Population Aging in India: A Regional Comparison and Implications for Older Persons' Welfare and Healthcare Infrastructure

Chandan Roy[1]*, Saurav Kumar[2], Gaurav Kumar[3], Vishwambhar Prasad Sati[1], and Murali Dhar[4]

[1] Department of Geography and Resource Management, Mizoram University, Aizawl, Mizoram, India
[2] Department of Geography, Royal Global University, Guwahati, Assam, India
[3] Department of Commerce, Mizoram University, Aizawl, Mizoram, India
[4] Department of Bio-statistics and Epidemiology, International Institute for Population Sciences, Mumbai, India
* Chandan Roy, corresponding author. Email: chandan96.roy@gmail.com
Submitted: 11 March 2023. Accepted: 11 October 2023. Published: 19 January 2024
Volume 32, 2024. pp. 399–415. http://doi.org/10.25133/JPSSv322024.024

Abstract

Population aging is an inevitable consequence of demographic transitions, and declining fertility causes a rising burden of aging. The present study aims to project the aging index of various states nationwide up to 2031. In addition, the study estimates the year by which different states and union territories (UTs) will reach the Kerala levels index of aging (i.e., aged society). To conduct this study, data were gathered from the 2001 and 2011 Census of India. Using simple trend extrapolation techniques, we produced projections of aging indices up to 2031. Further, an index of aging of each state and union territory up to the level of Kerala state (i.e., aged society) was projected. The results showed that there will be a change in the age structure of the population from 2011 to 2031. There will be a 6% increase in the working-age group (15–59 years) and a 5% in the older population (60 years and above). However, there will be a decline of 11.2% in the children ages 0–14 years. The southern states and some states of north India, such as Punjab and Himachal Pradesh, are likely to attain Kerala's level of aging index in the next few years. However, northern states are expected to take more years to achieve it. Therefore, there is a need to promote harmony between development and demographic change by expanding economic and social resources for older persons. The time has come to plan for the future burden of the older population across the country and arrange appropriate health facilities for them.

Keywords

Demographic transition; health infrastructure; index of aging; India; old-age dependency

Introduction

Population aging is an inevitable consequence of the demographic shift experienced by most countries worldwide. It results from declining fertility and mortality and increased life expectancy over time (Malik et al., 2021). It contributes to an increase in the median age and changes in the age-sex structure of the population, with a narrow base and a wide apex. Changes in population and demographics worldwide profoundly impact economic, social, political, and cultural issues (Sander et al., 2015). Worldwide, the proportion of older people is growing faster than all other age groups (World Health Organization, 2022). The United Nations (2022) recently projected that the old age population (aged 65 and above) would rise from 10% in 2022 to 16% in 2050.

The older population is expected to outnumber the younger children (less than five years) by 2050. Moreover, the number of people aged 80 years or above is estimated to triple by 2050, reaching 426 million from 143 million in 2019. Besides, 80% of the old-age population is estimated to live in lower and middle-income countries by 2050 (World Health Organization, 2022). Population aging is a global phenomenon experienced by developed countries (especially in Europe and North America) and developing countries (mainly in Southeast Asia and South America). However, the pace/rate of population aging is not uniform globally. In developing countries, the rate of aging is much faster than in developed countries (Subaiya & Bansod, 2014). For example, Southeast Asia is a rapidly aging region with an older population that is expected to reach 26.6% by 2035 (Arifin & Ananta, 2009).

The older population in Asia was roughly around 57.6 million in 1950, but it accounted for only 4.1% of the region's total population. However, it is estimated that by the middle of this century, Asia's older population will reach the mark of 922.7 million and account for 17.5% of the total population in the region. In China, the number of people aged 60 and above was 280.04 million in 2022, representing 19.8% of its total population, and expected to rise shortly (Peng, 2023). In Singapore, the proportion of older people has been increasing rapidly and currently stands at 25.4% of the total population (Subramaniam et al., 2019). There is an urgent need to formulate target-oriented policies in Southeast Asia that aim to change human behavior and refashion their institutions to prepare for the inevitable consequences (Menon & Melendez-Nakamura, 2009).

The Total Fertility Rate (TFR) has declined to 2.5 live births per woman in 2019 from 3.2 in 1990 in the World and is expected to decrease further to 2.2 in 2050 and 1.9 by 2100 (United Nations, 2020). Besides, life expectancy at birth has increased from 61.7 years in 1980 to 71.8 years in 2015, while the mortality rate has declined to 4.5% in 2015 from 22.5% in 1950 (Usha, 2004; Wang et al., 2016). These changing age structures and demographic shifts in the population show a considerable improvement in the healthcare system and overall development across the globe. Meanwhile, these trends will exacerbate the need for holistic care of a particular section (e.g., older people) of the population. Additionally, it will raise the cost of healthcare worldwide and increase socioeconomic stress.

India is the world's most populated country. It has seen a significant decline in fertility and an increase in life expectancy in recent decades (Chaudhary & Thakur, 2023). In India, TFR has decreased from 2.7 births per woman in 2005–2006 to 2.0 in 2019–2021. It is expected to decline to 1.72 from 2031 to 2035, much below the replacement level. Besides, the Crude Birth Rate (CBR) dropped from 23.1 in the National Family Health Survey-3 (NFHS-3) to 14.0 in the

NFHS-5 in India (Das et al., 2023; Sawe, 2020). Over the last few decades, life expectancy has increased significantly, from 36.2 years in 1950 to 67.5 years in 2015, and is projected to increase to 75.9 years by 2050 (Dhakal et al., 2022). Also, the country's infant mortality rate was 46 in 2010 and is expected to decline to 30 by the end of 2031–2035 (National Commission on Population, 2020). These demographic shifts contribute to a rise in the proportion of the older population across the country. The proportion of people aged 60 and above has increased from 5.4% in 1950 to 7% in 2009 and is expected to rise to 20% by 2050 (Subaiya & Bansod, 2014). Meanwhile, the aging population has been a significant problem in southern states like Andhra Pradesh, Karnataka, Kerala, and Tamil Nadu. However, the states such as Haryana, Himachal Pradesh, Maharashtra, Odissa, and Punjab are also seeing an increase in the number of older people. The demographic structure of these states has changed significantly and is expected to continue, with decreasing fertility, mortality, and greater life expectancy.

The states with a higher level of fertility are experiencing a lower level of aging than the national average. The notable states are Bihar, Madhya Pradesh, Jharkhand, and Rajasthan; these states are experiencing higher TFR and lower life expectancy, contributing to a substantially lower aging population (Ram & Ram, 2021). According to a recent health ministry report, there are 11 states and three union territories (UTs) that have attained the goal of replacement level (TFR as 2.1) before the deadline of 2010 (Kumar et al., 2020). Among the Empowered Action Group (EAG) states, Uttar Pradesh and Bihar, which together account for 25.1% of the country's population, have the highest TFR in the country, with 3.5 in Bihar and 3.3 in Uttar Pradesh (TFR 3.3), and the lowest female literacy rates, 51.5 and 57.2 respectively. These disparities in demographic data between Indian states demonstrate the unevenness and complexities of demographic transition due to varying economic development, literacy, social and cultural norms, and political situations (Pandey, 2016).

Moreover, the growing older population has been a serious concern for the healthcare system due to a structural change in disease patterns, especially at later ages. In addition to the existing burden of communicable diseases, a new burden of non-communicable diseases has emerged in the last three decades, producing a dual burden of diseases. In 2004, the population aged 45 and above accounted for 25% of the total disease burden and more than half of the burden of NCDs, and this age group is expected to account for more than 45% of the total disease burden by 2030. This shift in disease patterns has increased morbidity, accompanied by a significant fall in mortality (Yadav & Arokiasamy, 2014). Notwithstanding this, owing to variations in demographic figures and healthcare development, there is heterogeneity in disease patterns among states.

With this background, the present study aimed to estimate the future burden of the older population across the country. It is mainly for the better management of resources to achieve good health and well-being of the older population. The current research will compute aging indices, which will help predict when different states will reach a considerable aging level. At last, the authors recommend that future studies focus on aging using recent data for spatially optimized targeted policies.

Data and methods

Data source

The data for five-year age groups was collected from the Census of India for 2001 and 2011. Additionally, projected data for 2021 and 2031 was gathered from a report published by the National Commission on Population in 2020. This report provides projection data for twenty states and one union territory (UT) based on the component method, while for the remaining states, and UTs mathematical method was applied. However, the report provides combined data for north-eastern states (excluding Assam). Kerala's aging level in 2011 was used as a benchmark. Further, different aging indices are calculated yearly for up to 2031.

Statistical analysis

The linear interpolation method was applied to find new data points between the discrete ranges of already known data points. This scientific method helps to find the missing values between the already known data points. The researcher rigorously uses it to fill the gap in data points for their scientific analysis (Noor et al., 2015). Meanwhile, the linear extrapolation method was also applied to find new data points based on existing ones. Moreover, the authors proportionally distributed age-not-stated observations among the different five-year age groups. Furthermore, we computed various aging indices and an age-sex pyramid for the selected states of India to demonstrate the demographic transition and regional heterogeneity of population aging on a Spatiotemporal scale. Lastly, based on the Kerala 2011 index of aging level, the year in which states and UTs will achieve aging was analyzed for each state and UT. The mathematical equation of the linear interpolation which has been proposed by (Chapra & Canale, 1998) is as follows:

$$f(x) = f(x_0) + \frac{f_{(x1)} - f_{(x0)}}{x_1 - x_0}\,(x - x_0)$$

Where x is the outcome variable, x_1 and x_0 are known values of the explanatory variable, and $f(x)$ is the value of the outcome variable for a value of x of the explanatory variable. Researchers widely use this method (linear interpolation) for tabular data. However, the linear trend extrapolation method was used to predict the unknown data points from known data points. It is a statistical technique that researchers widely use for forecasts. For extrapolation of population aging, the MS-Excel 2013 'TREND' function was used by the authors to make accurate predictions. The notations of linear extrapolation are as follows:

$$P\,(t) = a + bt$$

Where P is the rate of the index of aging at the time (t), 'a' is an intercept, and 'b' is considered as a slope at times (t). However, analysis of predicted years in which aging will be achieved by different states and UTs has been performed using the MS-Excel 2013 'TREND' function.

Methods

The present study was carried out using age groups of 0–14 years (young age), 15–59 years (working age), and over 60 years (old age) to analyze the aging indices in India. The young

age group is individuals aged 0–14 years, whereas an age group of 15–59 years is regarded as a working age group. Lastly, a person aged 60 years and above is considered old.

Measure for aging indices

Median age: The median age is a mathematical value that equally divides a population into two halves. Furthermore, it is a single index that summarizes the age distribution of a population into two halves.

Aging index (elder-child ratio): The aging index is defined as the number of people aged 60 years and above per 100 youths under the age of 15 years.

Young age dependency ratio: The young age dependency ratio is the ratio between the numbers of young people and active working-age people. It is multiplied by 100 to show the percentage share of young-age people compared to working-age people.

Old-age dependency ratio: The old-age dependency ratio is the ratio between the number of old-age people compared to active working-age people. It is multiplied by 100 to show the percentage share of old-age people compared to working-age people.

Total dependency ratio: The total dependency ratio is the ratio between the sum of young-age dependency and old-age dependency compared to active working people. It is multiplied by 100 to show the percentage share of the dependent population compared to active working-age people.

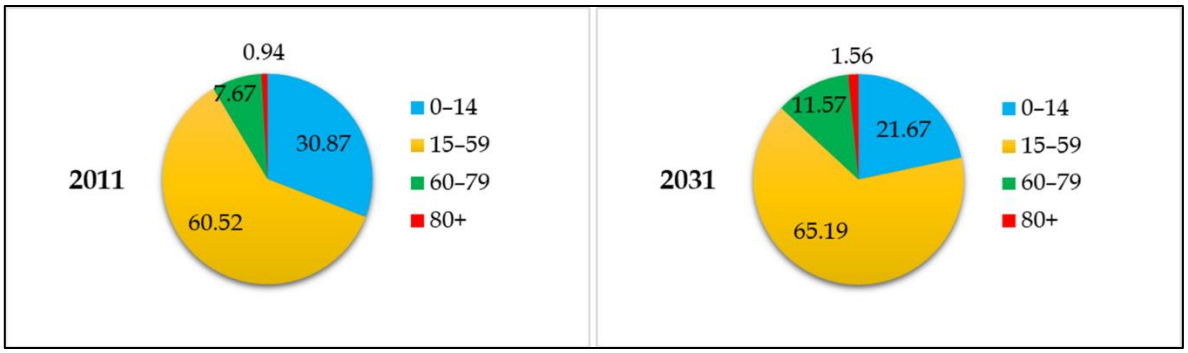
Age-sex pyramid: The age-sex pyramid is a graphical representation of the population age structure by age and sex in a country or region. When the population of a country is growing faster, then the age-sex pyramid looks like an expansive type of pyramid. On the other hand, factors like fertility, mortality, and migration rates play a vital role in determining the shape of the population pyramid.

Results

Profile of the older persons in India

The population aged 60 years and above was 8.61% in 2011, expected to increase to 13.13% in 2031. The working-age population (ages 15 to 59) is projected to grow 65.19% in 2031 from 60.52 in 2011. On the other hand, the population of children aged 0–14 years is expected to decline by 9.2%, from 30.87% in 2011 to 21.67% in 2031. Also, the proportion of the oldest old people (those aged 80 and over) is estimated to rise to 1.56% in 2031, up from 0.94% in 2011. The median age was 22.7 years in 2001 and would increase to 32.5 years in 2031. Also, the Index of Aging was 13.5 in 2001 and will rise to 40.9 in 2031, indicating a 9.8% and 27.4% increase from 2001 to 2031, respectively. In 2001, the young age dependency ratio was 59.3, dropping to 31.2% in 2031. Similarly, the old age dependency ratio was 8% in 2001 and will rise to 12.7% in 2031 (Figure 1).

Figure 1: Percentage of Population by Broad Age Groups in India, 2011 and 2031



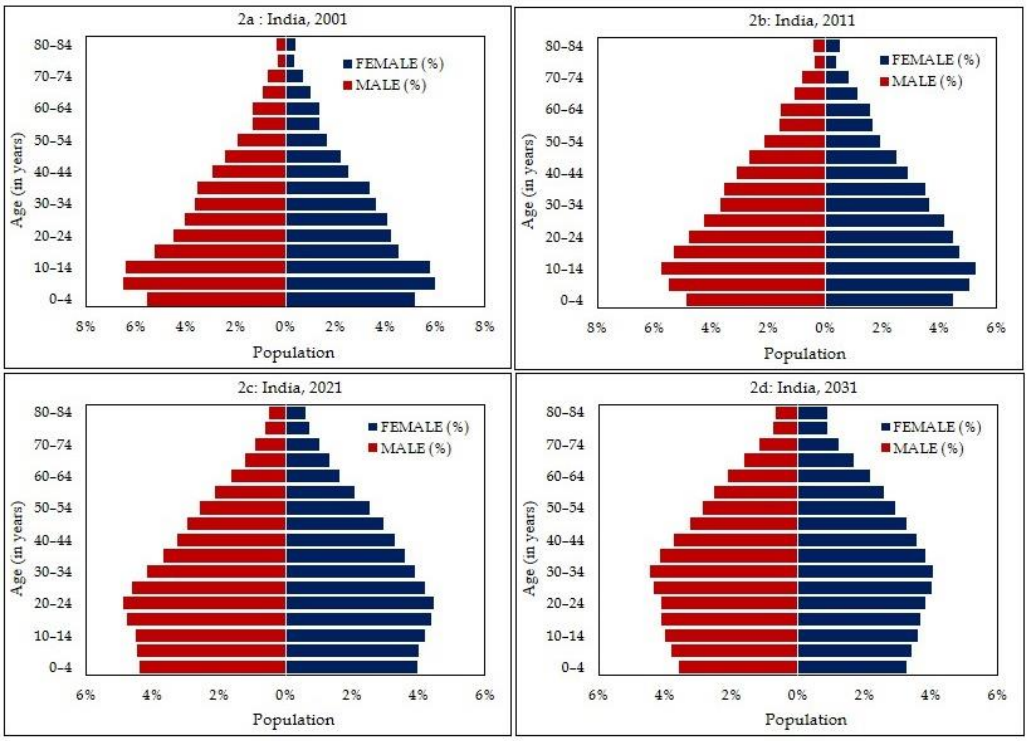
There will be a 28.1% decline in the young age dependency ratio between 2001 and 2031. However, between 2001 and 2031, the overall dependency ratio is expected to fall from 67.3% to 43.9% (Table 1).

Table 1: Population Aging Indices of India, 2001–2031

Year	Median Age	Index of Aging	Young Age Dependency	Old-Age Dependency	Total Dependency
2001	22.7	13.5	59.3	8.0	67.3
2011	24.9	17.8	48.5	8.6	57.1
2021	28.4	26.9	37.7	10.1	47.8
2031	32.5	40.9	31.2	12.7	43.9

In 2001 and 2011, the population pyramid of India was of the expansive types, with a wide base and pointed apex, indicating that more people die in each higher group; however, in the year 2011, the pyramid base began to narrow (or shift to old age), increasing the share of the old age population of the country. Meanwhile, based on comparing two pyramids from 2001 and 2011, we can observe that the country is in the midst of a demographic transition. According to projections estimates, the base of the pyramid is expected to narrow, and a significant proportion of the country's older population will increase in the coming years. Furthermore, between 2021 and 2031, the population pyramid begins to approximate a constrictive pyramid, with a slight constriction in the younger age groups, indicating an increase in the number of working-age people. Therefore, the slightly broad apex of the pyramid can be seen in 2021 and 2031, suggesting that the proportional share of the working-age population is increasing, and the absolute numbers of the older population are larger than in the expansion stage. Overall, a comparison of India's population pyramid suggests an inevitable transition of demographics and the age-sex structure of the population in the country (Figure 2).

Figure 2: Age-Sex Pyramid of India From 2001–2031 (a–d**)**



Aging in India by states

There are regional variations in the aging process in India, with southern states at the forefront. In 2001, Kerala had the highest median age (32 points and index of aging (35.5%), while Uttar Pradesh had the lowest median age (21.4 points) and index of aging (13.7%). In 2031, however, it is expected that the median age and index of aging will increase in all states across the country, with the highest increase in the index of aging in Kerala (81.2%) by 45.7% and the lowest increase in the index of aging in Uttar Pradesh (27.3%) by only 13.6%. Between 2001 and 2031, the old age dependency ratio will rise in each state including the highest in Kerala (12.2% to 22.4%) followed by Punjab (10% to 15.8%), Maharashtra (10% to 14.2%), Assam (6.6% to 10.8%), West Bengal (8.1% to 14.6%), and Uttar Pradesh (8.3% to 10%). The total dependency ratio of Kerala will increase to 50% in 2031, up from 46.6% in 2001, making it the highest among the selected states (Table 2).

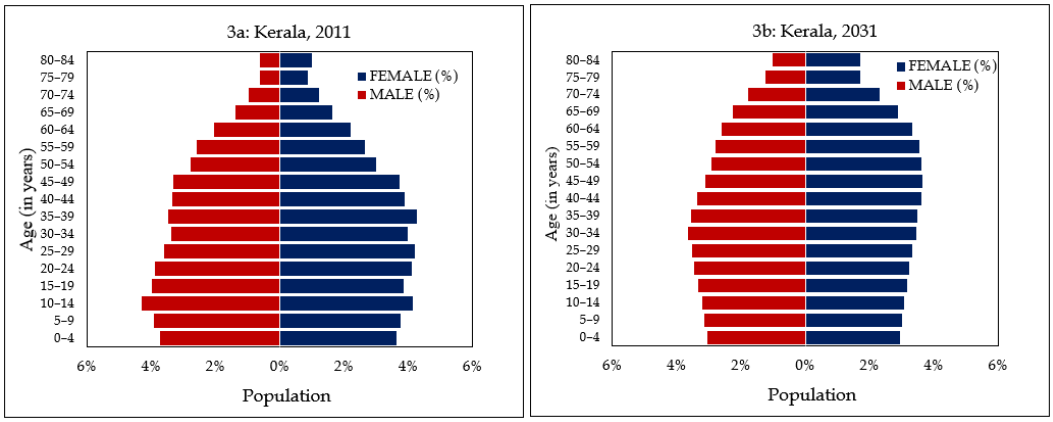
Table 2: Population Aging Indices for Selected States from 2011 and 2031

Index	2011					
	Kerala	Maharashtra	Uttar Pradesh	West Bengal	Punjab	Assam
Median Age	32.0	27.1	21.4	26.7	27.4	23.9
Index of Ageing	35.5	25.0	13.7	20.2	26.4	12.7
Young Age Dependency Ratio	34.4	40.1	60.9	40.3	37.8	52.2
Old Age Dependency Ratio	12.2	10.0	8.3	8.1	10.0	6.6
Total Dependency Ratio	46.6	50.1	69.2	48.4	47.8	58.8

Index	2031					
	Kerala	Maharashtra	Uttar Pradesh	West Bengal	Punjab	Assam
Median Age	38.2	35.6	29.3	36.4	36.6	31.5
Index of Ageing	81.2	56.4	27.3	59.8	65.7	33.3
Young Age Dependency Ratio	27.6	25.3	36.6	24.4	24.1	32.4
Old Age Dependency Ratio	22.4	14.2	10.0	14.6	15.8	10.8
Total Dependency Ratio	50.0	39.5	46.6	38.9	39.9	43.3

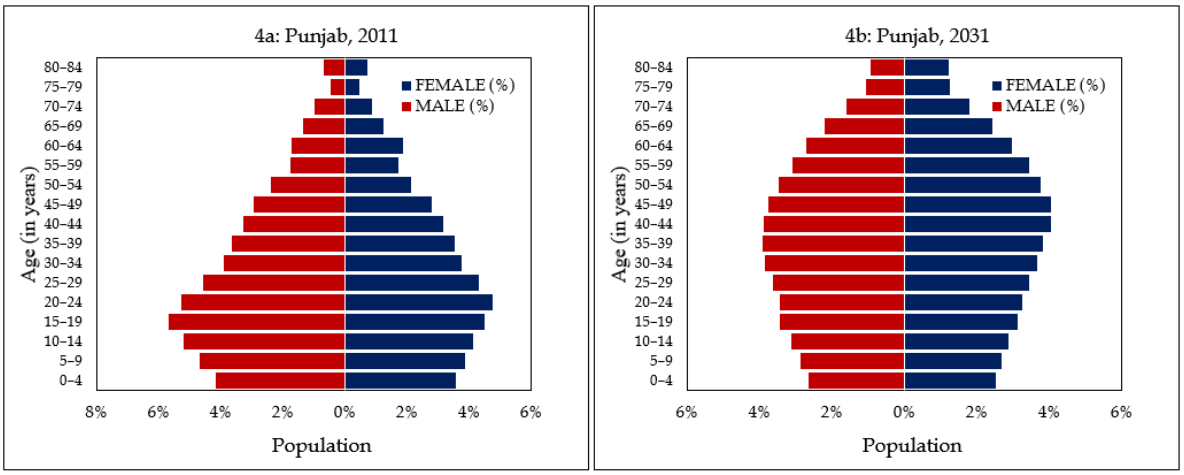
Similarly, regional variation in the population's age structure has been observed. In 2011 and 2031, the population pyramid of most of the states changed over the years due to changes in age structure, with the base narrowing and the apex widening. In 2011, the population pyramid of Kerala looked like a constrictive type, but by 2031, the pyramid base will have shrunk even more, and the pyramid apex will have widened, bringing it closer to the stationary stage (Figure 3).

Figure 3: Age-Sex Pyramid of Kerala, 2011 and 2031 (a & b)



For Punjab, a considerable drop in the young population will shrink the pyramid base, while a significant increase in the old population will widen the pyramid apex between 2011 and 2031. Meanwhile, between 2011 and 2031, Punjab's working-age population will grow faster than any other age group (Figure 4).

Figure 4: Age-Sex Pyramid of Punjab, 2011 and 2031 (a & b)



On the other hand, the population pyramids of Bihar and Uttar Pradesh showed different scenarios (almost expansive type pyramid); these are the states with the highest fertility rates, the fastest-growing populations, and more young people than older people (Figures 5 & 6).

Figure 5: Age-Sex Pyramid of Uttar Pradesh, 2011 and 2031 (a & b)

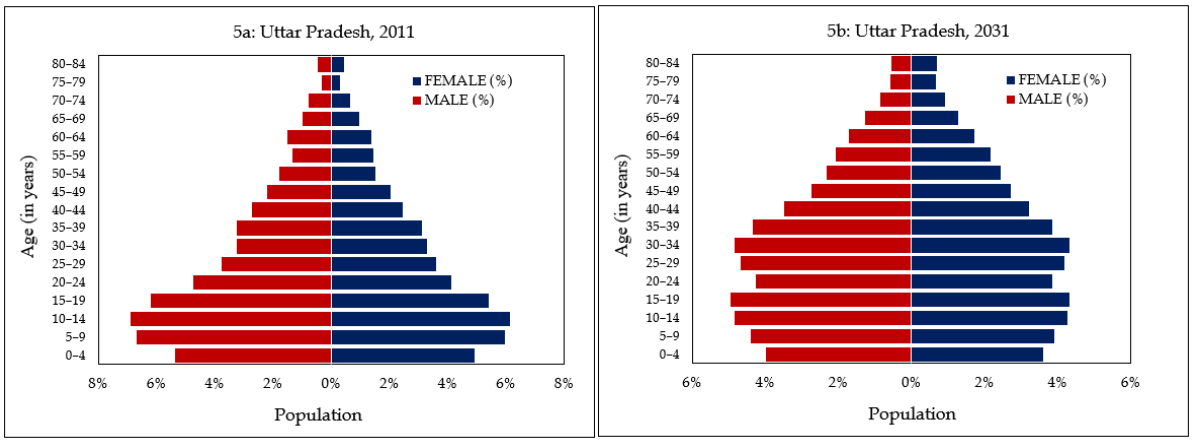
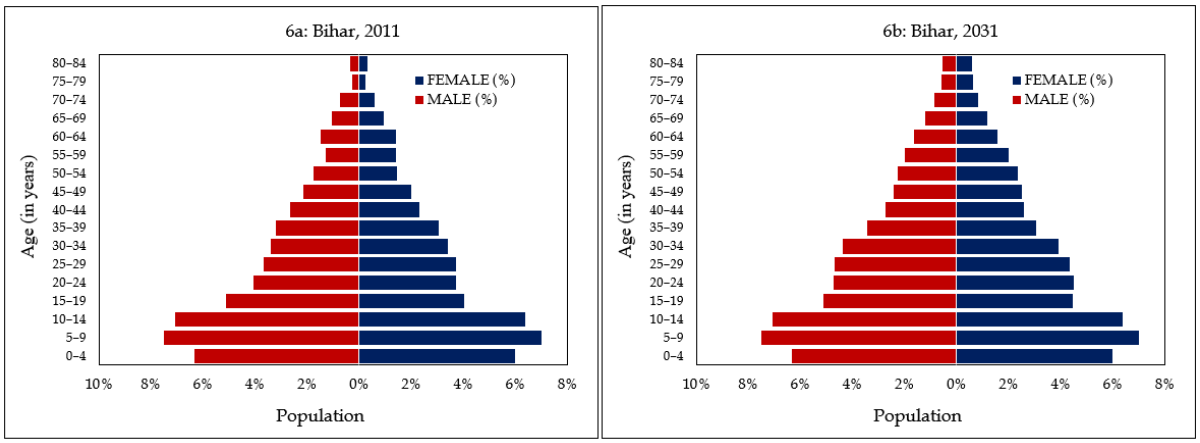


Figure 6: Age-Sex Pyramid of Bihar, 2011 and 2031 (a & b)



In 2011, the population pyramid of Uttar Pradesh was expansive. Over time, the population pyramid of Uttar Pradesh will shift, with a steady drop in the young age share (0–9 years) expected in 2031. However, between 2011 and 2031, there will be a considerable increase in the working-age population, increasing the older-age population in the future (Figure 5). The increase in the working-age population will be observed in the country due to the demographic transition (young to old).

Expected time when aging will be achieved by different states and UTs in India

As per the estimate, some of the states have achieved the aging level of Kerala (index of aging: 35.5 in 2011) before 2020, and it's faster than the rest of the states in India. Tamil Nadu was the first state to achieve this status in 2015, followed by Punjab and Himachal Pradesh in 2016 and Andhra Pradesh in 2017.

Table 3: Expected Year When Aging will be Achieved by Different States and UTs in India

State / UT	Population Aging Index				
	Median Age	Index of Aging	Young Age Dependency Ratio	Old Age Dependency Ratio	Total Dependency Ratio
Andhra Pradesh	2020	2017	2014	2021	2012
Assam	2033	2032	2027	2034	2022
Bihar	2044	2046	2041	2039	Beyond 2050
Chhattisgarh	2035	2033	2032	2034	2030
Delhi	2027	2026	2016	2033	2010
Gujarat	2030	2029	2029	2032	2020
Haryana	2029	2028	2025	2032	2021
Himachal Pradesh	2020	2016	2015	2019	2014
India	2032	2028	2026	2029	2024
Jammu & Kashmir	2028	2024	2021	2031	2019
Jharkhand	2038	2035	2035	2036	2033
Karnataka	2023	2021	2017	2025	2013
Madhya Pradesh	2037	2035	2034	2035	2034
Maharashtra	2023	2020	2017	2024	2015
N-E States (excluding Assam)	2028	2027	2020	2032	2017
Odisha	2025	2022	2021	2022	2020
Punjab	2021	2016	2014	2019	2013
Rajasthan	2033	2033	2033	2034	2032
Tamil Nadu	2016	2015	2011	2019	2002
Telangana	2023	2021	2016	2027	2015
Uttar Pradesh	2037	2036	2033	2039	2031
Uttarakhand	2029	2024	2021	2028	2020
West Bengal	2022	2021	2016	2026	2013

Note: Kerala's 2011 aging index was used as a benchmark

Some states, however, will reach it by 2025, including Maharashtra in 2020, Karnataka, West Bengal, and Telangana in 2021, Orissa in 2022, and Jammu & Kashmir in 2025. In 2016, Tamil Nadu became the first state to reach Kerala's aging level (median age: 32.0 in 2011). Some states, including Andhra Pradesh, Telangana, West Bengal, Orissa, Himachal Pradesh, and Punjab, will reach Kerala's aging level before 2025. While Bihar is expected to reach Kerala's level of aging (index of aging: 35.5 in 2011 and median age: 32.0 in 2011) in 2046 and 2044, respectively, as it is the slowest of the states to do so, requiring a longer time. Before 2030, the North-Eastern states will reach Kerala's level of aging (index of aging: 35.5 in 2011 and median age: 32.0 in 2011), whereas Assam will reach it by 2033.

There are a total of seven states, namely Andhra Pradesh, Himachal Pradesh, Karnataka, Maharashtra, Orissa, Punjab, and Tamil Nadu, that will reach the aging level of Kerala (Old-age dependency ratio: 12.2 in 2011) by 2025. Meanwhile, Uttar Pradesh and Bihar will achieve Kerala's aging level (Old-age dependency ratio: 12.2, Kerala, 2011) by 2039. Furthermore, a few northern states, such as Bihar and Uttar Pradesh, are reaching the aging level of Kerala, which is far behind several southern states (e.g., Tamil Nadu, Andhra Pradesh, Telangana, etc.). According to estimates, Bihar's total dependency ratio will take more than 50 years to reach Kerala's level (46.6 in 2011), making it the state that would take the longest. However, before 2025, most states will achieve the total dependency ratio of Kerala (Table 3).

Discussion

India has been experiencing a demographic transition with decreasing fertility and increasing life expectancy for the last three decades. This has resulted in a significant increase in the older population across the country. The country is in the process of an epidemiological shift, with a surge in non-communicable diseases (NCDs), which are particularly prevalent among older persons. The NCDs have added to the burden of existing communicable diseases, resulting in a dual burden of diseases. Besides, the aging of the population poses significant challenges to healthcare financing (Sahoo et al., 2023). According to Yenilmez (2015), population aging significantly impacts all aspects of society, including health, social security, education, socio-cultural activities, family life, and the labor market. On the other hand, a decrease in the working-age population lowers labor-force participation, increasing the proportion of retired people.

A study conducted by Bhan et al. (2017) in India revealed that road accidents, crime, and loneliness have become significant concerns of the older population. Therefore, the study suggests lifestyle counseling, health service outreach, community monitoring of healthcare, and public awareness activities for them. Moreover, Havighurst (1961) proposed the activity theory of population aging, often referred to as a psychological theory of aging. This theory describes the success of aging is enhanced when older adults are involved in social interactions and productive activities. Therefore, the present study assumes that the involvement of social activities helps improve older persons' satisfaction and happiness (Teles & Ribeiro, 2019). We found regional heterogeneity in the aging process of the Indian population in this study. This study further suggests spatially optimized targeted policy implications to promote healthy aging in India (Banerjee, 2021).

There is a variation among the country's states, with those in the southern region leading the way compared to other states. However, all states are in a period of transition, with dropping fertility and rising life expectancy. It will increase the proportion of older people in each state in the future, but the rate and pace will differ. Therefore, the current study estimates the aging level using several aging indices and projects the aging process in each state.

Findings from the present study showed that there will be a change in the age structure of the population from 2001 to 2031, with an increase in the working-age group and the older population. However, there will be a decline in the younger population ages 0–14 years. The country’s aging rate was slow due to the high fertility rate in the past. However, the rate of aging is now expected to rise as fertility rates decrease (Usha, 2004). Further, previous studies have predicted that by 2030, the young population will have shifted into an aging population due to altering demographic structures (James, 2011). This is a demographic achievement due to improved healthcare, increasing literacy levels among women, rising living standards, and better nutrition.

These findings raise an alert about the need to prepare for the challenges of an aging population across the country. Following this, a body of research has found that the impact of an aging population in the future will be significant in terms of economic, health, and social security across the country (Bhattacharya, 2005; Dey et al., 2012; James, 2011; McPake & Mahal, 2017). These issues are becoming more of a concern to the country as the nuclear family structure replaces the joint family structure, causing social and mental health issues among older persons (Bhat & Dhruvarajan, 2001; Golandaj et al., 2013).

Moreover, results from the projected aging indices show a remarkable increase in the median age, index of aging (aged-child ratio), and old-age dependency ratios in India. However, these indices are increasing at diverse rates in different states. Meanwhile, the strongest indicator of population aging has been the median age, which splits the population into two equal parts. It indicated that half of the population is older and half young. By 2031, Kerala is expected to have the highest median age, while Uttar Pradesh will have the lowest.

Nevertheless, population projection indicates that Uttar Pradesh's population will increase more than the other states. Between 2011 and 2031, Kerala would have the highest expected increase in the aging index among southern states, followed by Maharashtra, West Bengal, and Punjab. Furthermore, Kerala will have the highest growth in the old-age dependency ratio between 2011 and 2031. It was claimed that Kerala had already reached a substantial level of aging in the year 2011 and that the remaining states are on their path to accomplishing the same level of aging as Kerala (Bhat & Rajan, 1990; James, 2011; Rajan et al., 2020; Ratcliffe, 1983; Zachariah, 2017). However, because of demographic and health indicators variations and the fact that different states are at varying stages of economic development and demographic transition, the population will age at variable rates in other states to reach the Kerala level.

The present study projected the year by which states will achieve Kerala's aging level of 2011. A few states have already reached Kerala's level of median age and index of aging by the year 2020. These states are Tamil Nadu, Punjab, Andhra Pradesh, and Himachal Pradesh. Further, by or before 2025, Karnataka, Maharashtra, Telangana, Odisha, and West Bengal will reach Kerala's median age of 2011. According to the data, it has been observed that these states have the highest proportion of older people after Kerala, owing to their advanced level of mortality, fertility, and demographic changes as compared to their counterparts (Bose, 2013; Sekher et al., 2001; Spoorenberg, 2010).

Likewise, these states have already been more economically and socially developed, having a significant level of education, especially among women, early adaptation of family planning methods, and awareness about modern contraception, which has been contributing to a sharp decline in fertility (Basu & Sidh, 2008; Jejeebhoy et al., 2014; Mathew et al., 2009; Murthy, 2014; Singh et al., 2020). Consequently, the overall population of these states has decreased significantly and is anticipated to continue to decline. Similar patterns for dependency ratios across the states in the country can be observed in the present study. The dependency ratio is one measure that gives an idea about the demographic dividend. The demographic dividend mainly refers to the potential economic growth resulting from shifts in the population's age structure, especially when the working-age population is larger than the non-working-age population (Bloom et al., 2003).

Previous studies stated that as the older population increases, old age dependency ratios will rise, posing issues such as limited mobility, social and structural impediments, wage loss, familial dependencies, and declining social involvement (Chanana & Talwar, 1987; Dey et al., 2012; Smith & Majmudar, 2012). The projected figures suggest that states in advanced demographic transition are expected to achieve Kerala's old age dependency ratio early in the upcoming few years. Consequently, the demographic dividend is on the wane in these states, including Kerala, much earlier than in the rest of the country. Therefore, these states are needed to prioritize in terms of health care, financial assistance, and social and emotional support.

On the other hand, by the year 2035 and later, a specific northern state, as well as other states, such as Bihar, Uttar Pradesh, Madhya Pradesh, Jharkhand, and Chhattisgarh, are expected to reach Kerala's median age and index of aging. These states have a slow demographic change due to high fertility and lower life expectancy (Jeffery & Jeffery, 1998; Tandon et al., 2018). These states are still facing challenges in terms of economic development, leading to poor healthcare, low female literacy, and infant survival rates (Chowdhury et al., 2017; Patkar, 1995; Singh et al., 1997; Singh et al., 1998; Singh et al., 2016). Even though fertility is declining in these states, it is slow, leading to a shift in the age group of 0–6 years into the working ages in the upcoming decades. Meanwhile, there has been an increase in the working-age population, and the future economic potential of the country is locked in these states that are experiencing a late demographic transition. A panel study has documented a strong and positive association between the age structure transition and economic growth in China and India (Bloom et al., 2003). The shift in demographic structure will help the country's economy to thrive, but it will depend on the country's policy environment and governance (James, 2008).

Additionally, an increase in the working-age population may substantially burden education, employment, and health. Therefore, projection estimates from the present study suggest that policymakers should prioritize taking full advantage of demographic bonuses by offering high-quality education, particularly for women, and greater job opportunities, especially in states with a larger population. Therefore, there is a need to make approachable efforts to address the growing aging population on a macro level and a household level from a social, medical, and financial perspective.

Variations in the process of demographic changes across different states will invite different challenges for providing socioeconomic and health-related opportunities in the future. Access to pensions, healthcare, long-term care, and other care for this population segment will improve the quality of life among older adults (Kaye et al., 2010; Seltzer et al., 2005). However, due to unemployment and lower female education, the government expenditure for social welfare schemes and health care will be a considerable concern for those states in the advanced midst of demographic transition. The predicted projections from this study will contribute to the existing literature on social welfare programs and the associated financial outlays to satisfy the increasing demand for old-age dependency and decreasing support base, which will be essential for policy consideration in the coming days.

Conclusions

The remarkable growth of the older population raises many points for policymakers, researchers, academicians, and civil society, as well as their partnership regarding practical and sustainable care and support for senior citizens. The rising burden of the older population implies the need for a better quality of geriatric services, financial security arrangements, and enhanced quality of life. Therefore, there is an urgent need for area-specific targeted healthcare infrastructure development, management of the older population, promotion of healthy aging, particular emphasis on older persons' welfare schemes, and increasing the retirement age for older people for the states, which will achieve Kerala-level of aging (index of aging: 35.5 in 2011) within 2030. It is time to start planning for the future burden of the older population across the country and arrange adequate health infrastructure for the older population.

Acknowledgments

The authors would like to thank the Registrar General and Census Commissioner of India for providing the Census dataset for free use.

References

Arifin, E. N., & Ananta, A. (2009). *Older persons in Southeast Asia: An emerging asset.* Institute of Southeast Asian Studies.

Banerjee, S. (2021). Determinants of rural-urban differential in healthcare utilization among the elderly population in India. *BMC Public Health*, *21*(1), Article 939. https://doi.org/10.1186/s12889-021-10773-1

Basu, S., & Sidh, S. N. (2008). Work status and health of women: A comparative study of northern and southern states of rural India. *World Health & Population*, *10*(2), 40–52. https://doi.org/10.12927/whp.2008.19930

Bhan, N., Madhira, P., Muralidharan, A., Kulkarni, B., Murthy, G., Basu, S., & Kinra, S. (2017). Health needs, access to healthcare, and perceptions of ageing in an urbanizing community in India: A qualitative study. *BMC Geriatrics*, *17*(1), Article 156. https://doi.org/10.1186/s12877-017-0544-y

Bhat, A. K., & Dhruvarajan, R. (2001). Ageing in India: Drifting intergenerational relations, challenges and options. *Ageing & Society*, *21*(5), 621–640. https://doi.org/10.1017/S0144686X0100842X

Bhat, P. M., & Rajan, S. I. (1990). Demographic transition in Kerala revisited. *Economic and Political Weekly*, *25*(35/36), 1957–1980. http://www.jstor.org/stable/4396712

Bhattacharya, P. (2005, January 12–14). *Implications of an aging population in India: Challenges and opportunities* [Paper presentation]. https://www.silverinnings.com/old/docs/Ageing%20Indian/Implication%20of%20Ageing%20population%20in%20India.pdf

Bloom, D. E., Canning, D., & Sevilla, J. (2003). The demographic dividend: A new perspective on the economic consequences of population change (1st ed.). *Rand Corporation*. https://www.rand.org/content/dam/rand/pubs/monograph_reports/2007/MR1274.pdf

Bose, A. (2013). Demographic transition and Demographic imbalance in India. *Health Transition Review*, *6*(1996), 89–99. http://www.jstor.org/stable/40652253

Chanana, H. B., & Talwar, P. P. (1987). Aging in India: Its socioeconomic and health implications. *Asia-Pacific Population Journal*, *2*(3), 23–38. https://doi.org/10.18356/5c692b25-en

Chapra, S. C. & Canale, R. P. (1998). *Numerical Methods for Engineers*. Singapore: McGraw-Hill.

Chaudhary, J., & Thakur, K. (2023). India the world's most populous country: Boon or Bane. *The Agriculture Magazine*, *2*(6), 159–160. https://theagricultureonline.com/volume-02-issue-6-april-2023/

Chowdhury, R., Taneja, S., Mazumder, S., Bhandari, N., & Strand, T. A. (2017). Gender differences in infant survival: A secondary data analysis in rural North India. *BMJ Open*, *7*(8), Article e014179. https://doi.org/10.1136/bmjopen-2016-014179

Das, P., Das, T., & Roy, T. B. (2023). Role of proximate and non-proximate determinants in children ever born among Indian women: Change detection analysis from NFHS-3 & 5. *Women and Children Nursing*, *1*(1), 9–17. https://doi.org/10.1016/j.wcn.2023.03.002

Dey, S., Nambiar, D., Lakshmi, J. K., Sheikh, K., & Reddy, K. S. (2012). Health of the elderly in India: Challenges of access and affordability. In J. P. Smith & M. Majmundar (Eds.), *Aging in Asia: Findings from new and emerging data initiatives*. National Academies Press (US). https://www.ncbi.nlm.nih.gov/books/NBK109208/

Dhakal, S., Nankervis, A., & Burgess, J. (Eds.). (2022). *Ageing Asia and the Pacific in changing times: Implications for sustainable development*. Springer Nature Singapore. https://doi.org/10.1007/978-981-16-6663-6

Golandaj, J. A., Goli, S., & Das, K. C. (2013). Living arrangements among older population and perceptions on old age assistance among adult population in India. *International Journal of Sociology and Social Policy*, *33*(5), 367–379. https://doi.org/10.1108/IJSSP-09-2012-0083

Havighurst, R. J. (1961). Successful Aging. *The Gerontologist*, 1(1), 8–13. https://doi.org/10.1093/geront/1.1.8

Yenilmez, M. I. (2015). Economic and social consequences of population aging the dilemmas and opportunities in the twenty-first century. *Applied Research in Quality of Life*, *10*(4), 735–752. https://doi.org/10.1007/s11482-014-9334-2

James, K. S. (2008, June 21). *Glorifying Malthus: Current debate on "Demographic dividend" in India*. Economic and Political Weekly. https://www.epw.in/journal/2008/25/special-articles/glorifying-malthus-current-debate-demographic-dividend-india.html

James, K. S. (2011). India's demographic change: Opportunities and challenges. *Science*, *333*(6042), 576–580. https://doi.org/10.1126/science.1207969

Jeffery, R., & Jeffery, P. (1998). *Population, gender and politics: Demographic change in rural north India.* Cambridge University Press.

Jejeebhoy, S. J., Santhya, K. G., & Zavier, A. J. F. (2014). Demand for contraception to delay first pregnancy among young married women in India. *Studies in Family Planning*, *45*(2), 183–201. https://doi.org/10.1111/j.1728-4465.2014.00384.x

Kaye, H. S., Harrington, C., & LaPlante, M. P. (2010). Long-term care: Who gets it, who provides it, who pays, and how much? *Health Affairs*, *29*(1), 11–21. https://doi.org/10.1377/hlthaff.2009.0535

Kumar, S., Sahu, D., Mehto, A., & Sharma, R. K. (2020). Health inequalities in under-five mortality: An assessment of Empowered Action Group (EAG) States of India. *Journal of Health Economics and Outcomes Research*, *7*(2), 189–196. https://doi.org/10.36469/JHEOR.2020.18224

Malik, C., Khanna, S., Jain, Y., & Jain, R. (2021). Geriatric population in India: Demography, vulnerabilities, and healthcare challenges. *Journal of Family Medicine and Primary Care*, *10*(1), 72–76. https://doi.org/10.4103/jfmpc.jfmpc_1794_20

Mathew, K., Zachariah, S., Shordt, K., Snel, M., Cairncross, S., Biran, A., & Schmidt, W.-P. (2009). The sustainability and impact of school sanitation, water and hygiene education in southern India. *Waterlines*, *28*(4), 275–292. https://doi.org/10.3362/1756-3488.2009.029

McPake, B., & Mahal, A. (2017). Addressing the needs of an aging population in the health system: The Australian Case. *Health Systems & Reform*, *3*(3), 236–247. https://doi.org/10.1080/23288604.2017.1358796

Menon, J., & Melendez-Nakamura, A. (2009, February). *Aging in Asia: Trends, impacts and responses* (ADB Working Paper Series No. 25). Asian Development Bank. https://www.adb.org/sites/default/files/publication/28500/wp25-aging-asia.pdf

Murthy, M. S. R. (2014). Knowledge of emergency contraception in the Southern States of India. *Studies on Ethno-Medicine*, *8*(3), 277–283. https://doi.org/10.1080/09735070.2014.11917644

National Commission on Population. (2020, July). C*ensus of India 2011: Population Projections for India and States 2011–2036*. Ministry of Health and Human Welfare. https://main.mohfw.gov.in/sites/default/files/Population%20Projection%20Report%202011-2036%20-%20upload_compressed_0.pdf

Noor, N. M., Al Bakri Abdullah, M. M., Yahaya, A. S., & Ramli, N. A. (2015). Comparison of linear interpolation method and mean method to replace the missing values in environmental data set. *Materials Science Forum*, *803*, 278–281. https://www.scientific.net/MSF.803.278

Pandey, M, M. (2016). Population stabilization and demographic dividend in India. *International Journal of Scientific & Engineering Research*, *7*(1), 16–33. https://www.ijser.org/researchpaper/Population-stabilization-and-Demographic-dividend-in-India.pdf

Patkar, A. (1995). Socio-economic status and female literacy in India. *International Journal of Educational Development*, *15*(4), 401–409. https://doi.org/10.1016/0738-0593(95)00023-V

Peng, D. (2023). Negative population growth and population ageing in China. *China Population and Development Studies*, *7*(2), 95–103. https://doi.org/10.1007/s42379-023-00138-z

Rajan, S. I., Shajan, A., & Sunitha, S. (2020). Ageing and elderly care in Kerala. *China Report*, *56*(3), 354–373. https://doi.org/10.1177/0009445520930393

Ram, U., & Ram, F. (2021, April 26). Demographic transition in India: insights into population growth, composition, and its major drivers. *Oxford Research Encyclopedia of Global Public Health*. https://doi.org/10.1093/acrefore/9780190632366.013.223

Ratcliffe, J. W. (1983). Toward a social justice theory of demographic transition: Lessons from India's Kerala State. *Janasamkhya*, *1*(1), 1–38.

Sahoo, P. M., Rout, H. S., & Jakovljevic, M. (2023). Consequences of India's population aging to its healthcare financing and provision. *Journal of Medical Economics*, *26*(1), 308–315. https://doi.org/10.1080/13696998.2023.2178164

Sander, M., Oxlund, B., Jespersen, A., Krasnik, A., Mortensen, E. L., Westendorp, R. G. J., & Rasmussen, L. J. (2015). The challenges of human population ageing. *Age and Ageing*, *44*(2), 185–187. https://doi.org/10.1093/ageing/afu189

Sawe, B. E. (2020, January 14). *India's falling fertility rate: 1950 to 2020*. WorldAtlas. https://www.worldatlas.com/articles/india-s-falling-fertility-rate-1950-to-2020.html

Sekher, T. V., Raju, K. N. M., & Sivakumar, M. N. (2001). Fertility transition in Karnataka: Levels, trends and implications. *Economic and Political Weekly*, *36*(51), 4742–4752. https://www.jstor.org/stable/4411509

Seltzer, J. A., Bachrach, C. A., Bianchi, S. M., Bledsoe, C. H., Casper, L. M., Chase-Lansdale, P. L., DiPrete, T. A., Hotz, V. J., Morgan, S. P., Sanders, S. G., & Thomas, D. (2005). Demographic changes across different states will invite different challenges. *Journal of Marriage and Family*, *67*(4), 908–925. https://doi.org/10.1111/j.1741-3737.2005.00183.x

Singh, P., Singh, K. K., Singh, A., & Pandey, A. (2020). The levels and trends of contraceptive use before first birth in India (2015–16): A cross-sectional analysis. *BMC Public Health*, *20*(1), Article 771. https://doi.org/10.1186/s12889-020-08917-w

Singh, R. B., Beegom, R., Ghosh, S., Niaz, M. A., Rastogi, V., Rastogi, S. S., Singh, N. K., & Nangia, S. (1997). Epidemiological study of hypertension and its determinants in an urban population of North India. *Journal of Human Hypertension*, *11*(10), 679–685. https://doi.org/10.1038/sj.jhh.1000511

Singh, R. B., Niaz, M. A., Thakur, A. S., Janus, E. D., & Moshiri, M. (1998). Social class and coronary artery disease in an urban population of North India in the Indian Lifestyle and Heart Study. *International Journal of Cardiology*, *64*(2), 195–203. https://doi.org/10.1016/S0167-5273(98)00048-5

Singh, T., Roy, P., Jamir, L., Gupta, S., Kaur, N., Jain, D. K., & Kumar, R. (2016). Assessment of universal healthcare coverage in a district of North India: A rapid cross-sectional survey using tablet computers. *PLOS ONE*, *11*(6), Article e0176063. https://doi.org/10.1371/JOURNAL.PONE.0157831

Smith, J. P., & Majmundar, M. (2012). *Aging in Asia: Findings from new and emerging data initiatives*. National Academies Press. https://doi.org/10.17226/13361

Spoorenberg, T. (2010). Fertility Transition in India between 1977 and 2004. *Population*, *65*(2), 313–331. https://doi.org/10.3917/pope.1002.0313

Subaiya, L., & Bansod, D. W. (2011, December). *Demographics of population ageing in India* (BKPAI Working Paper No. 1). United Nations Population Fund (UNFPA). http://www.isec.ac.in/BKPAI%20Working%20paper%201.pdf

Subramaniam, M., Abdin, E., Vaingankar, J. A., Sambasivam, R., Seow, E., Picco, L., Chua, H. C., Mahendran, R., Ng, L. L., & Chong, S. A. (2019). Successful ageing in Singapore: Prevalence and correlates from a national survey of older adults. *Singapore Medical Journal*, *60*(1), 22–30. https://doi.org/10.11622/smedj.2018050

Tandon, A., Bordoloi, B., Jaiswal, R., Srivastava, A., Singh, R. B., & Shafique, U. (2018). Demographic and clinicopathological profile of oral squamous cell carcinoma patients of North India: A retrospective institutional study. *SRM Journal of Research in Dental Sciences*, *9*(3), 114–118. https://doi.org/10.4103/srmjrds.srmjrds_21_18

Teles, S., & Ribeiro, O. (2019). Activity Theory. In D. Gu & M. E. Dupre (Eds.), *Encyclopedia of Gerontology and Population Aging* (pp. 1–8). Springer, Cham. https://doi.org/10.1007/978-3-319-69892-2_748-1

United Nations. (2020). *World Fertility and Family Planning 2020: Highlights* (ST/ESA/SER.A/440). Department of Economic and Social Affairs, Population Division. https://doi.org/10.18356/9789210043694

United Nations. (2022). *World Population Prospects 2022: Summary of Results* (UN DESA/POP/2022/TR/NO. 3). United Nations Department of Economic and Social Affairs, Population Division. https://www.un.org/development/desa/pd/content/World-Population-Prospects-2022

Usha, R. (2004). Emerging issues from declining fertility in India. In T. K. Roy, M. Guruswamy, & P. Arokiasamy (Eds.), *Population, Health and Development in India: Changing Perspective* (pp. 291–322). Rawat Publisher.

Wang, H., Naghavi, M., Allen, C. A., Barber, R. M., Bhutta, Z. A., Carter, A., Casey, D., Charlson, F. J., Chen, A. Z., Coates, M. M., Coggeshall, M., Dandona, L., Dicker, D., Erskine, H. E., Ferrari, A. J., Fitzmaurice, C., Foreman, K. J., Forouzanfar, M. H., Fraser, M., . . . Murray, C. J. L. (2016). Global, regional, and national life expectancy, all-cause mortality, and cause-specific mortality for 249 causes of death, 1980–2015: A systematic analysis for the Global Burden of Disease Study 2015. *The Lancet*, *388*(10053), 1459–1544. https://doi.org/10.1016/s0140-6736(16)31012-1

World Health Organization. (2022, October 1). *Ageing and health.* https://www.who.int/news-room/fact-sheets/detail/ageing-and-health

Yadav, S., & Arokiasamy, P. (2014). Understanding epidemiological transition in India. *Global Health Action*, *7*(1), Article 23248. https://doi.org/10.3402/gha.v7.23248

Zachariah, K. C. (2017, June 13). *Coping with demographic transition*. Economic and Political Weekly. https://www.epw.in/journal/2001/22/commentary/coping-demographic-transition.html