorce, loss of economic resources, and even annulment of rights to burial grounds (Greil, 2010). In Bangladesh, infertility as a health-related issue has been ignored in the reproductive health policy of the country (Nahar, 2012). The dominant state ideology focuses on fertility.

To the best of our knowledge, there is no national level study in Bangladesh that has estimated the prevalence of infertility in the country. The prevalence of infertility in Bangladesh is reported to be approximately 15 percent which is the highest among all south Asian countries (Kumar, 2007). There are, however, studies that have identified potential risk and causal factors of infertility in Bangladesh (Ahmad et al, 1999; Sala et al, 2018; Chowdhury et al, 2014; Momtaz et al, 2011; Nahar, 2012a). These include, among others, gynaecological problems, nutritional status as reflected through body mass index, age at marriage and poor living conditions. Other studies in South Asian countries suggest that sexually transmitted diseases (STDs), urinary tract infections (UTIs), reproductive tract infections (RTIs), unhygienic delivery, postpartum infection, unsafe obstetric practices and sepsis and pelvic infections linked to unsafe abortions are the causes of infertility (Singh and Shukla, 2015; Unisa, 2010; Jejeebhoy, 1998). Indirect causal factors of infertility include poverty, tuberculosis, under nutrition and anaemia (Ombelet et al, 2008; Ali et al, 2007; Inhorn, 2003). Poverty increases the risk of infertility in many ways. For example, scarcity of water and lack of access to nutrition and health care can make women more vulnerable to RTIs, which may cause infertility (Kumar, 2001).

In this paper, we analyse the prevalence and risk factors of infertility in Bangladesh based on the nationally representative Bangladesh Demographic and Health Survey 2014. Infertility in women is essentially a rare event and, therefore, we have applied Poisson regression model to analyse correlates and risk factors of infertility.

The paper is organised as follows. The next section describes the data source and the method used in the analysis. The study is based on a nationally representative household survey. Section three presents findings of the bivariate analysis. Section four presents findings of the Poisson regression analysis. Main findings and their policy and programme implications are discussed in the last section.

Data and Methods

The study is based on the data available from the Bangladesh Demographic and Health Survey (BDHS) 2014 (NIPORT, 2016). The BDHS was a nationally representative household survey which covered 17,863 ever-married women of reproductive age (15-49 years), out of which 8,388 currently women were not using any contraceptive method at the time of survey and were having at least one child. However, 1,064 currently women were considered infertile because they had no conception during the five years preceding the survey even though they or their husband did not use any contraceptive method during this period., Therefore, the study sample contains women whose age is more than or equal to 20 years. Both bi-variate and multi-variate analysis have been carried out to analyse the correlates and risks factors of infertility. The risk factors in this study are age, place of residence, religion, education, working status, wealth index (poor/middle/rich), age at marriage and the body-mass index (BMI) of the respondent. Along with these risk factors status of menstruation and any genital disease have also been taken into consideration as the biological risk factors of infertility. BMI is categories into two category, BMI more than 27.5 kg/m^2 is considered as obese and rest are not obese. The Chi-square test has been used for the bivariate analysis while Poisson regression analysis has been used in the multivariate analysis to identify risk factors and covariates of infertility.

Findings

Table 1 presents estimates of the prevalence of infertility by selected socio-demographic characteristics among ever-married women. An important covariate of infertility is the age of woman. The prevalence of infertility is high among women aged 20-34 years but low among women aged 35 years and above. Among different administrative divisions of Bangladesh, the prevalence of infertility is found to be relatively the highest in Sylhet division (16.73 percent) but the lowest in Barisal division (9.43 percent) indicating strong regional patterns in the prevalence of infertility within the country. The prevalence of infertility has also been found to be associated with socio-demographic characteristics of the women. The prevalence of infertility is found to be higher in urban than in rural women; in non-Muslims compared to Muslims; in literate women compared to illiterate women; and in working women compared to non-working women.

Table1: Prevalence of infertility in ever-married reproductive age women according to some selected socio-demographic characteristics of women in Bangladesh, 2014

Socio-demographic characteristics		N	Prevalence of infertility	*p*
Age				
	20-34 years	3391	15.1	0.000
	35+ years	4997	11.05	
		Administrative Division		
	Barisal	1007	9.43	0.000
	Chittagong	1175	15.4	
	Dhaka	1396	14.18	
	Khulna	1418	13.82	
	Rajshahi	1324	10.2	
	Rangpur	1315	10.11	
	Sylhet	753	16.73	
			Place of residence	
	Urban	2930	14.58	0.002
	Rural	5458	12.34	
			Religion	
	Non-Muslim	7474	13.22	0.000
	Muslim	914	8.35	

Socio-demographic characteristics	N	Prevalence of infertility	*p*
Education			
Illiterate	2588	11.17	0.002
Literate	5800	13.43	
Working Status			
Working	5291	13.57	0.001
Not working	3097	11.17	
Wealth Index			
Poor	3002	10.39	0.000
Middle	1761	12.04	
Rich	3625	14.9	
Age at marriage			
< 18 years	7563	12.31	0.002
>= 18 years	825	16.12	
BMI			
Not obese	7823	12.39	0.002
Obese	565	16.81	
Regular Menstruation			
No	2787	17.29	0.000
Yes	5601	10.39	
Genital diseases			
No	7102	12.62	0.005
Yes	1286	13.06	
Total	8388	12.68	

Source: Authors

The prevalence of infertility has also been found to be relatively the highest among the richest women but the lowest among the poorest women. Prevalence of infertility is found to be higher in women who were married after 18 years of age compared to women who were married before 18 years of age. Obesity is found to be associated with the prevalence of infertility. The prevalence of infertility is found to be higher in obese women compared to non-obese women. Gynaecological problems have been found to be having as impact on infertility. The prevalence of infertility is found to be higher in women having irregular menstruation compared to women having regular menstruation. Similarly, the prevalence of infertility is found to be higher in women having some genital disease compared to women not having any genital disease.

Table 2 presents results of the Poisson regression analysis. The probability of being infertile is expressed in terms of incidence rate ratio (IRR). Among women aged 20-34 years, the IRR is found to be 12 percent higher than the IRR in women aged 35 years and above and the difference is found to be statistically significant. Spatial differences in the prevalence of infertility within the country are also evident from the table. Compared to the Barisal division, the IRR is found to be statistically significantly higher in Dhaka, Chittagong, Sylhet, and Khulna Divisions but lower in Rajshahi and Rangpur divisions of the country. The analysis also confirms that the prevalence of infertility ever married reproductive age women is lower in the rural areas as compared to the urban areas of the country.

The risk of infertility has also been found to be higher in non-Muslim as compared to Muslim women. Women's education status has a statistically significant negative impact on the risk of infertility as IRR is found to be higher in literate compared to illiterate women. Similarly, working women are found to be more prone to infertility than non-working women. The risk of infertility is found to be relatively higher in middle-class women compared to rich and poor women. Women married after 18 years of age have higher risk of infertility compared to women married before 18 years of age. Similarly, obese women are at higher risk of infertility than non-obese women. Women having irregular menstruation are at about 13 percent significantly higher risk of infertility as compared to women having regular menstruation. Women suffering from genital diseases have higher risk of infertility than women not suffering from genital diseases.

Table 2: Results of the Poisson regression analysis of infertility on selected characteristics of the respondents

Socio-demographic covariates	Incidence rate ratio (IRR)	*p*	95% confidence interval	
			Lower	Upper
Age				
35⁺ years®				
20-34 years	1.118	0.000	1.093	1.162
Division				
Barisal®				
Chittagong	1.139	0.005	1.122	1.161
Dhaka	1.093	0.015	1.072	1.125
Khulna	1.044	0.018	1.026	1.082
Rajshahi	0.971	0.011	0.956	0.991
Rangpur	0.951	0.000	0.927	0.976
Sylhet	1.213	0.000	1.196	1.251
Place of residence				
Rural®				
Urban	1.217	0.000	1.191	1.239
Religion				
Muslim®				
Non-Muslim	1.103	0.000	1.066	1.116
Education level				
Illiterate®				
Literate	1.174	0.000	1.151	1.217

Socio-demographic covariates	Incidence rate ratio (IRR)	p	95% confidence interval	
			Lower	Upper
Working Status				
No®				
Yes	1.193	0.000	1.094	1.213
Wealth Index				
Poor®				
Middle	1.112	0.052	0.999	1.026
Rich	1.171	0.000	1.154	1.185
Age at marriage				
< 18 years®				
>= 18 years	1.426	0.000	1.411	1.411
BMI				
Not Obese®				
Obese	1.139	0.000	1.118	1.159
Regular menstruation				
Yes				
No®	1.135	0.000	1.106	1.171
Genital diseases				
No®				
Yes	1.117	0.005	1.109	1.139

®Reference category.
Source: Authors

Conclusions

Infertility remains a major public health challenge in Bangladesh. The present analysis shows that factors such as age of the woman and her age at marriage, region, education, religion, BMI, regularity of menstruation, and genital diseases are important causative factors of infertility in Bangladesh. Infertility varies widely across different regions of Bangladesh. Reasons for regional variation in the prevalence of infertility are not known at present. There is a need to explore the regional context of infertility in the country. At the same time, the public health care delivery system of the country should take into consideration the local level factors while addressing the challenge of infertility in the country which is quite high.

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Spatial and Temporal Variations in Child Mortality in Uttar Pradesh, India

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Abstract

This paper analyses spatial and temporal variations in child mortality in Uttar Pradesh, the most populous state of India based on data available from 2001 and 2011 population census. Both infant and under-five mortality has decreased in the state during 2001-2011 and the decrease in child mortality has been more rapid in rural than in urban areas of the state. GIS based thematic mapping has identified two clusters of high child mortality in central and eastern parts of the state. The analysis suggests that reduction in child mortality inequality within the state through a district-based approach can contribute substantially to reducing child mortality in the state. The high-risk population subgroups identified in the analysis and differential risk profile of these subgroups, can assist public health professionals to identify child mortality hotspots to guide policy interventions in resource-limited settings. A state specific child survival policy may be a beginning in this direction.

Introduction

Uttar Pradesh is the most populous state of India and accounts for more than 16.5 per cent population of the country according to the 2011 population census. This implies that mortality scenario of the state has a strong influence on the mortality scenario of the country. According to India's official Sample Registration System, the under-five mortality rate (${}_5q_0$) in the state was 47 under-five deaths per 1000 live births in 2018 which is substantially higher than the national average of 36 under-five deaths per 1000 live births (Government of India, 2020). On the other hand, the National Family Health Survey 2015-16 estimates that ${}_5q_0$ in the state was 78 under-five deaths per 1000 live births compared to the national average of 50 (Government of India, 2017a). It is obviously that an accelerated reduction in ${}_5q_0$ in the state will contribute significantly towards hastening the pace of the decrease in child mortality in the country. The United Nations 2030 Agenda for Sustainable Development calls for every country to reduce the under-five mortality rate to at least as low as 25 under-five deaths for every 1000 live births by the year 2030 and reduce inequalities in child mortality within the country as part of the Sustainable Development Goal 3: Ensure Healthy Lives and Promote Well-being for All at all Ages (United Nations, 2015). Similarly, India's National Health Policy

2017 aims at reducing under-five mortality rate to 23 under-five deaths for every 1000 live births by 2025; reducing infant mortality rate to 28 infant deaths for every 1000 live births by the year 2019; and reducing neonatal mortality rate to 16 neonatal deaths for every 1000 live births by 2025 in the country (Government of India, 2017b).

A major challenge to improving child survival in India is very pervasive within country inequality in child mortality which has persisted over time. Although child mortality in the country is decreasing, yet, within country inequalities in child mortality continue to persist (Behl, 2013). A reduction in within country inequality in child mortality can contribute significantly towards achieving the targets laid down in the National Health Policy 2017 and the targets set under the United Nations 2030 Sustainable Development Agenda. Evidence available from the Annual Health Survey 2012-13 indicates substantial variation in ${}_5q_0$ across districts of Uttar Pradesh ranging from 50 under-five death per 1000 population in district Kanpur Nagar to more than 130 under-five deaths per 1000 live births in district Shrawasti (Government of India, 2013a). It is also logical to assume that with every district, ${}_5q_0$ varies across different mutually exclusive population subgroups. However, the current understanding of within district inequality in ${}_5q_0$ in the state is very poor. It is obvious that a holistic understanding of inequality in the risk of death in the first five years of life can serve as the basis to suggest strategies to reduce the inequality and hence accelerate the pace of decrease in child mortality in the state.

An analysis of child mortality inequality in Uttar Pradesh is important because prevailing levels of child mortality in the state are at concordance with its income levels and economic development. Uttar Pradesh is one of the low-income states of India. The net state domestic product per capita at 2011-12 prices in Uttar Pradesh is estimated to be almost Rs 40 thousand in the year 2014-15 which is the second lowest among the major states of the country, states with a population of at least 200 million at the 2011 population census. Among the major states of the country, Uttar Pradesh is the 6th least urbanised state with less than 22.5 percent of the state population living in the urban areas as defined at the time of the 2011 population census. However, the distribution inequality in the state appears to be quite substantial as more than 29.4 per cent of the state population was living below the poverty line in 2011-12. This proportion was 30.4 per cent in the rural areas (Government of India, 2014).

The objective of this paper is to analyse spatial and temporal variations in the risk of death during the first five years of life across districts of the state and across mutually exclusive population subgroups within districts. GIS-based thematic mapping has been used to identify clusters of high risk of death during the first five years of life within the state and across different population subgroups. There are studies that have highlighted inter-district inequality in under-five mortality in Uttar Pradesh (India State-Level Disease Burden Initiative Child Mortality Collaborators, 2020; Bora and Saikia, 2018; Kumar et al, 2012; Liu et al, 2019). However, to the best of our knowledge, there is no study that has analysed within district inequality in child mortality across different mutually exclusive population sub-groups and how this inequality contributes to the child mortality in the district.

The paper is organised as follows. The next section of the paper describes the analytical strategy adopted for the analysis while section three describes the data source. Inter-district variation in ${}_5q_0$ is discussed in section four of the paper while section five discusses variation in ${}_5q_0$ across mutually exclusive population subgroups within each district of the state. The last section of the paper summarises main findings of the analysis and discusses their policy and programme implications in the context of an accelerated reduction in child mortality in the state.

Analytical Framework

The analytical strategy adopted in the present analysis comprises of two parts. The first part is devoted to the estimation of child mortality for different mutually exclusive subgroups of the population at state and district levels based on summary birth history data available from 2001 and 2011 population census. We have used the indirect method of child mortality estimation pioneered by Brass and Coale (1968). This method is based on reports from mothers about the survivorship of their ever-born children. The Brass and Coale method revolutionised estimation of child mortality in populations where direct estimation of child mortality is not possible because of the lack of necessary data. Although this approach of child mortality estimation has some limitations (Preston et al, 2003), yet, it has been found to be fairly reliable for estimating the risk of death during early childhood and the trend over a period of around 10 years (Hill, 1991). The rationale of the method and detailed step-by-step procedure of estimation are described in detail elsewhere (United Nations, 1983; Preston et al, 2003; Moultrie et al, 2013). Actual calculations have been carried out using the worksheet developed by Moultrie et al (2013). The method requires selection of a family of model life tables. We have selected the South-Asian family of the United Nations Model Life Table System (United Nations, 1982) for the purpose.

The second part of the analysis is devoted to the thematic mapping of inter-district variation in under-five mortality rate and estimation of within district, across mutually exclusive population subgroups, inequality in the under-five mortality rate (${}_5q_0$) for each district of the state. The thematic mapping was done using the ArcGIS 10.0 software package for Windows. The base map for thematic mapping was prepared by digitizing, editing, and processing the administrative map of Uttar Pradesh as published in the Administrative Atlas of India at the time of 2011 population census (Government of India, 2011). On the other hand, within district inequality in ${}_5q_0$ across mutually exclusive population subgroups was measured in terms of differential or the ratio of the maximum to minimum ${}_5q_0$ within the district and the unweighted coefficient of variation across different mutually exclusive population sub-groups in each district. We have not calculated the weighted coefficient of variation which also takes into the account the proportionate distribution of live births across different mutually exclusive population subgroup within the district.

Data Source

The data for the present analysis come from the 2001 and 2011 population censuses. In the population census, two questions were asked, one related to children ever born alive and the other related to children surviving from all ever-married women. The total number of children ever born alive to the woman included both living and dead daughters and sons. The number of daughters and sons ever born alive to the woman includes children born to her out of her earlier marriage(s) also. However, children that the husband of the woman that he had from his earlier marriage(s) were not included. Similarly, adopted daughter(s) or son(s) were also not counted for the purpose of this question. On the other hand, number of children surviving at the time of enumeration includes number of daughters and sons not staying with the household at the time of enumeration. The daughters and sons surviving at the time of enumeration included all daughters and sons surviving from the time she first got married, if married more than once, but exclude adopted children and the children her husband had from his earlier marriage(s) (Government of India, 2011). The data are available by the age of the ever-married women for total population of the district and separately for Scheduled Castes and Scheduled Tribes. For each social class, data are available separately for rural and urban areas and, within rural or urban areas, separately for male and female children. This means that the population of the or the state can be divided into the following 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
12. Urban Other Castes female

The Scheduled Tribes, however, constitute only 0.57 per cent of the state population. There are only 3 districts where Scheduled Tribes population was more than 100 thousand at the 2011 population census. As such, we have estimated $_5q_0$ for the 12 mutually exclusive population subgroups for these three districts only. In these 3 districts, within district inequality in $_5q_0$ is measured by taking into consideration 12 mutually exclusive population subgroups. In the remaining districts, $_5q_0$ has been estimated for 8 mutually exclusive population subgroups only and within district inequality in $_5q_0$ is measured in terms of variation in 8 mutually exclusive population subgroups only. The ever-married women with missing data on the number of children ever born alive or the number of children surviving, or both have been excluded from the estimation of $_5q_0$ as recommended by Hill (2013).

Child Mortality in Uttar Pradesh

Estimates of ${}_5q_0$ in the state and in its constituent districts, derived from the data on children ever born and children surviving available through 2001 and 2011 census data, are presented in table 1 for the total population and separately for rural and urban areas. For the state, ${}_5q_0$ is estimated to be 0.101 around the year 2005, according to the 2011 population census. According to the abridged life tables prepared by the Registrar General and Census Commissioner of India based on the age-specific deaths rates available through the official Sample Registration System, ${}_5q_0$ in the state is estimated to be around 0.108 for the period 2003-07 (Government of India, 2012). This shows that ${}_5q_0$ estimated from the data on children ever born and children surviving available through the 2011 population census is a very close approximation of the estimate based on the official Sample Registration System. This proximity justifies using the data on children ever born and children surviving collected from population census to estimate child mortality. Table 1 indicates that ${}_5q_0$ varies widely across districts of the state ranging from 0.075 in district Deoria to 0.127 in Kaushambi and Sitapur districts. Table 1 also suggests that ${}_5q_0$ in the state decreased by around 18 per cent between 1995 and 2005 but the decrease in the urban areas has been slower than that in the rural areas. There is also consideration variation in the decrease in ${}_5q_0$ across districts. There are three districts – Ghaziabad, Kushinagar, and Mau – where ${}_5q_0$ appears to have increased whereas it decreased by at least 30 per cent in 7 districts.

The decrease in ${}_5q_0$ in the rural areas has been different from that in the urban areas in the state and in its constituent districts of the state. In the state, ${}_5q_0$ in the rural areas decreased from 0.130 based on 2001 population census to 0.106 based on 2011 population census. The ${}_5q_0$ in the rural areas also decreased in all but two districts of the state. The two districts where ${}_5q_0$ in the rural areas increased according to the data available from 2001 and 2011 population census are Ghaziabad and Mau. The pace of decrease in ${}_5q_0$ in the rural areas, however, varied across districts. There are only 9 districts in the state where ${}_5q_0$ in the rural areas decreased by at least 30 per cent whereas in 32 districts, the decrease in rural ${}_5q_0$ ranged between 20-30 per cent. This leaves 14 districts where rural ${}_5q_0$ decreased by less than 10 per cent.

By contrast, the decrease in urban ${}_5q_0$ has been slow. In the state, as a whole, the ${}_5q_0$ in the urban areas decreased from 0.088 according to the 2001 population census to only 0.080 according to the 2011 population census. There are 17 districts in the state where ${}_5q_0$ in the urban areas has increased over time compared to only 2 districts in the rural areas. In more than half of the districts of the state the decrease in ${}_5q_0$ in the urban areas ranged between 10-20 per cent as revealed through 2001 and 2011 population censuses. There are only 20 or less than one third districts in the state where ${}_5q_0$ in the urban areas decreased by at least 20 per cent. The increase in ${}_5q_0$ in the urban areas of many districts of the state appears to be largely responsible for very slow decrease in ${}_5q_0$ in the urban areas of the state as compared to its rural areas. The slow decrease in ${}_5q_0$ in the urban areas of the state has implications for the pace of the decrease in ${}_5q_0$ in the state.

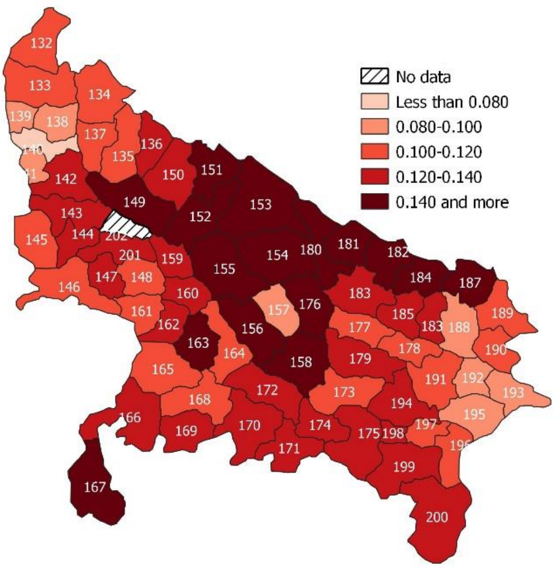

Figure 4: Under-five mortality rate in districts of Uttar Pradesh, total population, 2001
Remarks: Labels are district codes (Table 1)
Source: Authors

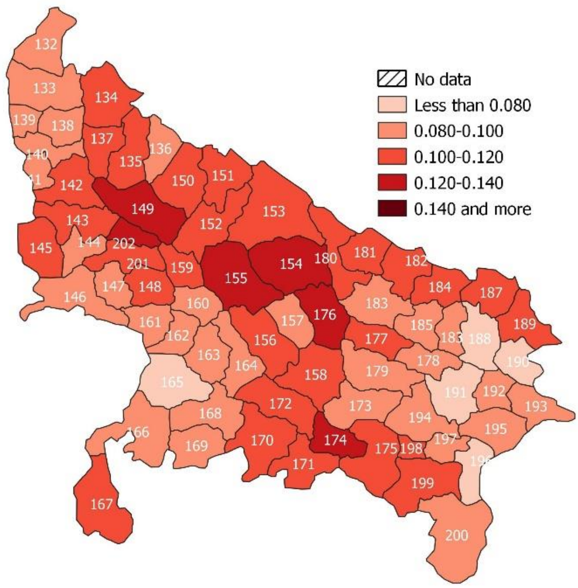

Figure 5: Under-five mortality rate in districts of Uttar Pradesh, total population, 2011
Remarks: Labels are district codes (Table 1)
Source: Authors

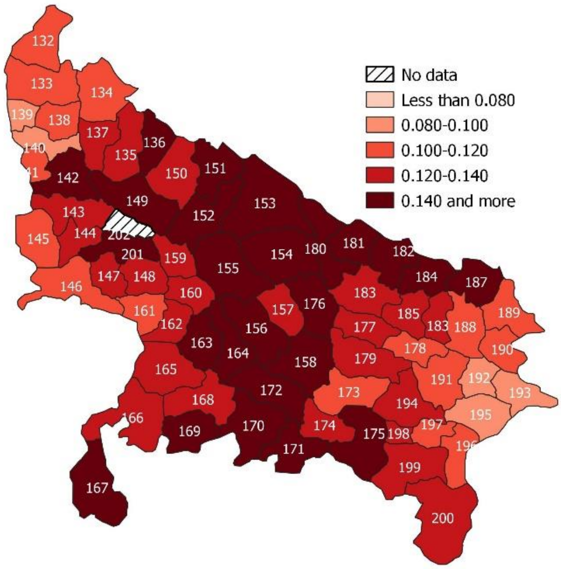

Figure 6: Under-five mortality rate in districts of Uttar Pradesh, Rural population, 2011
Remarks: Labels are district codes (Table 1)
Source: Authors

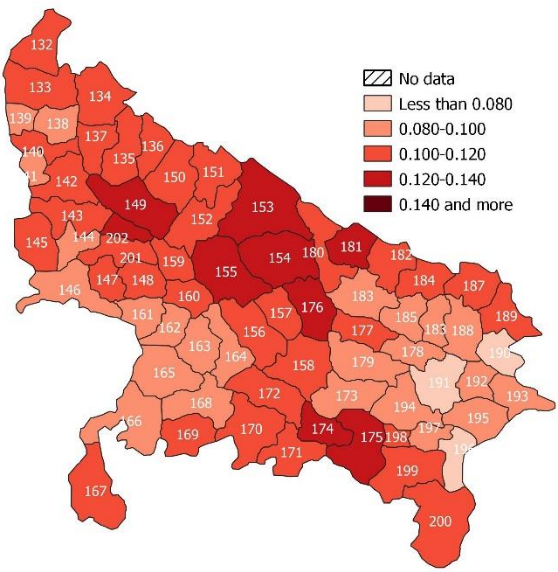

Figure 7: Under-five mortality rate in districts of Uttar Pradesh, rural population 2011
Remarks: Labels are district codes (Table 1)
Source: Authors

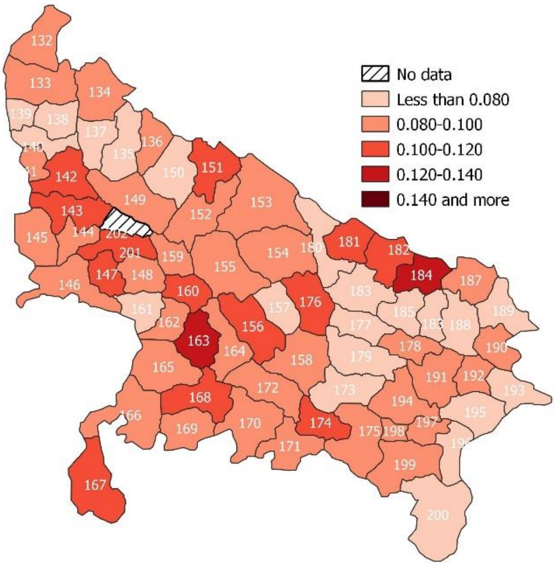

Figure 8: Under-five mortality rate in districts of Uttar Pradesh, urban population, 2001
Remarks: Labels are district codes (Table 1)
Source: Authors

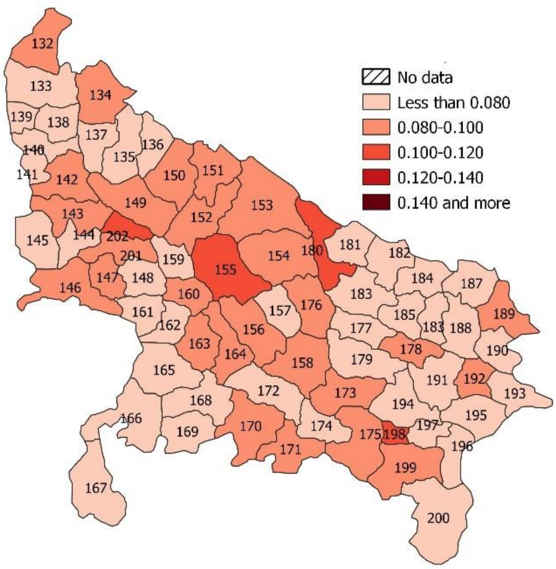

Figure 9: Under-five mortality rate in districts of Uttar Pradesh, urban population, 2011
Remarks: Labels are district codes (Table 1)
Source: Authors

Table 1: Probability of death during the first five years of life, ${}_5q_0$, in Uttar Pradesh based on 2001 and 2011 population census

Code	State/District	2001 population census			2011 population census		
		Total	Rural	Urban	Total	Rural	Urban
0	Uttar Pradesh	0.123	0.131	0.088	0.101	0.106	0.080
132	Saharanpur	0.108	0.114	0.087	0.099	0.105	0.084
133	Muzaffarnagar	0.106	0.110	0.094	0.096	0.105	0.074
134	Bijnor	0.109	0.114	0.090	0.104	0.110	0.082
135	Moradabad	0.112	0.128	0.067	0.109	0.120	0.080
136	Rampur	0.133	0.142	0.098	0.098	0.105	0.072
137	Jyotiba Phule Nagar	0.112	0.121	0.078	0.103	0.111	0.075
138	Meerut	0.092	0.110	0.070	0.085	0.100	0.069
139	Baghpat	0.087	0.092	0.069	0.084	0.088	0.068
140	Ghaziabad	0.079	0.099	0.062	0.089	0.110	0.079
141	Gautam Budaha Nagar	0.096	0.102	0.084	0.083	0.096	0.074
142	Bulandshahr	0.136	0.141	0.120	0.104	0.111	0.083
143	Aligarh	0.133	0.137	0.120	0.104	0.109	0.092
144	Hathras	0.127	0.134	0.097	0.088	0.091	0.075
145	Mathura	0.109	0.117	0.085	0.106	0.115	0.080
146	Agra	0.113	0.120	0.100	0.089	0.095	0.081
147	Firozabad	0.128	0.135	0.109	0.098	0.104	0.084
148	Mainpuri	0.120	0.126	0.085	0.109	0.114	0.075
149	Budaun	0.147	0.157	0.094	0.125	0.130	0.096
150	Bareilly	0.123	0.139	0.080	0.112	0.118	0.096
151	Pilibhit	0.141	0.147	0.109	0.109	0.114	0.084
152	Shahjahanpur	0.141	0.152	0.092	0.113	0.118	0.083
153	Kheri	0.143	0.149	0.086	0.118	0.121	0.089
154	Sitapur	0.147	0.155	0.084	0.127	0.130	0.092
155	Hardoi	0.157	0.164	0.096	0.125	0.128	0.101
156	Unnao	0.141	0.147	0.102	0.108	0.111	0.093
157	Lucknow	0.098	0.132	0.072	0.080	0.102	0.065
158	Rae Bareli	0.142	0.147	0.089	0.108	0.110	0.081
159	Farrukhabad	0.122	0.129	0.093	0.101	0.106	0.079
160	Kannauj	0.125	0.129	0.102	0.099	0.101	0.091
161	Etawah	0.104	0.112	0.076	0.086	0.092	0.062
162	Auraiya	0.122	0.127	0.083	0.090	0.093	0.073
163	Kanpur Dehat	0.149	0.150	0.128	0.096	0.097	0.085
164	Kanpur Nagar	0.112	0.142	0.094	0.084	0.086	0.083
165	Jalaun	0.116	0.124	0.086	0.076	0.081	0.057
166	Jhansi	0.121	0.138	0.090	0.084	0.090	0.074
167	Lalitpur	0.156	0.164	0.102	0.113	0.118	0.076
168	Hamirpur	0.120	0.124	0.103	0.091	0.096	0.071
169	Mahoba	0.133	0.143	0.096	0.096	0.101	0.075
170	Banda	0.138	0.144	0.096	0.102	0.104	0.086

Code	State/District	2001 population census			2011 population census		
		Total	Rural	Urban	Total	Rural	Urban
171	Chitrakoot	0.140	0.144	0.093	0.102	0.104	0.083
172	Fatehpur	0.137	0.142	0.087	0.108	0.112	0.070
173	Pratapgarh	0.117	0.119	0.079	0.095	0.095	0.096
174	Kaushambi	0.135	0.137	0.112	0.127	0.130	0.077
175	Allahabad	0.136	0.143	0.098	0.118	0.125	0.087
176	Barabanki	0.141	0.143	0.113	0.123	0.126	0.090
177	Faizabad	0.115	0.122	0.062	0.101	0.105	0.071
178	Ambedkar Nagar	0.117	0.119	0.092	0.094	0.095	0.093
179	Sultanpur	0.130	0.133	0.077	0.092	0.093	0.064
180	Bahraich	0.144	0.150	0.078	0.115	0.116	0.109
181	Shrawasti	0.151	0.152	0.119	0.119	0.121	0.056
182	Balrampur	0.157	0.160	0.105	0.110	0.112	0.080
183	Gonda	0.123	0.127	0.063	0.095	0.097	0.054
184	Siddharthnagar	0.147	0.147	0.124	0.106	0.108	0.072
185	Basti	0.127	0.130	0.072	0.092	0.094	0.052
186	Sant Kabir Nagar	0.134	0.137	0.100	0.088	0.089	0.070
187	Mahrajganj	0.145	0.147	0.098	0.109	0.111	0.066
188	Gorakhpur	0.095	0.101	0.066	0.079	0.081	0.069
189	Kushinagar	0.107	0.109	0.076	0.108	0.108	0.094
190	Deoria	0.108	0.109	0.096	0.075	0.077	0.062
191	Azamgarh	0.109	0.110	0.088	0.076	0.076	0.079
192	Mau	0.089	0.090	0.086	0.093	0.092	0.097
193	Ballia	0.085	0.086	0.076	0.081	0.081	0.075
194	Jaunpur	0.127	0.129	0.096	0.095	0.096	0.078
195	Ghazipur	0.097	0.098	0.080	0.097	0.098	0.076
196	Chandauli	0.104	0.107	0.078	0.077	0.078	0.070
197	Varanasi	0.107	0.118	0.088	0.091	0.098	0.079
198	Sant Ravidas Nagar	0.134	0.139	0.094	0.114	0.115	0.103
199	Mirzapur	0.128	0.134	0.083	0.112	0.115	0.087
200	Sonbhadra	0.127	0.140	0.063	0.098	0.103	0.066
201	Etah	0.140	0.145	0.112	0.107	0.111	0.085
202	Kanshiram Nagar	na	na	na	0.121	0.124	0.105

Source: Authors' calculations based on the data available through 2001 and 2011 population census.
Remarks: District Kanshiram Nagar was not in existence at the 2001 population census

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Table 2: ${}_5q_0$ in different mutually exclusive population subgroups and inter-district and within district inequality, 2011

State/district	Rural						Urban						D	CV
	Scheduled Castes		Scheduled Tribes		Other Castes		Scheduled Castes		Scheduled Tribes		Other Castes			
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female		
Uttar Pradesh	0.111	0.124	0.111	0.114	0.097	0.108	0.083	0.092	0.065	0.072	0.075	0.083	1.888	0.192
Saharanpur	0.097	0.122	*	*	0.092	0.115	0.075	0.088	*	*	0.075	0.095	1.630	0.167
Muzaffarnagar	0.103	0.120	*	*	0.096	0.112	0.080	0.086	*	*	0.068	0.080	1.777	0.180
Bijnor	0.110	0.121	*	*	0.105	0.111	0.082	0.085	*	*	0.080	0.084	1.506	0.154
Moradabad	0.117	0.136	*	*	0.114	0.124	0.072	0.086	*	*	0.078	0.082	1.881	0.223
Rampur	0.110	0.118	*	*	0.098	0.109	0.068	0.090	*	*	0.072	0.072	1.737	0.200
Jyotiba Phule Nagar	0.111	0.128	*	*	0.105	0.114	0.082	0.084	*	*	0.073	0.074	1.747	0.201
Meerut	0.107	0.122	*	*	0.089	0.104	0.072	0.081	*	*	0.064	0.072	1.903	0.213
Baghpat	0.100	0.095	*	*	0.081	0.093	0.094	0.106	*	*	0.063	0.069	1.680	0.163
Ghaziabad	0.122	0.134	*	*	0.097	0.115	0.083	0.095	*	*	0.073	0.082	1.841	0.202
Gautam Buddha Nagar	0.096	0.118	*	*	0.084	0.105	0.081	0.089	*	*	0.070	0.075	1.685	0.167
Bulandshahr	0.115	0.133	*	*	0.100	0.114	0.088	0.101	*	*	0.078	0.084	1.708	0.169
Aligarh	0.107	0.131	*	*	0.097	0.116	0.093	0.095	*	*	0.088	0.096	1.484	0.130
Mahamaya Nagar	0.089	0.111	*	*	0.079	0.098	0.087	0.099	*	*	0.067	0.075	1.649	0.152
Mathura	0.120	0.142	*	*	0.101	0.121	0.091	0.098	*	*	0.077	0.079	1.846	0.203
Agra	0.091	0.124	*	*	0.080	0.103	0.079	0.093	*	*	0.071	0.088	1.732	0.168
Firozabad	0.105	0.121	*	*	0.089	0.116	0.088	0.096	*	*	0.077	0.088	1.557	0.144
Mainpuri	0.115	0.129	*	*	0.098	0.128	0.068	0.099	*	*	0.067	0.082	1.933	0.236
Budaun	0.123	0.145	*	*	0.120	0.140	0.096	0.115	*	*	0.092	0.098	1.578	0.160
Bareilly	0.118	0.138	*	*	0.108	0.126	0.098	0.108	*	*	0.092	0.099	1.501	0.131
Pilibhit	0.115	0.148	*	*	0.100	0.119	0.075	0.109	*	*	0.070	0.097	2.119	0.224
Shahjahanpur	0.119	0.130	*	*	0.108	0.127	0.076	0.084	*	*	0.081	0.086	1.705	0.204
Kheri	0.125	0.137	*	*	0.108	0.127	0.065	0.112	*	*	0.082	0.098	2.121	0.214

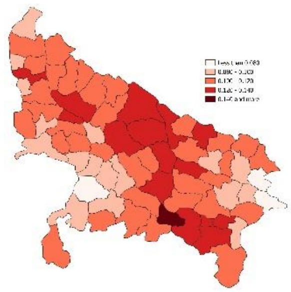
State/district	Rural						Urban						D	CV
	Scheduled Castes		Scheduled Tribes		Other Castes		Scheduled Castes		Scheduled Tribes		Other Castes			
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female		
Sitapur	0.127	0.148	*	*	0.117	0.137	0.092	0.102	*	*	0.089	0.095	1.661	0.183
Hardoi	0.124	0.141	*	*	0.116	0.135	0.100	0.113	*	*	0.091	0.111	1.559	0.136
Unnao	0.112	0.118	*	*	0.108	0.111	0.104	0.099	*	*	0.090	0.092	1.301	0.088
Lucknow	0.111	0.112	*	*	0.095	0.096	0.076	0.073	*	*	0.062	0.065	1.793	0.214
Rae Bareli	0.122	0.120	*	*	0.106	0.101	0.115	0.115	*	*	0.077	0.070	1.746	0.179
Farrukhabad	0.100	0.117	*	*	0.095	0.118	0.069	0.089	*	*	0.074	0.085	1.701	0.180
Kannauj	0.104	0.122	*	*	0.092	0.104	0.096	0.118	*	*	0.080	0.099	1.518	0.124
Etawah	0.093	0.115	*	*	0.082	0.093	0.059	0.070	*	*	0.055	0.068	2.106	0.239
Auraiya	0.094	0.103	*	*	0.089	0.093	0.075	0.080	*	*	0.066	0.079	1.557	0.131
Kanpur Dehat	0.099	0.110	*	*	0.089	0.100	0.080	0.118	*	*	0.082	0.081	1.474	0.140
Kanpur Nagar	0.095	0.104	*	*	0.079	0.082	0.091	0.102	*	*	0.076	0.086	1.374	0.109
Jalaun	0.078	0.094	*	*	0.074	0.085	0.061	0.065	*	*	0.053	0.058	1.784	0.188
Jhansi	0.092	0.103	*	*	0.086	0.086	0.080	0.076	*	*	0.072	0.075	1.446	0.117
Lalitpur	0.117	0.140	*	*	0.104	0.115	0.109	0.079	*	*	0.072	0.072	1.951	0.227
Hamirpur	0.088	0.118	*	*	0.088	0.100	0.081	0.105	*	*	0.058	0.071	2.015	0.200
Mahoba	0.102	0.116	*	*	0.092	0.103	0.065	0.062	*	*	0.072	0.083	1.883	0.213
Banda	0.109	0.135	*	*	0.091	0.107	0.076	0.107	*	*	0.078	0.093	1.768	0.180
Chitrakoot	0.114	0.139	*	*	0.086	0.103	0.096	0.101	*	*	0.069	0.087	2.025	0.197
Fatehpur	0.117	0.129	*	*	0.104	0.112	0.088	0.092	*	*	0.062	0.071	2.071	0.222
Pratapgarh	0.106	0.112	*	*	0.088	0.094	0.086	0.087	*	*	0.095	0.100	1.308	0.093
Kaushambi	0.145	0.149	*	*	0.119	0.120	0.094	0.092	*	*	0.068	0.078	2.206	0.260
Allahabad	0.139	0.155	*	*	0.109	0.124	0.092	0.108	*	*	0.081	0.089	1.926	0.216

State/district	Rural						Urban						D	CV
	Scheduled Castes		Scheduled Tribes		Other Castes		Scheduled Castes		Scheduled Tribes		Other Castes			
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female		
Barabanki	0.134	0.135	*	*	0.122	0.123	0.111	0.107	*	*	0.093	0.083	1.634	0.154
Faizabad	0.121	0.122	*	*	0.097	0.100	0.089	0.075	*	*	0.071	0.067	1.810	0.214
Ambedkar Nagar	0.102	0.107	*	*	0.091	0.091	0.109	0.100	*	*	0.093	0.090	1.208	0.073
Sultanpur	0.109	0.114	*	*	0.086	0.089	0.083	0.075	*	*	0.061	0.064	1.864	0.208
Bahraich	0.126	0.141	*	*	0.106	0.120	0.134	0.090	*	*	0.117	0.099	1.567	0.139
Shrawasti	0.117	0.149	*	*	0.102	0.136	0.019	0.036	*	*	0.053	0.061	7.973	0.539
Balrampur	0.121	0.138	*	*	0.101	0.117	0.086	0.114	*	*	0.067	0.092	2.066	0.203
Gonda	0.107	0.122	*	*	0.087	0.102	0.076	0.081	*	*	0.050	0.054	2.451	0.279
Siddharthnagar	0.119	0.130	*	*	0.102	0.107	0.069	0.090	*	*	0.071	0.070	1.891	0.234
Basti	0.099	0.109	*	*	0.087	0.094	0.060	0.062	*	*	0.051	0.049	2.232	0.288
Sant Kabir Nagar	0.089	0.092	*	*	0.086	0.092	0.069	0.109	*	*	0.061	0.072	1.784	0.172
Mahrajganj	0.117	0.118	*	*	0.109	0.111	0.102	0.072	*	*	0.064	0.062	1.906	0.240
Gorakhpur	0.085	0.091	*	*	0.078	0.081	0.071	0.071	*	*	0.063	0.074	1.461	0.109
Kushinagar	0.115	0.117	*	*	0.109	0.104	0.085	0.055	*	*	0.095	0.096	2.131	0.194
Deoria	0.080	0.087	0.087	0.076	0.074	0.076	0.068	0.063	0.071	0.071	0.057	0.067	1.525	0.117
Azamgarh	0.088	0.088	*	*	0.071	0.073	0.085	0.079	*	*	0.079	0.077	1.251	0.078
Mau	0.092	0.097	*	*	0.090	0.092	0.085	0.092	*	*	0.100	0.095	1.183	0.047
Ballia	0.076	0.084	0.087	0.085	0.079	0.084	0.078	0.094	0.062	0.088	0.071	0.076	1.523	0.102
Jaunpur	0.109	0.117	*	*	0.088	0.093	0.094	0.105	*	*	0.077	0.074	1.587	0.151
Ghazipur	0.104	0.107	*	*	0.094	0.098	0.066	0.077	*	*	0.070	0.085	1.616	0.166
Chandauli	0.088	0.095	*	*	0.069	0.076	0.065	0.084	*	*	0.066	0.073	1.458	0.134
Varanasi	0.125	0.138	*	*	0.086	0.094	0.089	0.091	*	*	0.077	0.078	1.788	0.211
Sant Ravidas Nagar	0.136	0.161	*	*	0.098	0.111	0.114	0.150	*	*	0.093	0.101	1.722	0.196

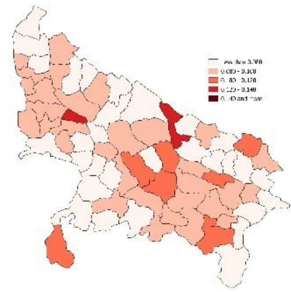
State/district	Rural						Urban						D	CV
	Scheduled Castes		Scheduled Tribes		Other Castes		Scheduled Castes		Scheduled Tribes		Other Castes			
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female		
Mirzapur	0.137	0.149	*	*	0.096	0.111	0.108	0.124	*	*	0.077	0.087	1.927	0.206
Sonbhadra	0.112	0.122	0.117	0.121	0.083	0.094	0.072	0.076	0.109	0.097	0.058	0.069	2.097	0.226
Etah	0.107	0.143	*	*	0.093	0.124	0.087	0.096	*	*	0.072	0.097	1.994	0.205
Kanshiram Nagar	0.133	0.143	*	*	0.115	0.127	0.133	0.119	*	*	0.102	0.103	1.402	0.114
Differential	1.905	1.902	*	*	1.765	1.919	7.139	4.205	*	*	2.337	2.277		
Coefficient of Variation	0.138	0.145	*	*	0.129	0.147	0.208	0.198	*	*	0.176	0.158		

Source: Authors' calculations

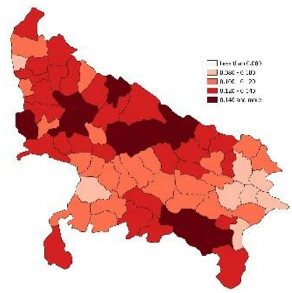
Remarks: * estimates of 5q0 are not calculated because of very small Scheduled Tribes population in these districts.



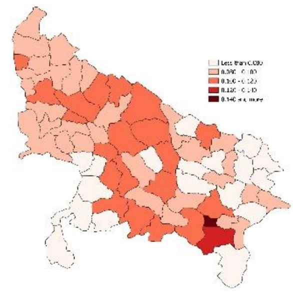
Rural Scheduled Castes male



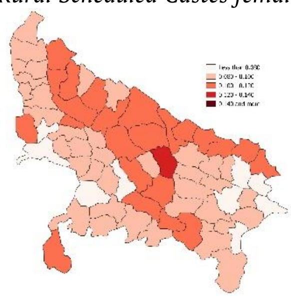
Urban Scheduled Castes male



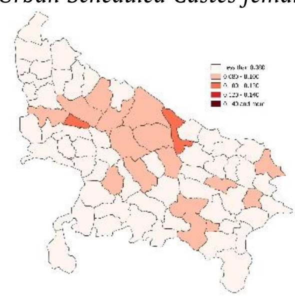
Rural Scheduled Castes female



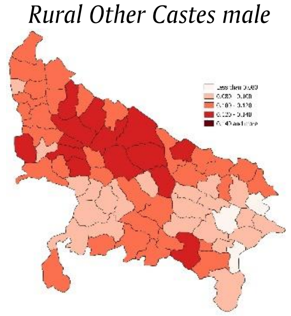
Urban Scheduled Castes female



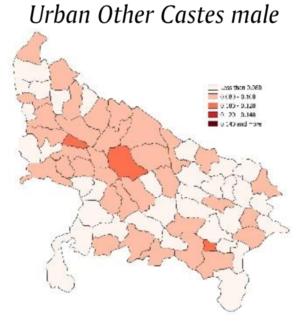
Rural Other Castes male



Urban Other Castes male



Rural Other Castes, female



Urban Other Castes female

Figure 7: Under-five mortality rate in districts of Uttar Pradesh for different mutually exclusive population groups, 2011

Table 2 presents estimates of $_5q_0$ for 12 mutually exclusive population subgroups in the state and in districts as they existed at the 2011 population census. At the state, level, $_5q_0$ is estimated to be the highest in female Scheduled Tribes children living in the rural areas (0.124) but the lowest in male Scheduled Tribes children living in the urban areas (0.065). It may also be seen from the table that $_5q_0$ in female Scheduled Castes children living in rural areas is the highest in 62 districts of the state. There is no district where $_5q_0$ in male Other Castes children in the rural areas is the highest among mutually exclusive population subgroups. Similarly, there is no district where $_5q_0$ in female Other Castes children in urban areas is the highest. Among the 3 districts where Scheduled Tribes population is at least 100 thousand, $_5q_0$ is the highest in male Scheduled Tribes children in rural areas in district Deoria and in female Scheduled Tribes children in rural areas in district Ballia. In other population subgroups, $_5q_0$ is the highest in only a few districts. Taking variation across districts and across population subgroups within district, $_5q_0$ is estimated to be the highest in Scheduled Castes female children in the rural areas of district Sant Ravidas Nagar (0.161) but the lowest in the Scheduled Castes male children in the urban areas of district Shrawasti (0.019).

The residence and gender effects of $_5q_0$ are very strong in the state. Rural $_5q_0$ is higher than urban $_5q_0$ in the state and in all districts but rural-urban gap has decreased in the state and in most of the districts. There are 12 districts where rural-urban gap has widened. Similarly, $_5q_0$ is higher in female compared to male children in all social classes in both rural and urban areas. In the urban areas, female $_5q_0$ is substantially higher than male $_5q_0$ in Other Castes. In case of male Scheduled Castes children, $_5q_0$ is higher in urban than in rural areas in 3 districts, whereas in case of female Scheduled Castes children, $_5q_0$ is higher in urban than in rural areas in 4 districts. In Other Castes, male $_5q_0$ is higher in urban than in rural areas in 5 districts.

Child Mortality Inequality

Figure 1 shows district wise distribution of $_5q_0$ for the combined population for 2001 and 2011 census which depicts inter-district variation in the child mortality in the state. of Uttar Pradesh. The figure reveals that inter-district disparity in $_5q_0$ in the state has decreased over time. The data available from 2011 population census suggest that $_5q_0$ was higher than the state average in 35 of the 71 districts that existed at the 2011 population census whereas data available from 2001 population census suggest that $_5q_0$ was higher than the state average in 36 of the 70 districts which existed at the 2001 population census. According to the 2001 population census, $_5q_0$ was very high (>0.130) in 29 of the 70 districts. However, there was no district according to the 2011 population census where $_5q_0$ was very high. On the other hand, according to the 2001 population census, $_5q_0$ was very low (≤0.085) in only 2 districts of the state whereas according to the 2011 population census, $_5q_0$ was very low in 12 districts of the state. The differential or the ratio of the highest to the lowest $_5q_0$ across districts decreased from 1.99 based on 2001 population census to 1.69 based on 2011 population census whereas the inter-district coefficient of variation decreased from 0.152 to 0.134 reflecting the decrease in inter-district inequality and the convergence in $_5q_0$ across the districts of the state over time.

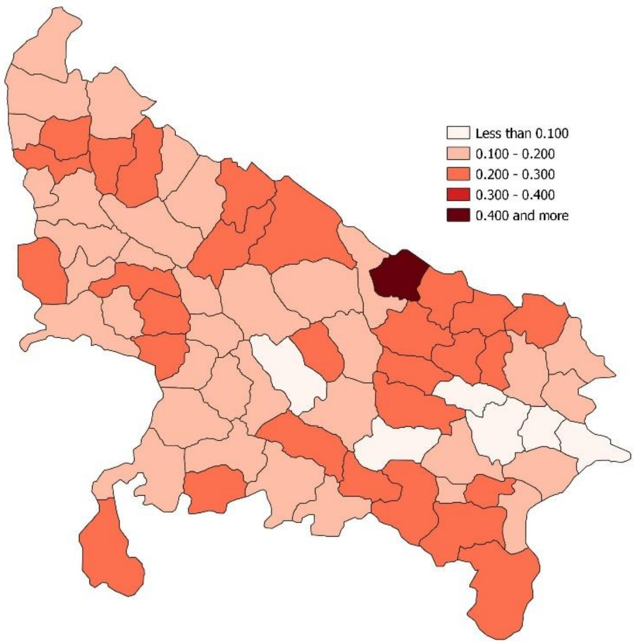


Figure 8: Within-district inequality in under-five mortality rate in Utter Pradesh, total population, 2011

The inter-district inequality in $_5q_0$ has been found to be relatively higher in the urban as compared to the rural areas of the state according to the 2011 population census. More importantly, inter-district inequality in the rural areas appears to have decreased over time as the inter-district differential (ratio of highest to lowest under-five mortality rate) decreased from 1.907 to 1.693 and inter-district coefficient of variation decreased from 0.140 to 0.134 according to 2001 and 2011 population census. In the urban areas, however, the inter-district differential in $_5q_0$ increased from 2.065 to 2.096 but the inter-district coefficient of variation decreased from 0.170 to 0.151. It appears that there has been only a marginal decrease in the inter-district inequality in $_5q_0$ in the urban areas of the state.

The inter-district inequality in $_5q_0$ has been found to be different in different mutually exclusive population sub-groups. Both inter-district differential and inter-district coefficient of variation in $_5q_0$ are found to be the lowest in Other Castes male children in the rural areas but the highest in Scheduled Castes male children in the urban areas. Inter-district inequality in Scheduled Castes female children in the urban areas has also been found to be very high. In the urban areas, inter-district inequality in ${}_5q_0$ is found to be substantially lower in Other Castes children compared to Scheduled Castes children. In the rural areas, however, inter-district inequality in Other Castes female children is higher than that in Scheduled Castes female children but inter-district inequality in ${}_5q_0$ in Other Castes male children is found to be lower than that in Scheduled Castes male children.

Finally, within district inequality in ${}_5q_0$ across mutually exclusive population subgroups varies widely across the districts of the state (Figure 8). This inequality is found to be the highest in district Shrawasti but the lowest in district Mau of the state. In district Shrawasti, ${}_5q_0$ in Scheduled Castes female children living in the rural areas is found to be almost 8 times the ${}_5q_0$ in Scheduled Castes male children living in the urban areas of the district. By contrast, in district Mau, ${}_5q_0$ is the in the Other Castes male children living in the urban areas which is the highest in the district is less than 20 per cent higher than the ${}_5q_0$ in the Other Castes male children living in the rural areas which is the lowest in the district.

Conclusions

The present analysis shows that the inequality in child mortality within Uttar Pradesh are quite pervasive and addressing these differentials is necessary to increase the survival chances of young children in the state. The analysis also emphasises that the current, heavily centralised, approach to promoting child survival in the state should be replaced by a decentralised institutional set-up which can effectively address the local context of child mortality, and which may provide better opportunities for people's participation in child efforts directed towards preventing unwanted, premature, child deaths. Such a shift in the approach towards child survival, however, requires significant improvement in the administrative capacity and organisational efficiency of the public health care delivery system along with the reduction in the residence and social class inequalities in the quality of life. There is a need of a long-term vision, strong political commitment for child survival in the state which remains to be unacceptably low.

The analysis also reveals substantial within-district inequality in child mortality. This inequality reflects both inequality in living standards and disproportionate use of health care services such as immunisation against vaccine preventable diseases and use of oral rehydration salt to prevent deaths due to dehydration during diarrhoea across different mutually exclusive population groups within the same district. It appears that the reach of child survival efforts in the state is not the same in different population groups which again reflects that there is scope for improvement in the needs effectiveness and capacity efficiency of child survival efforts in the state. At present, very little is known about the needs effectiveness and capacity efficiency of child survival efforts in the state, especially at the local level. A data revolution is needed to generate the data necessary for analysing both endogenous and exogenous factors of child mortality at the local level.

Probably, and so obviously, Uttar Pradesh needs a policy on children to address the child mortality inequality that appears to be so pervasive and persistent in the state. A state policy on children is also necessary to address regional, social class, residence, and gender inequality in child mortality. The state endorses the National Policy on Children (Government of India, 2013) which is, however, silent about the need of addressing the regional, social class, residence, and gender inequalities in child mortality. Uttar Pradesh can accelerate the pace of reduction in child mortality just by reducing inter-district, social class, residence, and gender inequalities in child mortality by suitably reorienting its child survival efforts. A state-specific policy on children may be the beginning in this direction.

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Consequences of the Benefits from Promotional Safety Net Programmes in Bangladesh and Factors for Not Graduating from Poverty

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Abstract

This paper evaluates selected social safety nets programmes (SSNPs) in Bangladesh with respect to livelihood issues and identifies reasons behind their ineffectiveness in the graduation from poverty. The paper suggests that moderate food insecurity status and 'extremely poor' condition has decreased significantly in households covered under these programmes, but only about three-in-ten respondents agreed that benefits from SSNPs helped to overcome poverty. The analysis reveals four major dimensions of ineffectiveness: 1) lack of skills development; 2) poor quality of goods; 3) insufficient programme benefits; and 4) loss of investment or rather delayed disbursement. Increasing benefits package and duration can make these programmes more effective.

Introduction

Bangladesh is implementing several social safety nets programmes that target different population groups to cope with adverse situations that are either individualistic or combined in nature. It is documented that safety nets contribute to the development policies of Bangladesh in four ways: 1) redistribution of income to the poorest and most vulnerable to overcome the vulnerability; 2) enabling households to make better investments in future; 3) helping households to manage risk; and 4) allowing the government to make choices that support efficiency and growth (World Bank, 2008). Poverty is considered as a great obstruction for the development of Bangladesh and, therefore, social safety net programmes become the integral part as anti-poverty strategy. Although, there has been a long struggle to reduce poverty and improve living standards of the people, yet, Bangladesh has recently been successful in reducing poverty. However, about one-fifth of its population is still living below the poverty line. It is documented that social safety net programmes are the basis of the social protection approach of the country and are the backbone of poverty alleviation strategy (World Bank, 2006). The social safety net programmes in Bangladesh are being implemented following both protection and promotion approaches (Khuda, 2011). The programmes that were launched in 1972 followed the protection approach. The promotion approach was introduced later to raise income and employment opportunities of the poor to graduate them from poverty.

Many studies have analysed SSNPs in Bangladesh from different aspects including targeting effectiveness, leakages, challenges, productive outcomes, and impact (Ahmed *et al*, 2009; Ahmed *et al*, 2014; Barkat *et al*, 2013; Hossain *et al,* 2018; Ismat Ara, 2013; Rahman *et al*, 2011; Rahman and Choudhury, 2012; Zohir *et al*, 2010). Studies on consequence and productive outcomes of these programmes indicate encouraging effects on the standard of living of the beneficiary households (Ahmed *et al,* 2009; Hulme and Moore, 2010; Ismat-Ara *et al,* 2013; NFPCSP and BRAC, 2009). Some studies show that most of the households which benefited from cash-based transfer programmes have increased household income, which helped in improving both quality and quantity of food-intake but addressed only the transient poverty in the short-run (Ninno and Dorosh, 2001; Matin and Hulme, 2003). Comparing food and cash transfers to the ultra poor, Ahmed *et al* (2009) have shown that transfers under SSNPs have played a crucial role in improving food security and expanding the assets base of the poor housheolds. Some programmes such as Vulnerable Group Development Programme (VGD), Rural Employment and Road Maintenance Programme (RERMP), Old Age Allowance (OAA), and microcredit schemes have been documented to have long-term development impact on the life and livelihood of the members of the beneficiary households (Khanum, 2000; Karim *et al*, 2003). It is also documented that the development impact of these programmes also included improvement in housing conditions, accumulation of assets for income generation, and other development issues like increase in female age at marriage, women empowerment, and old age security.

Reviewing the VGD activities in Bangladesh, Begum (2018) has documented that this programme is contributing to the resilience of beneficiary households in terms of decreasing begging and landlessness and increasing dignity and social status. Recently, Bangladesh Institute of Development Studies has assessed the appropriateness, effectiveness, and efficiency of the Employment Generation Program for the Poorest (EGPP) with a view to provide insights and recommendations regarding ensuring better livelihood, better coping mechanism and increasing the involvement of women in the decision-making process within the household (BIDS, 2018). The study found that beneficiary households are in a better position regarding livelihood strategy, accumulation of assets and acquiring position in the society. Using very small micro-level data, Uddin (2013) has attempted to evaluate the impact and implications of the Old Age Allowance Program to identify factors influencing program operations and performance. The study shows that the programme has a positive impact on food accessibility in the beneficiary households. The study has also documented that both quality and quantity of food has improved in the beneficiary households. On the other hand, the Power and Participation Research Centre (PPRC) of Bangladesh has conducted a study to provide guidelines for making essential reforms policy framework and portfolio of social safety net programmes (Rahman *et al*, 2011; Rahman and Choudhury, 2012). After empirical evaluation of ten major social safety nets programmes, the study has documented that, although, there has been a significant decline in the worst-off category (chronic deficit households), improvement at the highest end of the poverty scale (the surplus category) has been muted. Some studies, however, question whether these programmes do really provide a strategy for poverty alleviation, or they are limited to consumption and income smoothing (World Bank, 2006). It is, therefore, necessary to evaluate whether participation in social safety net programmes has resulted in an increase in household consumption and household income and has a beneficial impact on human capital formation and longer-term income generation.

The review of literature also suggests that SSNPs, to some extent, have been able to reduce the vulnerability of the poor. There are, however, only a few studies that paid due attention to the impact of SSNPs on poverty elimination. There is, therefore, a need to explore the contribution of SSNPs in the graduation from poverty. There is also a need to investigate why beneficiary households covered under SSNPs have not been able to come out of the poverty. The present study aims to explore the impact of SSNPs on the economy of the beneficiary households. The study also attempts to identify major factors of not graduating from poverty. The study covers only three important social safety nets programmes of Bangladesh – Vulnerable Group Development Programme (VGD,) EGPP and Rural Employment and Road Maintenance Programme (RERMP).

Data and Methods

The study is based on the data collected under the project "Effectiveness of Some Selected Promotional Social Safety Nets Programmes in Bangladesh: Formulation for Future Strategies", which was sponsored by the Social Science Research Council, Ministry of Planning, Government of Bangladesh. The sample for the study was selected following the cluster sampling method with primary sampling units (PSUs) of Bangladesh Bureau of Statistics as clusters. The necessary data were collected from 900 households covering 30 rural clusters in Sylhet division of the country. Out of 900 households, 600 were beneficiaries of any one of the three social safety nets programmes - VGD, EGPP and RERMP - while 300 were not beneficiaries of these programmes, although, they were eligible for benefits under these programmes (Hossain, 2020a).

The methods of analysis included case-control and before-and-after comparison analysis. Exploratory factor analysis was used to identify major dimensions of factors of not graduating from poverty. Factor analysis is considered as an ideal method to identify the major dimensional components and has been used in several studies of similar nature (Hossain, 2020b; Hossain *et al*, 2011). Theoretical and computational aspects of factor analysis are available in many textbooks (Manly, 2004; Rencher, 2002). The impact of the programme was explored by comparing the situation prevailing in 2015 - before receiving benefits under the programme – and the situation that prevailed in 2018 - receiving the benefits under the programme. The impact was measured from two perspectives: i) food security, social and economic status and expenditure on health and education; and ii) programme effectiveness and likely solutions. The exploratory factor analysis was able to identify main dimensions of factors that inhibit beneficiary households from graduating from poverty.

Results and Discussions

Food Security

The household food insecurity status was classified into four categories – severe, moderate, mild, and no food insecurity. A household, which reported that the members of the household were bound to sleep in hunger, was classified as severely food insecure. A household which could not provide three meals in a day to its members was classified as moderately food insecure. A household which reported some days of hunger was classified as mild food insecure. Finally, a household which could provide three meals in a day throughout the year to its members was classified as household with no food insecurity. The proportion of households with severe food insecurity was 11.7 per cent in beneficiary households in 2015 which decreased to 9 per cent in 2018 but the decrease was not statistically significant (z =1.54, p>0.05). On the other hand, the proportion of households with severe food insecurity was 10.1 per cent in non-beneficiary households in 2015 which increased to 11.4 per cent in 2018 but the increase was not statistically significant (z =-0.51, p>0.05). The difference in the proportion of severely food insecure beneficiary households and non-beneficiary households was also not statistically significant either in 2015 (z =0.71, p>0.05) or in 2018 (z =-1.13, p>0.05). This shows that the social safety net programmes have contributed little to reducing severe food insecurity (Table 1). It may, however, be seen from table 1 that social safety net programmes have been able to reduce moderate and mild food insecurity. The proportion of households without any food insecurity also increased statistically significantly in the beneficiary households whereas the increase in this proportion in the non-beneficiary households was statistically insignificant.

Table 1: Percentage of households suffered from different levels of food insecurity in 2015 and in 2018

Food insecurity status	Percentage of Households with Types								
	Beneficiary			Non-Beneficiary			Overall		
	2015	2018	'P'	2015	2018	'p'	2015	2018	'p'
Severe	11.7	9.0	0.123	10.1	11.4	0.351	11.2	9.8	0.251
Moderate	23.4	18.0	0.028	33.3	30.7	0.318	26.6	22.1	0.034
Mild	24.2	20.1	0.092	30.9	32.1	0.380	26.4	24.0	0.202
No insecurity	40.6	52.9	<0.001	25.7	25.9	0.398	35.8	44.1	0.001

Source: Authors

In addition to quantifying the food security status, the opinion of the respondents of beneficiary households on the beneficial effects of the programme was also sought. The perceptions of beneficiary households are shown in Appendix Table 1. Nine out of every ten respondents of the beneficiary households agreed that benefits of the programme helped the household to improve food security. Besides, about 42 percent of the respondents reported for creation of additional work opportunities and about 46 percent reported for increasing working hours of household members as beneficial effects of SSNPs. These findings suggest that social safety net programmes helped, to some extent, in improving household food security situation as well as creating additional work opportunity and increasing working hours.

Socio-economic Status

About 33 percent beneficiary households and about 32 percent non-beneficiary households were ‘extremely poor’ in 2015 and the difference between the two was statistically insignificant (z =0.30, $p>0.05$). However, the proportion of ‘extremely poor’ households among the beneficiary households decreased to around 25 per cent in 2018 and the decrease was statistically significant (z =3.40, $p>0.05$) whereas the decrease in non-beneficiary households was marginal and statistically insignificant (z = 0.26, $p>0.05$). On the other hand, the proportion of poor and middle-class households increased among the beneficiary households and the increase was statistically significant (z = -2.76, $p<0.01$ & z = -1.92, $p<0.07$) whereas the proportion of moderately poor households decreased in the non-beneficiary households and the decrease was statistically insignificant (z =0.64, $p>0.05$). There has, however, been no change in the proportion of rich households among beneficiary households. By contrast, the change in the socio-economic status of the non-beneficiary households was not statistically significant (Table 2).

Table 2: Percentage of households with self-assessed socioeconomic status for the period 2015 and 2018

Socio-economic Status	Percentage of Households with Types								
	Beneficiary			Non-Beneficiary			Overall		
	2015	2018	p	2015	2018	p	2015	2018	p
Extremely poor	33.4	24.5	0.001	32.4	31.4	0.386	33.1	26.7	0.005
Moderately Poor	25.6	24.0	0.325	29.0	29.3	0.398	26.7	25.7	0.356
Poor	33.6	41.3	0.009	35.5	34.8	0.393	34.2	39.2	0.036
Middle-class	7.0	10.1	0.063	2.8	4.1	0.276	5.6	8.2	0.038
Rich	0.2	0.2	0.399	0.3	0.3	0.399	0.1	0.2	0.344

Source: Authors

The respondents of the beneficiary households were also asked about the beneficial effects of the promotional safety nets programmes in terms of improvement in the living conditions, change in the status of the household in the society, increase in the household income, increase in the ownership of livestock and poultry, and the capability of the household to tackle the asset depletion. More than half of the respondents of the beneficiary households reported that benefits of the promotional social safety nets programmes helped to change the status of the household in the society, while about 56 percent reported that these safety nets helped in increasing household income. On the other hand, about 37 percent of the respondents reported that household ownership of livestock and poultry had increased whereas nearly two-third of the respondents reported that these programmes helped in tackling household asset depletion.

Table 3: Perceptions on change in educational and health expenditure in 2018 compared to 2015

Indicators	Beneficiary	Non-Beneficiary	p-value	Overall
Education Expenditure				
Increased (percent)	64.4	56.6	0.032	61.8
No change (percent)	25.5	36.6	0.001	29.1
Decreased (percent)	10.1	6.9	0.118	9.1
Average expenditure per household in 2015 (Taka)	9138.1	9085.9	0.398	9122.9
Average expenditure per household in 2018 (Taka)	11914.0	10349.5	0.157	11436.8
Health Expenditure				
Increased (percent)	63.4	61.0	0.314	62.6
No change (percent)	20.6	25.5	0.102	22.2
Decreased (percent)	16.0	13.4	0.239	15.2
Average expenditure per household in 2015 (Taka)	9827.6	11392.0	0.123	10334.4
Average expenditure per household in 2018 (Taka)	11830.5	12800.1	0.278	12147.9

Source: Authors

Education and Health Expenditure

About 64 percent respondents of the beneficiary households reported an increase in the household education expenditure whereas only about 10 percent respondents of the beneficiary households reported that there was a decrease in the household education expenditure between 2015 and 2018. The corresponding proportions for the non-beneficiary households was 57 percent and 7 percent respectively. The increase in the average expenditure on education per household was, however, more in beneficiary households as compared to non-beneficiary households and the difference was found to be statistically significant ($z=-3.01$, $p<0.01$). Almost similar findings have been observed in case of health expenditure. About 63 percent of the respondents of the beneficiary households and 61 percent respondents of the non-beneficiary households reported an increase in health expenditure during 2015-18. The increase in the average health expenditure in beneficiary households between 2015 and 2018 has been found to be statistically significant ($z=-2.82$, $p<0.01$). On the contrary, the increase in the health expenditure in non-beneficiary households has, however, not been found to be statistically significant (z=-1.04, p>0.05).

Programme Effectiveness and Probable Solutions

The respondents of beneficiary households were asked whether they were satisfied from the provisions of the social safety nets programmes. A little more than four-fifth of the respondents reported that provisions under the social safety nets programmes were up to the mark, and they were satisfied from the provisions (Appendix Table 1). However, only 27 percent respondents agreed that social safety nets programmes were able to fulfil their purpose. In addition, about 30 percent of the respondents were of the view that provisions under the programmes helped in overcoming household poverty (Appendix Table 1). However, about four-fifth of the respondents were of the view that these programmes needed to be modified to make them more effective.

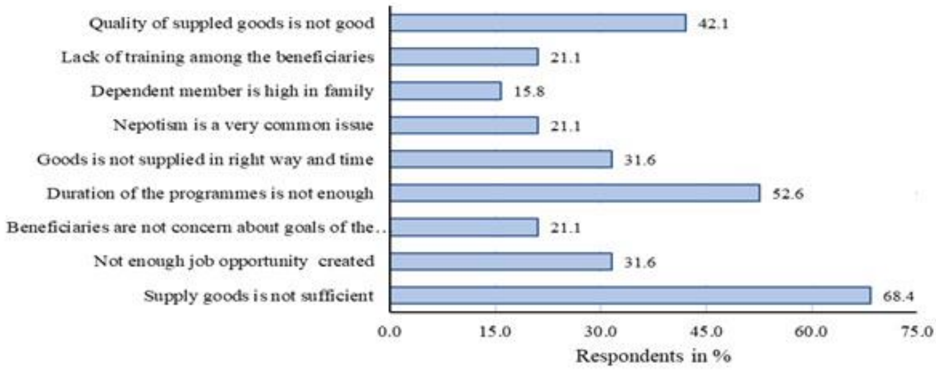

Figure 10: Reasons of ineffectiveness of VGD programme.
Source: Authors

The study also explored reasons of the ineffectiveness of VGD and probable solutions to improve the effectiveness of SSNPs. The main reason for programme ineffectiveness, was inadequate quantity of the goods supplied, followed by short duration of the programme. Inferior quality of goods supplied was also reported to be an important factor behind the ineffectiveness of these programmes (Figure 1). On the other hand, nearly one-third of the respondents were of the view that these programmes were not able to create enough job opportunities while one-third of the respondents argued that the benefits of these programmes could not be disbursed in an appropriate manner and in time among beneficiaries.

In the context of VGD programme, the respondents gave three main suggestions to improve the effectiveness: 1) increasing the benefit amount; 2) relevant skills development training; and 3) increase in programme duration (Figure 2). Another suggestion was related to the quality of goods provided through the programme.

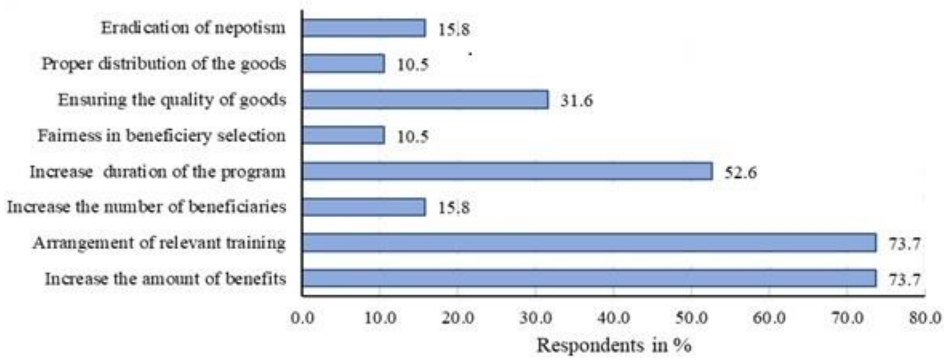

Figure 11: Suggestions to for graduating from poverty through VGD programme
Source: Authors

Major Dimensions for Not Graduating from Poverty

The respondents of the beneficiary households were asked to rank some pre-determined reasons that may be responsible for not graduating from poverty from social safety net programmes. Using these rankings, exploratory factor analysis was carried out to identify main dimensions which are responsible for not graduating from poverty. A set of nine reasons was selected for the purpose and for each reason, ranking was done on 5-point Likert scale - Strongly disagree, disagree, no comments, agree, and strongly agree (Appendix Table 2). The nine reasons were mutually exclusive. They were selected by reviewing the available literature on this issue.

Appendix table 2 gives the mean rankings and the correlation matrix. The mean rank is found to be the highest for insufficient benefits from the programme which means that majority of the respondents strongly agreed that this was the main reason for not graduating from poverty. The other reason that showed moderate agreement was inadequate programme duration. The mean rank was also found to be more than the median (as the Likert scale ranges from 1-5) for inferior quality of goods, inappropriate market value of goods, inability to invest benefits in productive sectors, lack of training, and training are not relevant with skills. On the other hand, the mean rank was found to be less than the median in case of 1) not getting benefit in time; and 2) damage of investment.

Results of exploratory factor analysis are presented in table 4. The principal component method with varimax rotation was used to extract factors. The table suggests that the nine reasons can be grouped into four dimensions. The first dimension includes three reasons: 1) training do not match with personal skills; 2) lack of training; and 3) unable to invest benefits in productive sectors. This dimension can be named as lack of skills development. The second dimension comprises of two reasons: 1) quality of in-kind goods is not up to the mark; and 2) not getting appropriate market value of the in-kind goods provided under the programme and may be termed as insufficient programme benefits. The third dimension also comprises of two reasons: 1) allocation amount was insufficient; and 2) programme duration was short and may be named as loss of investment rather delayed payment. Finally, the fourth dimension comprising of: 1) damage of investment; and 2) not getting benefit in due time may be termed as delayed disbursement. The exploratory factor analysis suggests that these four dimensions contribute for not graduating from poverty.

Table 4: Major dimensions for not graduating from Poverty

Reasons		Factor loadings				Communalities
		F1	F2	F3	F4	
1	Allocation amount is not sufficient			0.814		0.703
2	Program duration is not sufficient			0.816		0.686
3	Not getting benefit in due time				-0.796	0.683
4	Quality of in-kind benefit goods in not decent		0.890			0.801
5	Not getting appropriate market value of the in-kind benefit goods		0.817			0.729
6	Unable to invest benefits in productive sectors	0.590				0.579
7	Lack of training	0.778				0.664
8	Training is not relevant to skills	0.795				0.657
9	Damage of Investment				0.660	0.593
Percentage of Explained Variation		26.89	16.45	13.22	11.17	
Total Variation explained by the extracted factors		67.72				
K-M-O Measure of sampling adequacy		0.639				
Bartlett's test of sphericity		Chi-square = 591.69, p<0.0000				

Source: Authors

Conclusions

The present study reveals that households benefitted from social safety net programmes are relatively in better position in terms of food security, socio-economic status, and investment in education and health as compared to households which are not benefitted from these programmes. The study also suggests that benefits received under the social safety net programmes have helped households to create work opportunities, increase working hours, harness better living conditions, increasing household income, and tackle household asset depletion. However, only about a quarter of the respondents agreed that social safety nets programmes had fulfilled their purpose. The study shows that, although, the vulnerability of the beneficiary households has decreased remarkably due to safety nets programmes, yet the improvement was not up to the mark with respect to graduation from poverty. There is a need of increasing the benefit amount and programme duration and strengthening the skill development activities to make these programmes more effective.

Based on the findings of the study, the following recommendations may be put forward to make social safety programmes in Bangladesh more effective:

- The benefit amount of the programmes needs to be increased up to a satisfactory level so that beneficiary households can save adequate amount to invest in any income generating activity after the completion of programme cycle.
- The duration of the programmes needs to be extended, so that beneficiary households can get space for making future plans.
- Skills development activities under these programmes need to be strengthened to improve the competency of the beneficiaries in performing income generating activities. Training under VGD program should be aligned with the strengths and opportunities of the beneficiary households in terms of the capacity of household members.

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Appendix Table 1: Perception of beneficiary households on SSNPs

Perception on SSNP Benefits	Type of SSNP Benefits				
	VGD	EGPP	RERMP	Food for work/ Work for money	Total
	%	%	%	%	%
Helps for improving food security status					
Yes	96.2	47.5	93.3	100.0	92.8
No	3.8	52.5	6.7	-	7.2
Helps for making work/job opportunity					
Yes	34.4	85.0	71.1	100.0	42.3
No	65.6	15.0	28.9	-	57.7
Helps for increasing working hour					
Yes	43.0	30.0	77.8	100.0	46.3
No	57.0	70.0	22.2	-	53.7
Helps for better livelihood					
Yes	84.4	75.0	91.1	100.0	84.7
No	15.6	25.0	8.9	-	15.3
Helps for changing the social status					
Yes	53.2	32.5	53.3	75.0	52.4
No	46.8	67.5	46.7	25.0	47.6
Effect on monthly income in last one year					
Increased	56.4	47.5	46.7	100.0	56.2
No Change	40.8	45.0	22.2	-	38.6
Decreased	2.8	7.5	31.1	-	5.2
Helps for increasing the ownership of poultry and livestock					
Yes	35.0	20.0	62.2	87.5	37.4
No	65.0	80.0	37.8	12.5	62.6
Helps to tackle down the asset depletion					
Yes	64.4	37.5	71.1	93.8	63.9
No	35.6	62.5	28.9	6.3	36.1
Satisfaction on Safety nets services					
Yes	85.0	60.0	91.1	68.8	83.4
No	15.0	40.0	8.9	31.3	16.6
Fulfilment of the purposes of beneficiaries					
Yes	24.6	17.5	64.4	25.0	27.1
No	75.4	82.5	35.6	75.0	72.9
Helps to overcome from poverty condition					
Yes	26.8	25.0	68.9	25.0	29.8
No	73.2	75.0	31.1	75.0	70.2
Necessity of modification of the SSNP program					
Yes	79.8	92.5	77.8	81.3	80.5
No	20.2	7.5	22.2	18.8	19.5
N	500	40	45	16	601

Source: Authors

Appendix Table 2: Correlation matrix of causes for not getting out of poverty along with mean responses*

SN	Causes of not graduating from poverty	2	3	4	5	6	7	8	9
1	Allocation amount is insufficient	0.451*	-0.021	0.248*	0.266*	0.284*	0.062	0.020	0.112*
2	Programme duration is insufficient		-0.012	0.124*	0.169*	0.124*	0.031	-0.092*	0.102*
3	Not getting benefit in due time			0.119*	0.063	0.066	-0.039	0.005	-0.148*
4	Quality of in-kind benefits not decent				0.577*	0.176*	0.115*	0.151*	0.193*
5	No appropriate market value of in-kind benefits					0.290*	0.229*	0.136*	0.182*
6	Unable to invest benefits in productive sectors						0.268*	0.242*	0.110*
7	Lack of appropriate training							0.445*	0.285*
8	Training is not relevant to skills								0.156*
Mean (n=422)		4.06	2.78	3.23	3.28	3.46	3.30	3.20	2.90

* $p<0.05$.

Source: Authors

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Patterns of Migration in Uttar Pradesh: Evidence from Population Census

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Abstract

This paper analyses the movement of the population of Uttar Pradesh using the data from 2001 and 2011 population censuses. At the 2011 census, nearly 13 million persons born in Uttar Pradesh were enumerated in other states of India while 2.8 million persons born in other states were enumerated in the state. The paper also reveals substantial movement of the population within and across districts of the state which has implications for development.

Introduction

Uttar Pradesh, with population of 199 million at the 2011 population census, constitutes about one sixth of India's population. The average annual population growth rate of the state was 1.84 percent per year during the period 2001-2011 according to the 2011 population census. The state is one of the high population density states of the country with a population density of 828 persons per square kilometres. Fertility and mortality parameters of the state are amongst the poorest in the country. According to the National Family and Health Survey 2015-16, infant mortality rate in the state was 64 infant deaths for every 1000 live births; under-five mortality rate was 78 under-five deaths for every 1000 live births while total fertility rate was 2.7 children per women around the year 2015 (Government of India, 2017). Although, fertility and mortality are decreasing in the state, yet they remain high compared to other states of the country.

Uttar Pradesh has historically been an out-migration state of India with people born in the state moving out for livelihood. Descents of migrants from the state may be found in countries like Mauritius, Fiji, Guyana, Jamaica, and Trinidad and Tobago. There has also been substantial movement of the population within the state, across districts, because of differential level and pace of social and economic development across different regions. Many studies on the level and pattern of migration in India have discussed migration from and to Uttar Pradesh based on the data from decennial population census of the country (Davis, 1951; Premi, 1980; 1984; Skeldon, 1986;

Bhagat, 2010; Srivastava, 1979; Singh, 1996; 1998). There are also studies that are based on the data from the National Sample Survey. These studies have primarily analysed the determinants and characteristics of migrants (Keshri and Bhagat, 2012; Banerji and Raju, 2009; Singh, 2005; Kundu and Ray, 2012). Some of the studies have analysed the impact of migration on females (Lingam, 1998). However, to the best of our knowledge, there is no study which has analysed within-state, inter-district, migration in Uttar Pradesh. This paper attempts to analyse migration across districts of Uttar Pradesh in terms of the level, reasons for migration, educational status and work participation rate of migrants based on 2001 and 2011 census data. At the same time, the paper presents an over-view of the migration out of and into the state.

The paper is organized as follows. The next section of the paper describes the sources of data used in the analysis. The paper is based on the data on place of birth and place of enumeration collected at the decennial population census in India. Section three of the paper presents a snapshot of the movement of the population of the state along with some characteristics of the migrant population and reasons for migration. Section four of the paper describes the movement of the population within the state, across districts, and migration into the state from other states of India and from other countries of the world. The last section of the paper summarises the findings of the analysis and discusses their implications for social and economic development of different regions of the state.

Data

The decennial population census of India is the main source of data on migration. In all decennial population censuses of India since 1872, migration status of the people has been collected in terms of "place of birth" and "place of enumeration". Since 1971, migration data were also collected about the of place of the last residence and the duration of migration. The place of birth and place of last residence of a person provide information on the spatial aspects of population movement, while the duration of residence at the place of enumeration provides information on the temporal aspects of migration (Singh, 2005). These data also cover the spatial movement of the population based on the crossing of geographical/administrative boundaries. During the population census, information about the exact distance moved is not collected but the distance travelled is classified in terms of short, medium, and long distance only.

The present study uses data about place of birth and place of enumeration from India's 2011 and 2001 population census which are classified by the place of birth, place of last residence and the duration of stay at the place of enumeration. Based on these data, an individual enumerated at a particular place at the time of population census may be classified into the following five mutually exclusive categories of migrants so that these five categories add up to the total population of the country or the state or the district:

A. Non-migrants. Persons who are enumerated at their place of birth at the time of population census.
B. Intra-district migrants. Persons who are enumerated at a place different from the place of birth within the same district.
C. Inter-district migrants. Persons who are enumerated in a district but born in another district of the same state.
D. Inter-state migrants. Persons who are enumerated in a state but born in another state of the country.
E. International Migrants. Persons who are enumerated in India but born in other countries.

Migration in and out of Uttar Pradesh

At the 2011 population census, almost 28 per cent population of Uttar Pradesh was classified as migrant population in the sense that this population was enumerated at the place different from the place of birth (Table 1). This proportion was around 24 percent at the 2001 population census. The proportion of population moving within the district and the proportion of population moving across the districts of the state have also increased over time. Similarly, the proportion of population moving in the state from other states of India has also increased. However, there has been a marginal increase in the proportion of the population moving into the state from other countries of the world. About 60 per cent of the migrant population in the state was within-district migrants while 31 per cent was inter-district migrants. Inter-state migrants constituted only 7 per cent of the state population at the 2011 population census. The migrant population of the state increased by 41 per cent between 2001 and 2011 compared to an increase of about 20 per cent in the non-migrant population.

Table 1: Population of Uttar Pradesh by migration categories 2001 and 2011.

Migration category	2011			2001		
	Persons	Male	Female	Person	Male	Female
Non-Migrant	72.2	89.6	53.2	76.1	92.3	58.1
Intra-district	16.9	6.5	28.3	15.1	4.3	27.1
Inter-district	8.7	2.8	15.1	7.0	2.4	12.1
Inter-state	2.0	1.0	3.1	1.7	0.9	2.6
International	0.1	0.1	0.2	0.1	0.1	0.1
Total Migrants	27.8	10.4	46.7	23.9	7.7	41.9
Population	199812341	104480510	95331831	166197921	87565369	78632552

Source: Population census 2001 and 2011.

The composition of the population by the migration status is found to be radically different in females as compared to males. The proportion of the migrant population was substantially higher in females as compared to males. The volume of female migration was nearly 80 per cent. The sex ratio of the migrant population is estimated to be 4091 females for every 1000 males compared to the sex ratio of 542 females for every 1000 males in the non-migrant population according to the 2011 population census (Figure 1). Females out-numbered males in all categories of migrant population, although the sex ratio of the migrant population is found to be less favourable to females at the 2011 population census as compared to the 2001 population census.

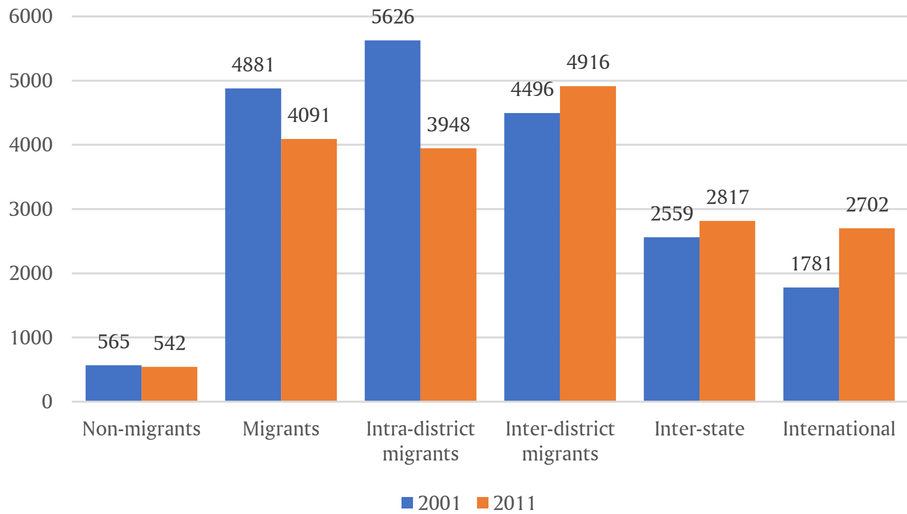

Figure 12: Sex ratio (females per 1000 males) of different categories of migrant population in Uttar Pradesh, 2001 and 2011.
Source: Authors

Table 2: Reasons for the movement of the population of Uttar Pradesh.

Reason for Migration	2011			2001		
	Person	Male	Female	Person	Male	Female
1. Employment	12.96	39.89	3.07	13.93	39.27	3.47
2. Business	0.84	1.79	0.49	0.60	1.38	0.28
3. Education	1.22	3.38	0.43	1.27	3.65	0.29
4. Marriage	51.3	2.83	69.09	48.11	1.63	67.29
5. Moved after birth	1.09	2.31	0.64	0.68	1.35	0.40
6. Moved with ousehold	19.98	29.76	16.39	19.91	27.03	16.98
7. Others	12.62	20.05	9.89	15.49	25.69	11.29
Total	100.00	100.00	100.00	100.00	100.00	100.00

Source: Authors' calculations based on 2001 and 2011 population census.

The reason for a very substantial movement of female population is the marriage of females (Table 2). By comparison, about 40 per cent of the male migrants moved in search of employment and this proportion was only around 3 per cent for females. A very small proportion of migrants, either male or female, moved for education purposes while a substantial proportion of the movement of both males and females was because of the movement of the entire household.

Table 3: Inter-state migration rates in Uttar Pradesh 1991-2011

Census Year		In-migration rate	Out-migration rate	Net migration rate
1991	Person	1.34	4.30	-2.95
	Male	0.67	4.21	-3.55
	Female	2.12	4.39	-2.27
2001	Person	1.69	5.79	-4.10
	Male	0.90	5.89	-4.99
	Female	2.57	5.69	-3.12
2011	Person	2.01	6.50	-4.49
	Male	1.01	6.37	-5.37
	Female	3.11	6.65	-3.54

Source: Authors' calculations based on data available through 1991, 2001 and 2011 population censuses.

Table 3 presents in-migration, out-migration, and net migration rates for Uttar Pradesh during the period 1991 through 2011. Uttar Pradesh has always been an out-migration state in the sense that the number of persons who moved out of the state is substantially higher that the number of persons who moved into the state. According to the 2011 population census, nearly 13 million persons born in Uttar Pradesh were enumerated in other states of India while 2.8 million persons born in other states of the country were enumerated in the state.

Table 4: Reasons for out migration from Uttar Pradesh

Reason for Migration	2011			2001		
	Person	Male	Female	Person	Male	Female
1. Employment	30.31	55.82	4.04	34.23	61.49	3.15
2. Business	1.14	1.83	0.44	1.49	2.59	0.24
3. Education	1.04	1.49	0.58	0.96	1.45	0.41
4. Marriage	24.91	1.04	49.51	24.27	0.48	51.39
5. Moved after birth	2.81	3.28	2.32	2.60	2.89	2.27
6. Moved with household	26.93	20.91	33.13	25.11	17.91	33.31
7. Others	12.86	15.64	9.99	11.34	13.19	9.22
Total	100.00	100.00	100.00	100.00	100.00	100.00

Source: Authors' calculations based on 2001 and 2011 population census.

Table 4 presents reasons for out migration from the state. Among males, the mail reason is employment while marriage is the main reason of out migration for females. Moreover, reasons for out migration from the state have virtually remained unchanged as revealed through 2001 and 2011 population census. A substantial proportion of out migration from the state for employment suggests that adequate employment opportunities are not available in the state which push the jobseekers out of the state for employment.

Table 5: Literacy rate (percent) of migrant and non-migrant population in Uttar Pradesh, 2001 and 2011.

Gender	2011		2001	
	Migrants	Non-migrants	Migrants	Non-migrants
Person	46.66	61.42	34.47	49.22
Male	72.57	64.44	66.53	54.87
Female	40.26	55.80	27.56	39.07

Remarks: Non-migrants literacy rate is calculated by subtracting migrant population from the total population.
Source: Authors

Table 5 presents literacy rate of the migrant and the non-migrant population of the state at the 2001 and 2011 population censuses. The literacy rate, in India's population census, is defined as the proportion of population aged 7 years and above who can read and write with understanding (Government of India, 2011). The gender difference in the literacy rate of migrant and non-migrant population is very much evident from the table. The literacy rate of male migrant population is higher than that of male non-migrant population, but the literacy rate of female migrant population is lower than that of female non-migrant population. This difference may be attributed to the reason for movement. Male population moves primarily for employment where the level of education matters significantly. The main reason for the movement of females, on the other hand, is marriage where the level of education hardly matters.

Table 6: Work participation rate in migrant and non-migrant population of Uttar Pradesh, 2001 and 2011.

Gender	2011		2001	
	Migrants	Non-migrants	Migrants	Non-migrants
Person	18.9	23.7	17.9	25.6
Male	47.5	34.4	50.2	38.2
Female	11.9	3.7	11.0	2.9

Source: Authors' calculations

Table 6 presents the work participation rate in migrant and non-migrant population of the state. Work, in the population census, is defined as participation in any economically productive activity with or without compensation, wages or profit. Such participation may be physical and/or mental in nature (Government of India, 2011). The work participation rate is defined as the proportion of population engaged in some work. Table 6 suggests that the work participation rate in the state has been higher in the non-migrant population compared to the migrant population. Moreover, there is big gap between the work participation rate in males as compared to females. However, the male work participation rate has decreased over time, but the female work participation rate has increase, albeit marginally. The increase in the female work participation rate may be attributed to the change in the definition of work in 2011 as compared to that in 2001 population census. In the 2011 population census unpaid engagement of females in household activities was also counted as work.

Migration within Uttar Pradesh

Very little is currently known about the migration within Uttar Pradesh. One approach to analysing the within state migration patterns is to measure and analyse the migration across the districts of the state. The measurement and analysis of inter-district migration within the state is important as it reflects the inter-district diversity or inequality in the level of social and economic development. It is well known that movement of the population can be explained in terms of 'push' and 'pull' factors. More developed districts 'pull' the population from the less developed districts as they offer comparatively better livelihood opportunities. At the same time, it has also been argued that poorly developed districts 'push' the people to move out of the district because of limited and poor livelihood opportunities in the district. In this sense, pattern of migration across districts reflects the within-state, inter-district inequalities in social and economic development.

The inter-district movement of the population can be analysed in the long-term context and in the immediate context. The long-term movement of population across districts may be captured through the life-time migrant population decided on the basis of the place of birth and the place of enumeration. Table 7 gives the proportionate distribution of the population by the life-time migration status. There are only two districts in the state - Ghaziabad and Gautam Buddha Nagar - where life-time migrants are more than the native population of the district – population born and enumerated in the district (Table 7). On the other hand, there are 15 districts in the state where life-time migrants constitute less than 25 per cent of the population of the district. The very large proportion of life-time migrants in Gautam Buddha Nagar and Ghaziabad districts of the state are primarily because of very large migration into these districts from other districts of the states and other states of the country. Both these districts are adjacent to the National Capital Territory of Delhi which may be the reason for the heavy migration into these districts from other districts of the state and from other states of the country. By comparison, the within-district migration in district Gautam Buddha Nagar is the lowest among all districts of the state. The inter-district coefficient of variation in the four categories of the life-time migrant population has been found to be the highest among migrants from outside the country but the lowest among intra-district migrants which means that in-migration from outside India is confined to selected districts of the state only. For example, in Siddharth Nagar and Maharajganj districts of the state, the proportion of life-time migrants from other countries is very high. These two districts adjoin the neighbouring country Nepal and people of Nepal appear to have moved into the district in search for livelihood opportunities. On the other hand, the intra-district life-time migrants account for more than 20 per cent of the total life-time migrants in eight districts of the state. All but two of these districts are located in the southern part of the state. In district Ballia, the intra-district life-time migrants constitute more than 22 percent of the population of the district at the 2011 population census which is the highest among all districts of the state.

Table 7: Distribution of the population by life-time migration status in districts of Uttar Pradesh, 2011

Code	State/District	Native	Life-time migrants				
			All	Intra-district	Inter-district	Inter-State	Inter-country
0	Uttar Pradesh	72.23	27.77	16.93	8.68	2.01	0.13
132	Saharanpur	73.50	26.50	16.51	5.59	4.21	0.19
133	Muzaffarnagar	72.26	27.74	16.74	8.54	2.40	0.07
134	Bijnor	76.54	23.46	18.51	3.12	1.71	0.10
135	Moradabad	77.22	22.78	14.01	7.23	1.43	0.07
136	Rampur	79.38	20.62	12.46	5.87	2.11	0.17
137	Jyotiba Phule Nagar	76.74	23.26	13.68	8.77	0.76	0.05
138	Meerut	65.90	34.10	18.37	12.55	2.81	0.22
139	Baghpat	73.23	26.77	11.85	13.37	1.51	0.04
140	Ghaziabad	48.83	51.17	14.39	23.45	12.87	0.33
141	Gautam Buddha Nagar	49.83	50.17	8.41	22.85	18.38	0.53
142	Bulandshahr	72.78	27.22	15.45	10.45	1.24	0.05
143	Aligarh	69.85	30.15	15.53	13.20	1.37	0.05
144	Mahamaya Nagar	73.50	26.50	8.57	16.61	1.28	0.03
145	Mathura	68.20	31.80	16.03	9.42	6.12	0.09
146	Agra	70.83	29.17	17.42	6.89	4.67	0.11
147	Firozabad	70.74	29.26	15.12	13.22	0.84	0.08
148	Mainpuri	73.62	26.38	11.14	14.67	0.55	0.03
149	Budaun	78.08	21.92	14.34	6.84	0.68	0.05
150	Bareilly	74.82	25.18	16.54	6.97	1.55	0.12
151	Pilibhit	75.38	24.62	15.06	7.11	1.93	0.52
152	Shahjahanpur	75.50	24.50	14.31	9.00	1.04	0.08
153	Kheri	73.40	26.60	19.31	6.19	0.86	0.21
154	Sitapur	74.24	25.76	20.14	5.19	0.36	0.05
155	Hardoi	77.79	22.21	16.05	5.88	0.26	0.02
156	Unnao	71.28	28.72	20.86	7.46	0.33	0.03
157	Lucknow	60.60	39.40	16.70	19.23	3.25	0.22
158	Rae Bareli	72.32	27.68	20.46	6.72	0.44	0.05
159	Farrukhabad	74.40	25.60	11.12	13.58	0.87	0.03
160	Kannauj	75.34	24.66	10.35	13.73	0.56	0.02
161	Etawah	69.22	30.78	14.69	14.19	1.87	0.03
162	Auraiya	70.89	29.11	12.18	16.12	0.78	0.02
163	Kanpur Dehat	72.82	27.18	14.56	12.19	0.39	0.03
164	Kanpur Nagar	70.95	29.05	11.10	15.95	1.80	0.19
165	Jalaun	68.60	31.40	20.54	8.54	2.27	0.03
166	Jhansi	67.60	32.40	18.15	6.19	8.00	0.06
167	Lalitpur	70.97	29.03	20.03	1.92	7.05	0.02
168	Hamirpur	71.88	28.12	16.35	10.56	1.18	0.02

Code	State/District	Native	Life-time migrants				
			All	Intra-district	Inter-district	Inter-State	Inter-country
169	Mahoba	70.54	29.46	14.87	8.42	6.14	0.02
170	Banda	73.76	26.24	18.30	5.28	2.63	0.02
171	Chitrakoot	74.92	25.08	16.30	6.02	2.74	0.02
172	Fatehpur	74.39	25.61	19.62	5.70	0.27	0.02
173	Pratapgarh	73.98	26.02	18.92	6.70	0.39	0.02
174	Kaushambi	74.15	25.85	20.75	4.76	0.31	0.02
175	Allahabad	71.97	28.03	20.03	6.10	1.84	0.04
176	Bara Banki	75.63	24.37	17.83	6.17	0.34	0.03
177	Faizabad	72.93	27.07	18.62	7.74	0.64	0.06
178	Ambedkar Nagar	74.95	25.05	17.37	7.28	0.36	0.03
179	Sultanpur	72.70	27.30	19.21	7.56	0.48	0.03
180	Bahraich	76.28	23.72	17.96	4.85	0.44	0.46
181	Shrawasti	74.32	25.68	18.04	6.76	0.34	0.52
182	Balrampur	76.86	23.14	17.12	5.15	0.43	0.43
183	Gonda	73.88	26.12	19.38	6.17	0.50	0.06
184	Siddharthnagar	76.23	23.77	16.92	5.06	0.52	1.26
185	Basti	74.52	25.48	17.90	6.95	0.58	0.04
186	Sant Kabir Nagar	74.77	25.23	14.87	9.87	0.42	0.07
187	Mahrajganj	74.61	25.39	17.19	6.54	0.42	1.23
188	Gorakhpur	71.60	28.40	19.81	7.43	0.93	0.16
189	Kushinagar	74.01	25.99	18.11	4.33	3.46	0.10
190	Deoria	72.76	27.24	18.93	4.71	3.56	0.04
191	Azamgarh	73.86	26.14	19.17	6.60	0.31	0.06
192	Mau	75.90	24.10	13.96	9.65	0.45	0.03
193	Ballia	72.33	27.67	22.21	3.07	2.37	0.01
194	Jaunpur	72.12	27.88	19.20	8.20	0.44	0.04
195	Ghazipur	73.35	26.65	19.55	5.25	1.76	0.06
196	Chandauli	71.84	28.16	17.76	6.89	3.46	0.05
197	Varanasi	68.14	31.86	20.22	9.35	2.21	0.08
198	Sant Ravidas Nagar	73.40	26.60	14.08	11.76	0.73	0.03
199	Mirzapur	73.51	26.49	17.03	8.24	1.19	0.02
200	Sonbhadra	68.70	31.30	18.37	6.86	6.02	0.05
201	Etah	72.29	27.71	12.04	14.92	0.69	0.04
202	Kanshiram Nagar	75.68	24.32	9.65	13.59	1.04	0.03

Source: Authors' calculations based on 2011 population census

Estimation of district-specific in-migration rate, out-migration rate, and net-migration rate during the period 2001-2011 is not possible because the relevant data are not available from the 2011 population census. Special tables for district-wise migrants reporting duration of residence of 0-9 years were prepared by the Registrar General and Census Commissioner of India for the first time based on the 2001 population census. A flow of 594 district as they existed at the time of 2001 population census, was made to know how many persons moved into a particular district from other districts of the country during the last 10 years as well how many persons moved out of the district during the last 10 years. This tabulation permit estimation of district-specific in migration, out migration and net migration rates for the period 1991-2001. However, similar special tabulations have not been carried out based on the 2011 population census because of the increase in the number of districts in the country from 594 in 2001 to 640 in 2011 so that estimation of in migration, out migration and net migration rate for the period 2001-2011 is not possible.

Table 8 presents in-migration, out-migration, and net migration rates, separately for males and females, for districts of the state for the period 1991-2001 as derived from the data available from the 2001 population census. The analysis is limited to 70 districts as they existed at the time of 2001 population census. It may be seen from the table that there were 7 districts where male in migration rate was higher than the male out migration rate. There are only two districts – Gautam Buddha Nagar and Ghaziabad – where the male in migration rate was more than 10 per cent during the period 1991-2001. Besides these two districts, Lucknow is the only other district where the in-migration rate was more than 5 percent. By contrast, the male out migration rate was at least 5 percent in 9 districts with the highest male out migration rate recorded in district Gorakhpur.

On the other hand, female in migration rate was found to be higher than the female out migration rate in 20 districts. The female in migration rate was more than 12 per cent in district Gautam Buddha Nagar which is the highest among all districts. Gautam Buddha Nagar is the only district where female in migration rate was more than 15 per cent during 1991-2001. The female in migration rate is found to be more than 10 per cent in district Ghaziabad also. In addition, there are 16 districts where female in migration rate is estimated to be more than 5 percent but less than 10 percent during 1991-2001. By contrast, in 29 districts, the female out migration rate is found to be more than 5 per cent with the highest female out migration rate recorded in district Etawah which is the only district where the female out migration rate was more than 10 per cent.

Table 8 reflects substantial inter-district variation in in-migration and out-migration rates for both males and females and for both sexes combined. The net in-migration rate is found to be the highest in district Gautam Buddha Nagar which is the only district where the net migration rate is more than 10 percent. There are, however, only 11 districts where the net migration rate is positive which means that these districts are nete in-migrant districts of the state. In the remaining districts, the met migration rate is negative which means that these districts are net out-migrant districts.

The inter-district migration pattern is different in males compared to females. In case of males, the net migration rate is positive in only 7 districts whereas in case of females, the net migration rate is positive in 19 districts. The net migration rate for both male and female is, however, found to be the highest in district Gautam Buddha

Nagar. The male in-migration rate in district Gautam Buddha Nagar is estimated to be more than 52 times the net migration rate district Shrawasti, the district with the lowest male in migration rate in the state. Similarly, the female in migration rate in district Gautam Buddha Nagar, the district with the highest female in migration rate is found to be more than 11 times the female in-migration rate in district Bahraich, the district with the lowest female in-migration rate. It may, however, be seen from table 8 that majority of the districts of the state are out-migrant districts. People move out of majority of the districts in search of better livelihood or employment opportunities.

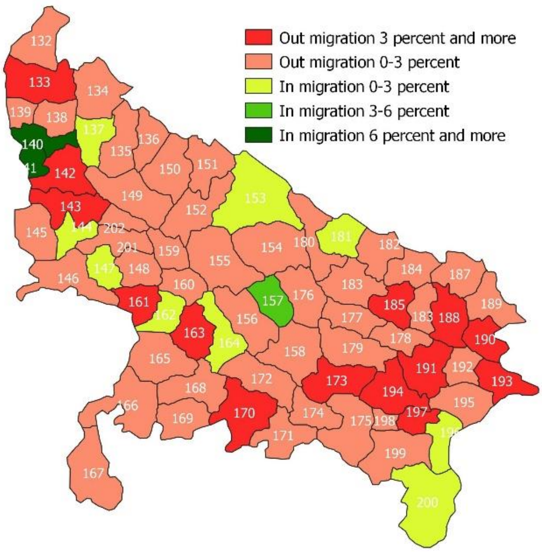

Figure 13: Net migration rate in districts of Uttar Pradesh, 1991-2001

Remarks: Labels in the map are district codes (Table 7). In 2001, district Kanshiram Nagar was part of district Etah.

Source: Authors

The male net migration rate has been found to be negative in all but 7 districts of the state. The 7 districts with positive net migration rate are: Gautam Buddha Nagar, Ghaziabad, Lucknow, Sonbhadra, Kanpur Nagar, Kheri and Jyotiba Phule Nagar. On the other hand, the female net migration rate is found to be negative in 50 districts. The male migration pattern across the districts of the state has been found to be different from inter-district female migration because main factors for male migration are different from main factors for female migration. The male migration whether in-migration or out-migration is primarily in the context of employment and livelihood opportunities and therefore is determined by both push and pull factors of migration. The female migration, either in-migration or out-migration, is primarily in the context of the marriage of the female and is not determined by the conventional push and pull factors of migration. Employment plays a minor role in deciding female migration across the districts of the state.

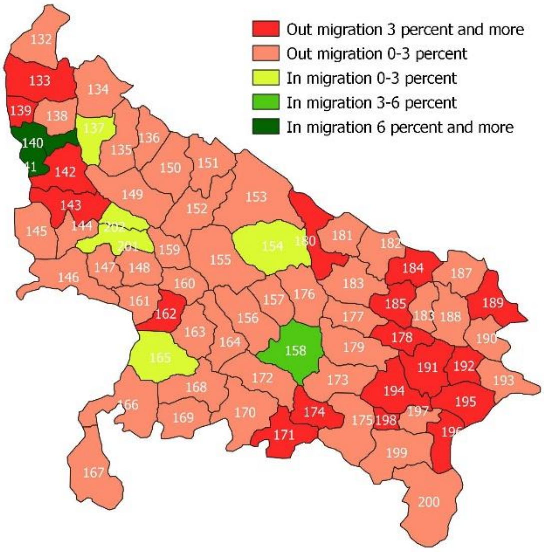

Figure 3: Male net migration rate in districts of Uttar Pradesh, 1991-2001

Remarks: Labels in the map are district codes (Table 7). In 2001, district Kanshiram Nagar was part of district Etah.

Source: Authors

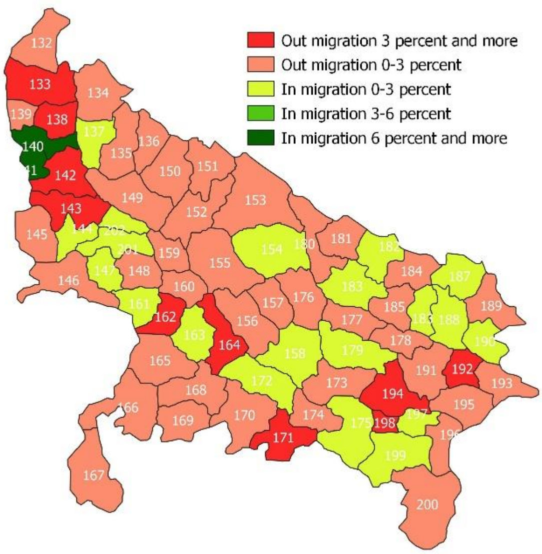

Figure 4: Male net migration rate in districts of Uttar Pradesh, 1991-2001

Remarks: Labels in the map are district codes (Table 7). In 2001, district Kanshiram Nagar was part of district Etah.

Source: Authors

Table 8: Migration rates (percent) in districts of Utter Pradesh during 1991-2001.

Districts	In-migration rate			Out-migration rate			Net migration rate		
	P	M	F	P	M	F	P	M	F
Saharanpur	4.45	1.11	3.74	2.33	2.87	6.27	-2.12	-1.77	-2.52
Muzaffarnagar	6.02	0.80	4.43	2.49	4.22	8.08	-3.52	-3.42	-3.64
Bijnor	3.62	0.58	2.08	1.28	2.95	4.38	-2.34	-2.37	-2.30
Moradabad	3.26	0.95	3.92	2.34	2.10	4.59	-0.92	-1.14	-0.67
Rampur	3.50	0.95	3.73	2.25	2.42	4.73	-1.25	-1.47	-1.01
Jyotiba Phule Nagar	1.88	0.91	4.25	2.48	0.89	2.99	0.60	0.02	1.26
Meerut	6.47	2.14	5.84	3.87	4.34	8.91	-2.60	-2.20	-3.07
Baghpat	6.22	1.01	6.78	3.66	4.24	8.56	-2.56	-3.23	-1.77
Ghaziabad	3.97	10.05	13.65	11.71	2.32	5.89	7.75	7.73	7.76
Gautam Buddha Nagar	2.70	12.02	16.86	14.23	1.51	4.11	11.54	10.51	12.75
Bulandshahr	6.95	0.75	4.50	2.51	5.02	9.15	-4.45	-4.27	-4.65
Aligarh	6.48	1.21	5.45	3.17	4.28	9.03	-3.30	-3.07	-3.58
Hathras	3.48	0.77	8.01	4.12	1.65	5.62	0.64	-0.87	2.40
Mathura	6.12	1.94	7.12	4.31	3.81	8.86	-1.81	-1.87	-1.74
Agra	4.66	0.82	4.09	2.32	2.88	6.77	-2.34	-2.05	-2.68
Firozabad	3.04	1.23	6.01	3.43	1.55	4.79	0.39	-0.32	1.22
Etah	5.09	0.61	5.10	2.67	3.24	7.26	-2.41	-2.63	-2.16
Mainpuri	5.34	0.74	6.84	3.56	3.05	8.00	-1.78	-2.31	-1.16
Budaun	3.87	0.50	4.01	2.11	2.57	5.41	-1.76	-2.06	-1.40
Bareilly	3.48	1.24	3.70	2.39	2.33	4.81	-1.10	-1.09	-1.11
Pilibhit	2.68	0.93	3.85	2.30	1.37	4.17	-0.38	-0.43	-0.32
Shahjahanpur	2.89	0.78	4.58	2.52	1.28	4.79	-0.37	-0.50	-0.22
Kheri	0.65	0.81	2.78	1.73	0.24	1.12	1.08	0.57	1.66
Sitapur	1.75	0.42	2.28	1.28	1.08	2.52	-0.47	-0.66	-0.24
Hardoi	2.70	0.36	3.02	1.58	1.59	4.02	-1.12	-1.23	-0.99
Unnao	3.15	0.88	2.90	1.83	2.51	3.86	-1.31	-1.63	-0.97
Lucknow	3.33	6.18	6.84	6.49	2.57	4.18	3.16	3.60	2.66
Rae Bareli	3.27	0.91	2.61	1.73	3.13	3.40	-1.53	-2.23	-0.80
Farrukhabad	5.60	0.87	6.13	3.28	3.02	8.65	-2.32	-2.15	-2.51
Kannauj	3.45	0.62	5.94	3.09	1.63	5.55	-0.36	-1.01	0.39
Etawah	8.89	1.04	5.92	3.29	6.17	12.07	-5.60	-5.13	-6.15
Auraiya	3.10	1.15	7.48	4.07	1.36	5.12	0.97	-0.21	2.36
Kanpur Dehat	5.79	0.94	4.29	2.48	3.90	8.00	-3.31	-2.96	-3.72
Kanpur Nagar	4.04	3.82	4.82	4.28	2.72	5.60	0.24	1.10	-0.78
Jalaun	4.07	0.50	3.85	2.03	2.52	5.91	-2.04	-2.02	-2.06
Jhansi	5.22	1.62	5.83	3.58	3.10	7.67	-1.65	-1.48	-1.84
Lalitpur	2.98	1.05	4.57	2.70	1.55	4.61	-0.28	-0.50	-0.04
Hamirpur	4.69	0.85	4.63	2.59	2.77	6.94	-2.10	-1.92	-2.32
Mahoba	5.14	1.40	7.24	4.11	3.14	7.44	-1.03	-1.74	-0.20
Banda	5.81	0.84	3.29	1.97	4.69	7.12	-3.84	-3.85	-3.83

Districts	In-migration rate			Out-migration rate			Net migration rate		
	P	M	F	P	M	F	P	M	F
Chitrakoot	2.32	0.78	3.85	2.21	1.58	3.16	-0.11	-0.81	0.70
Fatehpur	3.24	0.46	2.16	1.26	2.71	3.83	-1.97	-2.25	-1.66
Pratapgarh	5.28	0.54	2.55	1.54	5.62	4.95	-3.74	-5.09	-2.40
Kaushambi	1.03	0.24	1.57	0.87	0.63	1.48	-0.16	-0.39	0.10
Allahabad	4.33	1.28	1.85	1.54	4.18	4.51	-2.79	-2.90	-2.66
Barabanki	2.01	0.60	2.38	1.43	1.39	2.71	-0.58	-0.80	-0.33
Faizabad	4.91	1.37	3.21	2.26	4.92	4.89	-2.65	-3.56	-1.68
Ambedkar Nagar	1.97	0.73	2.71	1.71	1.67	2.27	-0.26	-0.94	0.44
Sultanpur	4.33	1.06	3.16	2.10	4.25	4.42	-2.23	-3.19	-1.25
Bahraich	1.54	0.45	1.48	0.93	1.29	1.84	-0.62	-0.84	-0.36
Shrawasti	0.80	0.23	2.72	1.39	0.37	1.29	0.59	-0.14	1.43
Balrampur	1.79	0.39	1.78	1.04	1.83	1.74	-0.74	-1.44	0.04
Gonda	3.90	0.62	2.46	1.50	3.98	3.81	-2.40	-3.36	-1.35
Siddharthnagar	3.61	0.48	1.81	1.13	4.27	2.92	-2.49	-3.79	-1.11
Basti	5.84	0.71	2.34	1.50	6.02	5.66	-4.34	-5.31	-3.31
Sant Kabir Nagar	2.70	0.59	3.84	2.19	2.45	2.97	-0.51	-1.85	0.87
Maharajganj	1.61	0.48	2.31	1.37	1.38	1.86	-0.24	-0.90	0.45
Gorakhpur	6.16	1.12	2.68	1.89	6.72	5.57	-4.27	-5.60	-2.89
Kushinagar	2.38	0.58	2.70	1.62	2.36	2.40	-0.76	-1.78	0.30
Deoria	5.25	0.48	2.39	1.43	5.50	4.99	-3.81	-5.03	-2.60
Azamgarh	5.77	0.61	2.20	1.41	6.19	5.36	-4.36	-5.58	-3.16
Mau	3.76	0.73	3.36	2.03	3.39	4.14	-1.73	-2.66	-0.79
Ballia	5.01	0.26	1.51	0.87	5.09	4.94	-4.15	-4.83	-3.43
Jaunpur	6.28	0.75	3.14	1.95	6.61	5.95	-4.32	-5.86	-2.80
Ghazipur	4.22	0.45	2.39	1.41	4.13	4.31	-2.81	-3.67	-1.93
Chandauli	1.82	1.05	3.69	2.32	1.13	2.56	0.50	-0.09	1.13
Varanasi	5.80	1.70	2.71	2.18	4.99	6.70	-3.62	-3.29	-3.99
Sant Ravidas Nagar	3.41	0.69	4.64	2.58	2.65	4.23	-0.83	-1.96	0.41
Mirzapur	3.04	0.69	4.17	2.34	2.01	4.18	-0.70	-1.32	-0.01
Sonbhadra	1.66	3.65	5.40	4.48	0.88	2.52	2.82	2.77	2.88

Remarks: Net migration rate = In-migration rate – Out-migration rate
P=Person; M=Male; F=Female
Source: Authors' calculations

Conclusions

This paper has analysed the patterns of migration in Uttar Pradesh along with the reasons for migration. The paper has also analysed, for the first time, migration across the districts of the state. Data available from the population census suggest that Uttar Pradesh remains an out-migration state as the rate of migration out of the state is higher than the rate of migration into the state. The primary reason for male migration in the state is employment but marriage is the primary reason for female migration. A substantial proportion of migration is also attributed to the movement with the household. Other reasons of migration are largely irrelevant to the movement of the population into or out of the state.

The inter-district movement of the population within the state, as revealed through the present analysis, reflects the disparities in social and economic development across the districts of the state. The in-migration districts of the state are comparatively more developed than the out-migration districts and the pace of social and economic development has been quite rapid in these districts in the recent past. The present analysis also indicates that the inter-district disparities in social and economic development within the state appear to have increased over time. This is a matter of concern.

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Modelling Seasonality of Deaths in Guwahati City, Assam, India

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Abstract

This paper attempts to model the seasonality in the occurrence of deaths from specific causes of death groups circular statistical data analysis tools. Parameter estimation of future observations based on the past and the current observations have been carried out assuming von Mises distribution. It is observed that for some causes of death groups, the hypothesis of seasonality is accepted whereas it is rejected for the other causes of death groups. Based on the estimated parameters of the von Mises distribution, the seasonality in the occurrence of deaths from different causes of death groups can be predicted.

Introduction

The seasonality in the occurrence of deaths has been known to the world, at least since Hippocrates, more than 2000 years ago. By seasonality, we mean the trend pattern that repeats every 12 months. Irrespective of the reasons behind seasonality, predicting seasonality in the occurrence of death plays an important role in planning and programming public health services. If any disease, and death following the disease, occur seasonally, "an environmental factor has to be considered in the etiology of that disease" (Marrero, 1983). There is already ample evidence to suggest that an enormous diversity of causes of death is related to seasonal incidence: cardiovascular diseases (Yen et al, 2000), asthma (Cadet et al, 1994), infectious diseases (Momiyama, 1987), diarrhoea and cholera (Bouma and Pascual, 2001; Villa, 1999), suicide (Hakko, 2000), and congenital malformations (Elwood and Elwood, 1987; Kanai and Nakamura, 1987) to name only a few. Different analytical approaches have been adopted to identify and test the seasonality in the occurrence of diseases and deaths. These include seasonal mortality ratio, concentration or dissimilarity indexes, time series modelling and the so-called X-11 method. Detailed description of these and other methods is given elsewhere (Rau, 2007). In this paper, we follow a modelling approach to analyse the seasonality in the occurrence of deaths due to selected causes of deaths groups. The approach adopted can also be used to predict seasonality in the occurrence of deaths.

The paper is organised as follows. Section 2 describes the model used to capture the seasonality in the occurrence of deaths. Section 3 describes the data used for the analysis including a description about the data collection methodology. Results of the test of seasonality in the occurrence of deaths due to different causes of death groups are presented and discussed in section 4 of the paper. Section 5 presents results of predictive modelling of seasonality in the occurrence of deaths due to selected causes of death groups. The last section of the paper summarises the findings of the analysis.

Methodology

The underlying assumption of the present analysis is that there is substantial degree of seasonality in the occurrence of deaths, but the magnitude of seasonality remains unpredictable. We, therefore, assume that the seasonality in the occurrence of deaths either from all causes of deaths or from specific causes of death groups is a circular random variable or a random variable on a circle and then apply circular statistical analysis tools and techniques to model the seasonality in the occurrence of deaths. The benefit of treating monthly occurrence of deaths as a circular random variable is the continuity of the curve between the months of December and January.

We analyse seasonality in terms of both month wise occurrence of deaths and season wise occurrence of deaths. For the month wise analysis, the angle of the circle at the centre (360°) is divided into 12 parts in accordance with the length of different months. For season wise analysis, the angle at the centre of the circle is divided into 4 quarters according to the length of the quarter. The seasons used in the present analysis are the same as identified by the Regional Meteorological Centre, Guwahati. The Regional Meteorological Centre classifies 12 months of the year into four seasons as follows:

1. Winter seasons - January, February
2. Pre-monsoon season - March, April, May
3. Monsoon season - June, July, August, September
4. Post-monsoon season - October, November, December

The most fundamental question in the circular data analysis is to test whether the data are uniformly distributed around the circle, or whether it is concentrated around at least one preferred direction. There are different tests available for the purpose including Rayleigh uniformity test, V-test, Watson's test, Kuiper's test, and Rao's spacing test (Landler et al, 2018). We have used the Rayleigh uniformity test in the present analysis. If there is no seasonality in monthly or seasonal occurrence of deaths, then the data can be regarded as drawn from a uniform distribution on the circle. We, therefore, frame our null and alternative hypothesis as:

H_0: The occurrence of deaths does not have any seasonality.
H_1: The occurrence of deaths has seasonality.

There are different approaches of finding the predictive densities in the circular data. These include: i) methods based on conditioning through sufficiency; ii) Bayes predictive densities; and iii) maximum or profile likelihood methods (Bjornstad, 1990; Butler, 1986). Different approaches used to generate models for circular data are discussed elsewhere (Mardia and Jupp, 1999). In this paper, we model the future occurrence of deaths by causes of death groups assuming the classical von Misses model (also known as circular normal distribution) for the past and present observations. The probability density function of the classical von Mises distribution is given by

$$f(\theta, \mu_0, \kappa) = \frac{1}{2\pi I_0(\kappa)} e^{\kappa \cos(\theta - \mu_0)}, \qquad 0 < \theta,\ \mu_0 \leq 2\pi,\ \kappa > 0 \tag{1}$$

Then, under the sufficiency approach, the predictive density of θ_{n+1} is givenby

$$g(\theta_{n+1} | \theta_1, \theta_2, \cdots, \theta_n) \propto \frac{1}{\psi_{n+1}(r_{n+1})}, \tag{2}$$

where$\psi_r = \int_0^\infty J_0(rt) J_0^n(t) dt,\ 0 \leq r < n,$ and $J_v(z)$ is the Bessel function of v^{th}order. The predictive density $g(.)$ Is proportional to the von Mises distribution $f(\theta_{n+1}; \bar{\theta}_n, 2\bar{R})$ for large n. (Rao and Sengupta, 2001, pp. 207). When κ=0 in equation (1), the von Mises distribution reduces to the circular uniform distribution. Mathematically, this result can be easily proved (Rao and Sengupta, 2001). Logically also, this is valid because, in the uniform distribution, the observations do not have a preferred direction which means that all directions are equally preferable. This, in turn, means that the concentration about the mean direction is not present in the data, i.e., it is 0. Accordingly, for large n, the distribution will tend to von Mises distribution with parameters $(\hat{\theta}_n, \hat{\kappa})$, where $\hat{\theta}_n$is based on the past n observations and $\hat{\kappa} = \frac{2r_n}{(n+1)}$ is the approximate maximum likelihood estimator for smaller values of κ (Rao and Sengupta, 2001). The value of mean direction μ indicates the direction towards which most of the observations are concentrated, on average. In the present case, the value of μ indicates the corresponding month or season in which most of the observations in the dataset are concentrated, on average. The value of estimated κ gives an idea about the spread or dispersion in the observations. The lower the value, lower is the variance in the data set or higher is the concentration and vice-versa.

Data

Data for the present study have been taken from the research project "Statistical Modelling of Circular Data: An Application to Health Science" which was funded by the University Grants Commission, India (Das, 2015). Under this project, 1371 deaths reported in Guwahati city during different months of the year 2013 and 2014 were covered. The sampling frame of all birth and death registration offices under Guwahati Municipal Corporation, Guwahati, Assam was first prepared and then, taking resort to simple random sampling scheme, three birth and death registration offices, viz. MMCH

PHC, Panbazar, Office of the Joint Director of Health, Uzan Bazar and Baripara PHC, Pandu were selected. Data have been collected for the years 2013 and 2014. These deaths were classified into the following causes of death groups

1. Respiratory diseases
2. Gastro-intestinal diseases
3. Diseases of the urinary tract
4. Cardio-vascular diseases
5. Neurological disorders
6. Accidents and injuries
7. Endocrinal diseases
8. Virological diseases
9. Parasitic diseases
10. All other diseases

Month wise occurrence of deaths from the 10 causes of deaths groups in the year 2013 and 2014 is given in table 1 along with the coefficient of variation (CV). These summary measures suggest that seasonality in the occurrence of deaths is the highest in January but the lowest in December. For all causes of death combined, the average monthly occurrence of deaths ranges from 85 in the month of January to 29 in the month of December while the overall coefficient of variation is 0.304.

Table 1: Reported occurrences of deaths by causes of death groups in Guwahati city, 2013 and 2014

Month	All	Reported deaths by causes of death									
		1	2	3	4	5	6	7	8	9	10
Jan	170	6	11	50	40	17	1	3	9	2	31
Feb	145	9	11	41	27	15	3	3	7	1	28
Mar	146	6	6	42	27	16	2	3	11	2	31
Apr	110	6	9	36	23	12	2	3	3	2	14
May	144	10	13	42	27	9	0	6	11	1	25
Jun	126	4	13	38	21	9	2	1	8	1	29
Jul	129	6	6	33	33	11	0	4	2	2	32
Aug	104	2	17	23	28	5	1	4	6	0	18
Sep	74	3	9	21	21	5	0	1	5	0	9
Oct	77	6	4	22	20	5	3	3	3	0	11
Nov	88	2	5	21	29	5	2	2	5	0	17
Dec	58	3	2	18	20	1	1	0	2	1	10
CV	0.304	0.488	0.496	0.334	0.226	0.559	0.765	0.583	0.541	0.852	0.422

Source: Authors
Remarks: CV is the coefficient of variation

Test of Seasonality in the Occurrence of deaths

The test statistic of the Rayleigh Uniformity test and the decision regarding rejection or acceptance of the hypothesis of seasonality in the occurrence of deaths due to the

10 causes of death groups covered in the present analysis is given in table 2. The null hypothesis was accepted in case of 7 of the 10 causes of deaths groups but in three causes of death groups, the null hypothesis was rejected. The table suggests that there is seasonality in the occurrence of deaths related to urinary tract infections, neurological disorders, and other causes of death but not in case deaths from respiratory disease, gastro-intestinal diseases, cardio-vascular diseases, accidents and injuries, endocrine diseases, viral infections, and parasitic diseases. Table 2 suggests the need of exploring the causes of seasonality in the occurrence of deaths due to urinary tract infections and neurological disorders. There may be environmental factors that may be responsible for the seasonality in the occurrence of deaths that need to be explored through public health perspective.

Table 2: Rayleigh test for seasonality in the season-wise occurrence of deaths from different causes of death groups.

	Causes of death group	Test statistic	Tabulated value	Decision
1	Respiratory diseases	6.03903	9.21	Accept
2	Gastro-intestinal diseases	7.01272	9.21	Accept
3	Disease of urinary tract	26.07613	9.21	Reject
4	Cardio-vascular diseases	0.80810	9.21	Accept
5	Neurological disorders	17.57457	9.21	Reject
6	Accidents and injuries	1.78778	9.21	Accept
7	Endocrine diseases	2.48050	9.21	Accept
8	Viral diseases	5.55901	9.21	Accept
9	Parasitic diseases	4.64273	9.21	Accept
10	Other diseases	14.85330	9.21	Reject

Source: Authors

Prediction the Occurrence of Deaths

The occurrence of deaths for those causes of death groups in which seasonality in the occurrence of deaths is not found as confirmed by Rayleigh uniformity test follows circular uniform distribution. Table 3 enlists parameters of the predicted von Mises density of the month-wise occurrence of deaths for those causes of death groups for which no seasonality in the occurrence of deaths was found. Here, n represents the number of deaths due to the causes of death group. These parameters can be used to derive the future month-wise occurrence of deaths due to specific causes of death groups by using equation (2). We see that in case of deaths from respiratory diseases and deaths from viral diseases, most of the deaths, on average, occur in the month of April (corresponding to the circular variable group 1.57 to 2.09 radians). On the other hand, most of the deaths from gastro-intestinal diseases and endocrine diseases, on average, occur in the month of May (corresponding to the circular variable group 1.57 to 2.09 radians). In case of deaths from cardio-vascular diseases, most of the deaths occur, on average, in the month of April (corresponding to the circular variable group

0.52 to 1.04 radians). Smaller values of the concentration parameter κ indicate that the month-wise deaths are not dispersed. Since the values of κ are closer to 0, they support the hypothesis of that the occurrence of deaths are circular uniformly distributed.

Table 3: Estimated parameters of the von Mises density of the month-wise occurrence of deaths for groups having uniformly distributed occurrence of deaths for which *n* is large

Groups	n	$\hat{\mu}$	$\hat{\hat{\kappa}}$
Respiratory diseases	63	1.63585	0.00684145
Gastro-intestinal diseases	106	2.74274	0.00339955
Cardio-vascular diseases	316	0.87082	0.00022560
Endocrine diseases	33	2.45545	0.01140377
Viral diseases	72	1.64273	0.00538300

Source: Authors

Table 4 gives the estimated values of the parameters of the von Mises density function based on the deaths registered in the selected areas of Guwahati city during the years 2013 and 2014 for six causes of death groups. In these causes of death groups, no seasonality in the occurrence of deaths was detected based on the Rayleigh uniformity test. The parameters given in table 4 can be used to predict month-wise occurrence of deaths due to the specific causes by using equation (2).

Table 4: Estimated parameters of the von Mises density of the season-wise occurrence of deaths for the uniformly distributed groups of causes of deaths for which *n* is large.

Causes of death group	n	$\hat{\mu}$	$\hat{\hat{\kappa}}$
Respiratory diseases	63	1.383007	0.007589
Cardio-vascular diseases	316	1.703929	0.000183
Endocrine diseases	33	2.455454	0.013384
Viral diseases	72	1.642727	0.006373
Gastro-intestinal diseases	255	2.081425	0.001059

Source: Authors

Our analysis suggests that for all the causes of death groups where the seasonality in the occurrence of deaths, most of the deaths, on average, occur in the pre-monsoon season or during the months of March, April, and May. The value of the concentration parameter κ is also found to be small which indicates that the season-wise dispersion of deaths is not large. It may also be observed that values of κ are close to 0, This confirms that there is no seasonality in the occurrence of deaths which implies that the occurrence of deaths from these causes of death groups is circular uniformly distributed.

Summary and Conclusion

In this paper we have attempted to model the seasonality in the occurrence of death from specific causes of death groups in Guwahati city of India. Using the circular data analysis tools, we found that there is seasonality in deaths from urinary tract infections, and deaths due to neurological disorders. There is no seasonality in deaths from other causes of death groups. In these causes of death groups in which there is no seasonality in the occurrence of deaths, the seasonal distribution of deaths may be characterised through the circular uniform distribution which means that occurrence of deaths from these causes of death groups is a special case of von Mises distribution with $\kappa = 0$. The future occurrence of deaths due to these causes of death groups can be modelled with the help of the estimated parameters obtained by fitting the von Mises distribution to the reported number of deaths in the past. Our analysis suggests that there is a surge in the deaths from these causes of death groups during the pre-monsoon season or during the months of April-May are seen to be having a surge of deaths from these causes of death groups. due to these causes, both month-wise and season-wise, having very little variation. The findings of the present analysis may help in planning and programming public health activities to minimize the diseases and death burden of the people.

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