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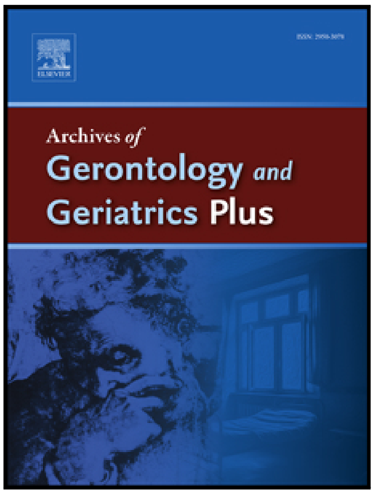


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Madhurima Sharma Doctoral fellow , Abdul Fathah Doctoral fellow , Indrajit Goswami Research Assistant

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**Cognitive-Impairment-Free Life Expectancy (CIFLE) among Older Adults in India: A Gender and Residence based Study**

**Authors:**

Madhurima Sharma[1*], Abdul Fathah[2], Indrajit Goswami[3]

[1] Doctoral fellow, International Institute for Population Sciences, Mumbai, India.

Email: madhurimasharma1@gmail.com

ORCiD: 0000-0002-9025-4260

[2] Doctoral fellow, International Institute for Population Sciences, Mumbai, India.

Email: fathah940@gmail.com

ORCiD: 0009-0001-6556-4742

[3] Research Assistant, International Institute for Population Sciences, Mumbai, India.

Email: indrajitgoswami124@gmail.com

ORCiD: 0009-0008-5980-9097

**Corresponding Author**

*Madhurima Sharma

Doctoral fellow, International Institute for Population Sciences, Mumbai, India

Email: madhurimasharma1@gmail.com

**Background:** While cognitive impairment (CI) and dementia are among the most severe morbid conditions in later life, life expectancies free from CI have been much less investigated than measures of physical functioning. This study aimed to determine the health expectancies in middle aged and older adults in India, considering cognitive status as a health indicator.

**Methods:** We estimated CI-free life expectancy in India for people aged 45 and older using data from Longitudinal Ageing Study in India (LASI), 2017-18. Mortality data has been derived from the Sample Registration System (SRS), 2016-20. Sullivan's method is used to estimate the average number of years a person can expect to live with and without cognitive impairment.

**Results:** The prevalence of CI among Indian adults 45 and above is 10.28%, increasing from 4.34% (45-49) to 47% (85+). Higher rates in females (13.65% vs 6.42% in males) and rural areas (12.39% vs 6.38% urban). The results indicate that after attaining age 60, males are expected to live 15 more years as cognitive impairment-free, which is only 12 years for females; though life expectancy for females is higher than that of males. Older adults in rural areas are expected to have fewer cognitive impairment-free years than in urban areas.

**Conclusion:** Longer life does not extend cognitive health. CI reduces quality of life and increases care needs, aligning with global trends. The disparities in CI-free life expectancy between genders and rural-urban areas highlight the need for targeted interventions and policies to address cognitive health inequalities in India.

**Keywords:** Older adults, Cognitive impairment, Life expectancy, Sullivan method, India.

**Background**

Cognitive impairment (CI) is a significant health challenge during old age. It is a leading cause of disability that may lead to a loss of independence in the oldest stages of life. CI has gained increasing attention due to its profound impact on aging populations. It is anticipated that the prevalence and treatment of CI will increase significantly in the ensuing decades, also in low and middle-income countries, making it a crucial public health issue (Ferri et al., 2005; McGrattan et al., 2021; Prince et al., 2013). Length of life with cognitive impairment is a good indicator of the burden of this condition for an average individual in the population. With rising life expectancy, researchers have started investigating whether the additional years are spent in good health or marked by illness and disability (Robine & Ritchie, 1991). Health expectancy metrics integrate morbidity and mortality rates to offer insights into both healthy and unhealthy life expectancy.

CI has become an increasing concern in India, driven by population ageing, rural-urban health gaps, and widespread low literacy among older adults. Limited formal care infrastructure and dependence on family caregivers further exacerbate the challenge. (Jadenur et al., 2022; Patel & Singh, 2018; Ravindranath & Sundarakumar, 2021). India is a nation with rapid ageing and is witnessing a surge in the aged population. Because of this demographic shift, the incidence and prevalence of neurodegenerative disorders are also a burdening concern (Ravindranath & Sundarakumar, 2021). These not only have an impact on health but also have an impact on the social cohesion and economic prosperity of the nation (Bhatia et al., 2020; Kumar et al., 2019; P et al., 2022; Sathianathan & Kantipudi, 2018).

With increasing global life expectancy (LE), recent literature has grown interested in whether the extra years gained are lived in good health. Cognitive Impairment-Free Life Expectancy (CIFLE) can be defined as the number of years lived with and without cognitive impairment, providing information about the quantity and quality of life lived at a population level (Chang et al., 2013; Dubois & Hébert, 2006; Mooldijk et al., 2022, 2022; Perenboom et al., 1996). Over the last decades, with increasing life expectancy, researchers have begun to explore whether these gains in years in life expectancy are healthy years or years lived with disease and disability (Robine & Ritchie, 1991). Health expectancy combines morbidity and mortality estimates to provide healthy and unhealthy life expectancy indicators. These measures are generally independent of the population's age structure; therefore, they can be compared across the time and population subgroups. Since the risk of CI is most significant in late life, it would be interesting to know how the number of years with this condition will likely be affected by the reduction in old-age mortality.

The majority of research on cognitive health expectancies has come from high-income nations with longitudinal ageing studies and similar cultural heritage, such as the United Kingdom (UK), the United States (US), and Canada (Bardo & Lynch, 2019; Dubois & Hébert, 2006; Lièvre et al., 2008; Sauvaget et al., 2001). There are a few isolated findings from low and middle-income nations that extend knowledge in this arena (Andrade et al., 2019; Ashby-Mitchell et al., 2015; Muangpaisan et al., 2012). The comparative studies between high-income countries (HICs) and middle-and low-income countries (LMICs) have highlighted the disparities in the burden of CI. Studies indicated that HICs tend to experience longer CIFLE compared to LMICs, which implied the differences in healthcare utilization, social factors and overall population health managements (Langa et al., 2008). According to a study conducted by Prince and colleagues in 2016, countries with higher incomes generally exhibit increased overall life expectancy due to better healthcare infrastructure, which results in improved cognitive health outcomes with longer CIFLE (Prince et al., 2016). In contrast the studies showed that LMICs encounter inadequate healthcare resources and socio-economic disparities, resulting into shorter CIFLE and higher burden of CI. A study from the middle-income country Cuba (Llibre Rodriguez et al., 2008) reported that CIFLE at age 60 was lower than that in HICs. This suggests that individuals from LMICs may spend a greater portion of their lives in later years with CI.

To date, Cognitive Impairment-Free Life Expectancy (CIFLE) has received much less attention in India, thus no studies have been done in this field. In recent years, literature on CIFLE has been increasing, but most is gathered from western countries. Although the Indian literature on various aspects of cognitive impairment and dementia is increasing, but still far short of assessment of the burden of cognitive loss in a population by highlighting whether additional years lived are spent cognitively healthy or in poor cognitive health. Thus, the present study will fill this research gap by providing estimates of Cognitive Impairment-Free Life Expectancy (CIFLE) at the national level. This study will investigate the specific dynamics of gender and residential differences in CIFLE within the Indian context.

Given the complexities of India's demographic diversity and its status as a lower-middle-income country, there is an urgent need of research that explores and delves into the intricate nature of CI. It will enable the policymakers to more effectively prevent dementia, slow its progression, and narrow the gender differentials. So, this study specifically aims to investigate the research question: Are the significant variations in gender and residential aspects of CI similar to the disparities observed in the life expectancies among the older population in India? By addressing this question, we seek a deeper emphasize on the importance of estimating CIFLE for older adults, as it reflects not only the length of life but the quality-of-life accounting for burden of CI. Understanding the correlation between life expectancies and CIFLE allows for assessment of healthcare needs and the quality of life of elder population.

## Material & Methods

### Data Sources

Our study is based on two types of data, the first wave of the Longitudinal Aging Study in India (LASI), 2017-18 for the prevalence of cognitive impairment and Mortality data is derived from the Sample Registration System (SRS), 2016-20, for both the genders and residences at national level. The Longitudinal Ageing Study in India (LASI) is a national representative survey of over 73,000 older adults aged 45 years and above (including spouses irrespective of their age) across all states and UTs in India. Its main goal is to provide valid, reliable data on the health, social, mental, and economic well-being of India's older adult (aged 45 and above) population. LASI is envisioned to be performed every two years for the next 25 years. LASI survey is conceptually similar to the United States Health and Retirement Study (HRS) and other HRS-type surveys in different countries, including China Health and Retirement Longitudinal Survey (CHARLS) in China, Indonesia Family Life Surveys (IFLS) in Indonesia, and English Longitudinal Study of Ageing (ELSA) in England. LASI data was utilized to assess the prevalence of cognitive impairment in older Indian adults. The present study was based on the eligible older adults aged 45 years and above, and the effective sample size was 66,606.

### Mortality data

Sample registration system abridged tables data were obtained from the repository of the Office of the Registrar General & Census Commissioner, India. Life tables for 2016-20 were employed. It provides a summary of mortality and life expectancy for different age groups within a population over a specific period, typically a single year. The life tables had an age interval of 5 years, starting from 45 years.

### Methodology

#### *Assessing Cognitive Impairment*

Five broad domains were used to assess cognitive impairment: memory, orientation, arithmetic function, executive function, and object naming. The cognitive score was constructed using tests such as immediate and delayed word recall, orientation to time and place, basic computation, arithmetic tasks like serial sevens and backward counting, executive function tasks like paper folding and pentagon drawing, and object naming. Higher overall scores indicated better cognitive functioning. Respondents who received assistance during the cognitive module were excluded from the analysis. Cognitive impairment was classified as scoring below the 10th percentile of the overall cognitive score distribution based on the LASI report and previous studies (IIPS & ICF, 2020; Pandav et al., 2002). Individuals below this threshold were classified as cognitively impaired, while those above were considered not impaired. A detailed breakdown of the cognitive assessment scale is provided below (**Table 1).**

**Table 1:** Description of domain-wise cognitive measures in LASI, 2017–2018

| Cognitive Domains | Measures | Measurement | Score Range |
|---|---|---|---|
| Memory | Immediate word recall | The interviewer recited a list of 10 words, and the respondents were asked to recall and repeat them. | 0–10 |
| | Delayed word recall | Respondents were later asked to recall the same set of words previously read to them, as part of the delayed recall task. | 0–10 |
| Executive function | Executive (paper folding) | This task involved three sequential instructions: respondents were asked to take a piece of paper from the interviewer, turn it over, fold it in half, and hand it back. Each correctly completed step was awarded one point. | 0–3 |
| | Pentagon drawing | Visuo-construction refers to the ability to integrate fine motor skills with visuospatial perception, often assessed through the replication of geometric shapes. In this task, respondents were asked to copy two overlapping pentagons and received one point for an accurate reproduction. | 0–1 |
| Orientation | Time | Respondents were asked to identify today's date, month, year, and the day of the week. Each correct answer was awarded 1 point, while incorrect answers received 0. The total score for time orientation ranged from 0 to 4. | 0–4 |
| | Place | Place orientation was assessed by asking respondents to identify the location of the interview, including the name of the village, street or neighbourhood, a nearby landmark or colony, and the name of the district. Each correct response was awarded 1 point. The total score for time was 0–4. | 0–4 |
| Arithmetic function | Backward counting | Respondents were instructed to count backward as quickly as possible, starting from 20. They were asked to stop after correctly counting down to 11 (or from 19 to 10). A fully correct sequence earned 2 points, responses with errors received 1 point, and those unable to perform the task were given 0 points. | 0–2 |
| | Serial 7 | Respondents were asked to begin by subtracting 7 from 100, and then to continue subtracting 7 from each subsequent result for | 0–5 |

| | | | |
|---|---|---|---|
| | | a total of five steps. Each correct subtraction was awarded 1 point. | |
| | Computation | This task assessed arithmetic reasoning. Respondents were asked to calculate the sale price of a product after deducting half of its original price. | 0–2 |
| Object naming | Object naming: 0–2 | The interviewer pointed to two specific objects and asked the respondent to name each one. One point was awarded for every correct identification, with a maximum of two points. | 0–2 |
| Cognitive Function | Composite cognitive index | The overall cognitive score was derived by combining the scores from five domains: memory (total word recall), orientation, arithmetic function, executive function, and object naming. | 0–43 |

***Life table Approach***

We utilized Sample Registration System (SRS) abridged life table data to derive Age-Specific Death Rates (ASDR) and life expectancy at age 45 by gender and place of residence in India. From the SRS life tables, we extracted age-specific mortality rates for males, females, urban, and rural populations to construct abridged life tables starting at age 45. This approach allowed us to calculate the probability of dying in each age interval and the corresponding life expectancy. Using life table functions, we computed the number of person-years lived in each age group and the total person-years lived beyond each age, which was essential for calculating life expectancy at age 45 for each demographic subgroup.

***Computation of Cognitive Impairment-Free Life Expectancy (CIFLE)***

We utilize the Sullivan method to estimate Cognitive impairment-free life expectancy (CIFLE) and Life Expectancy with Cognitive impairment (CILE) for individuals aged 45 years and older (Sullivan, 1971). The Sullivan method requires the age-specific prevalence (proportions) of cognitive impairment, which is obtained from LASI wave-1 data, and age-specific mortality information from SRS data. By incorporating these prevalence rates into the constructed life tables, we partitioned life expectancy into years lived with and without cognitive impairment, differentiated by gender and place of residence. The Sullivan method was selected for its precision, interpretability, and capacity to incorporate health status data into life table calculations, offering a comprehensive assessment of expected cognitive health in older age.

***Sullivan Method***

Using terms from life tables, a quick explanation of the Sullivan method's computing procedure is provided. The surviving population at exact age x, the number of person-years lived between exact age x and x+n, the number of person-years lived after exact age x, and the life expectancy at age x is represented by the variables lx, nLx, Tx, and ex, respectively. Super script T, H and U denote total, healthy state, and unhealthy state, respectively. Prevalence rates of the unhealthy population between age x and x + n is denoted by nPREVx. The number of person-years lived between exact age x and x + n in the unhealthy state is computed by Equation.

$$UnL_x = nL_{x*n}PREV_x$$

Then, these numbers are summed from exact age x to maximum age in the available or open-ended age group in the life table.

$$UT_x = \sum UL_x$$

The mean number of expected years to live for the unhealthy population is computed by Equation.

$$Ue_x = UT_x l_x$$

Because total life expectancy at exact age x is already given by the life table, the mean number of expected years to live in a healthy state is computed by subtracting expected unhealthy years from total life expectancy at exact age x.

$$He_x = Te_x - Ue_x$$

In this study, $Ue_x$ represents the expected number of years to be lived with cognitive impairment. It is calculated by dividing the total number of person-years lived in the cognitively impaired state ($UT_x$) by the number of survivors at the starting age ($l_x$). $He_x$, on the other hand, represents the expected number of years to be lived free of cognitive impairment. It is derived by subtracting the years lived with cognitive impairment ($Ue_x$) from the total life expectancy ($Te_x$).

**Ethics considerations**

The LASI survey, involving human participants, underwent review and received ethical clearance from Indian Council of Medical Research (ICMR). The study rigorously adhered to relevant guidelines and regulations, aligning with the ethical principles set forth in the World Medical Association's (WMA) Declaration of Helsinki. All study participants gave their informed consent prior to involvement, with options for both written and verbal consent formats. This comprehensive approach ensured ethical integrity of the study and participants' rights were protected throughout the research process.

**Results**

The age wise distribution of the total sample by gender and place of residence are given in **Table 2**, showing that, a slight female majority (53.40%) compared to males (46.60%). Over half the subjects (52.09%) are aged 45-59, with 28.84% in their 60s and 19.07% aged 70 or above. Females outnumber males in most age groups until 70, after which the gender ratio balances. The number of participants generally decreases with age, showing a steeper decline after 65-69 years. Rural residents (64.91%) significantly outnumber urban (35.09%) across all age groups. The largest single age cohort is the 45-49 age group, comprising 20.19% of the total sample, while the smallest is the 85+ category at 2.20%.

**Table 2**: Age wise distribution of subjects by gender and place of residence

| Age groups (years) | Number of subjects | | | | |
|---|---|---|---|---|---|
| | **Male** | **Female** | **Rural** | **Urban** | **Total** |
| 45-49 | 6046 (9.08) | 7407 (11.12) | 8515 (12.78) | 4935 (7.41) | 13453 (20.19) |
| 50-54 | 5093 (7.65) | 5991 (8.99) | 6993 (10.50) | 4091 (6.14) | 11084 (16.64) |
| 55-59 | 4560 (6.85) | 5607 (8.35) | 6644 (9.98) | 3523 (5.29) | 10167 (15.26) |
| 60-64 | 4707 (7.07) | 5560 (8.34) | 6808 (10.22) | 3459 (5.19) | 10267 (15.41) |
| 65-69 | 4381 (6.57) | 4563 (6.85) | 5844 (8.77) | 3100 (4.65) | 8944 (13.43) |
| 70-74 | 2933 (4.40) | 2878 (4.32) | 3807 (5.71) | 2004 (3.01) | 5811 (8.74) |
| 75-79 | 1697 (2.55) | 1742 (2.62) | 2236 (3.36) | 1203 (1.81) | 3439 (5.16) |
| 80-84 | 964 (1.44) | 1009 (1.51) | 1349 (2.02) | 624 (0.94) | 1973 (2.97) |
| 85+ | 658 (0.99) | 810 (1.23) | 1041 (1.56) | 427 (0.64) | 1468 (2.20) |
| **Total** | **31,039 (46.60)** | **35,567 (53.40)** | **43,240 (64.91)** | **23,366 (35.09)** | **66,606 (100)** |

***Note****: Figures in parentheses are weighted percentages.*

**Table 3** illustrates the age-wise prevalence of cognitive impairment among older adults in India, disaggregated by gender and place of residence. The prevalence increases with age, from 4.34% in the 45-49 age group to 47% in the 85+ age group. Across all age groups, females consistently exhibit a higher prevalence of cognitive impairment than males, with the difference peaking at 27.62% in the 85+ age group ($p < 0.001$). Similarly, rural residents have a higher prevalence than urban residents, with the largest rural-urban gap of 10.52% observed in the 80-84 age group ($p < 0.001$). Overall, cognitive impairment is significantly more common among females (13.65%) compared to males (6.42%), and among rural residents (12.39%) compared to urban residents (6.38%). Among females, the highest prevalence was observed in the 85+ age group (55.26%), followed by the 80-84 (43.13%) and 75-79 (32.10%) age groups. Rural residents consistently exhibit a higher prevalence of cognitive impairment than their urban counterparts, particularly in the older age groups, with the highest difference of 10.52% in the 80-84 age group.

**Table 3**: Age wise prevalence of cognitive impairment by gender and place of residence, India.

| Age groups (years) | Cognitive impairment, weighted % | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Male (n=31,039)** | **Female (n=35,567)** | **Difference [a]** | **p-value*** | **Rural (n=43,240)** | **Urban (n=23,366)** | **Difference [b]** | **p-value**** | **Total** |
| 45-49 | 2.75 | 5.64 | 2.89 | <0.001 | 5.25 | 2.78 | 2.47 | <0.001 | 4.34 |
| 50-54 | 3.24 | 7.18 | 3.94 | <0.001 | 6.89 | 2.76 | 4.13 | <0.001 | 5.37 |
| 55-59 | 4.17 | 8.31 | 4.14 | <0.001 | 8.02 | 3.49 | 4.53 | <0.001 | 6.45 |
| 60-64 | 4.97 | 11.87 | 6.90 | <0.001 | 10.58 | 5.03 | 5.55 | <0.001 | 8.71 |
| 65-69 | 6.94 | 16.85 | 9.91 | <0.001 | 14.70 | 6.9 | 7.80 | <0.001 | 12.00 |
| 70-74 | 10.13 | 23.28 | 13.15 | <0.001 | 19.70 | 10.83 | 8.87 | <0.001 | 16.64 |
| 75-79 | 13.32 | 30.54 | 17.22 | <0.001 | 25.81 | 15.05 | 10.76 | <0.001 | 22.04 |
| 80-84 | 20.95 | 42.62 | 21.67 | <0.001 | 35.36 | 24.84 | 10.52 | <0.001 | 32.03 |
| 85+ | 31.76 | 59.38 | 27.62 | <0.001 | 49.28 | 41.45 | 7.83 | 0.006 | 47.00 |
| **Overall** | **6.42** | **13.65** | **7.23** | **<0.001** | **12.39** | **6.38** | **6.01** | **<0.001** | **10.28** |

[a] *Difference in the percentage of male and female older adults*
[b] *Difference in the percentage of older adults reside in rural and urban areas*
* *p-values of proportion test of female-male older adults who experienced cognitive impairment*
** *p-values of proportion test of rural-urban older adults who experienced cognitive impairment*

**Table 4** and **Figure 1** presents both numerically ang graphically, total life expectancy (TLE), cognitive impairment-free life expectancy (CIFLE), and life expectancy with cognitive impairment (CILE) across different age groups by gender and place of residence in India. As can be expected, TLE declines with age. However, the absolute number of years with CI varies little. For men, the expected number of years with either form of CI is between 1.4 and 2.2 years at all ages. Similarly, for women, life expectancy with some form of CI is roughly ranges from 5.2 to 3 years. For rural residents the average life expectancy with CI is 3.2 years which higher than those who lived in urban areas (2.7 years).

Males tend to have higher CIFLE percentages compared to females, maintaining over 72.1% of life expectancy free from cognitive impairment until the age 85+. For females, the percentage of life free from cognitive impairment declines more rapidly, dropping from 83.5% at age 45-49 to 44.6% at age 85+ category. Rural residents generally experience lower CIFLE percentages compared to urban residents. At age 45-49, rural residents have 86.5% of their life free from cognitive impairment, which drops to 54.1% by age 85+. Urban residents fare better, with 90.6% CIFLE at age group 45-49 and 64.2% at age 85 years and above. Rural residents tend to have a higher CILE than urban residents, indicating that those in rural areas live more years with cognitive impairment.

**Table 4**: Total life expectancy and life expectancy free from and with cognitive impairment, by age, gender and place of residence, India

| Age groups (years) | Life expectancy, years | | | Cognitive impairment Free/Total, % |
|---|---|---|---|---|
| | Total (TLE) | Cognitive Impairment Free (CIFLE) | With Cognitive Impairment (CILE) | |
| **Male** | | | | |
| 45-49 | 29.2 | 27.0 | 2.2 | 92.4 |
| 50-54 | 25.0 | 22.9 | 2.1 | 91.6 |
| 55-59 | 21.0 | 19.0 | 2.0 | 90.3 |
| 60-64 | 17.5 | 15.6 | 1.9 | 89.0 |
| 65-69 | 14.2 | 12.3 | 1.9 | 86.8 |
| 70-74 | 11.4 | 9.5 | 1.9 | 83.3 |
| 75-79 | 8.9 | 7.1 | 1.8 | 79.9 |
| 80-84 | 6.8 | 5.3 | 1.5 | 77.7 |
| 85+ | 5.2 | 3.8 | 1.4 | 72.1 |
| **Female** | | | | |
| 45-49 | 31.6 | 26.4 | 5.2 | 83.5 |
| 50-54 | 27.2 | 22.1 | 5.1 | 81.2 |
| 55-59 | 23.0 | 18.1 | 4.9 | 78.9 |
| 60-64 | 19.2 | 14.4 | 4.8 | 75.2 |
| 65-69 | 15.5 | 11.1 | 4.4 | 71.4 |
| 70-74 | 12.4 | 8.2 | 4.2 | 66.0 |
| 75-79 | 9.6 | 5.7 | 3.9 | 59.0 |
| 80-84 | 7.2 | 3.7 | 3.5 | 51.5 |
| 85+ | 5.4 | 2.4 | 3.0 | 44.6 |
| **Rural** | | | | |
| 45-49 | 29.6 | 25.6 | 4.0 | 86.5 |
| 50-54 | 25.3 | 21.5 | 3.8 | 84.9 |
| 55-59 | 21.3 | 17.7 | 3.6 | 82.9 |
| 60-64 | 17.7 | 14.2 | 3.5 | 80.4 |
| 65-69 | 14.3 | 11.0 | 3.3 | 77.1 |
| 70-74 | 11.3 | 8.2 | 3.1 | 73.0 |
| 75-79 | 8.8 | 5.9 | 2.9 | 67.6 |
| 80-84 | 6.5 | 4.0 | 2.5 | 62.1 |
| 85+ | 4.9 | 2.6 | 2.3 | 54.1 |
| **Urban** | | | | |
| 45-49 | 32.1 | 29.1 | 3.0 | 90.6 |
| 50-54 | 27.7 | 24.9 | 2.8 | 89.7 |
| 55-59 | 23.6 | 20.7 | 2.9 | 87.8 |
| 60-64 | 19.7 | 16.9 | 2.8 | 86.0 |
| 65-69 | 16.2 | 13.4 | 2.8 | 82.9 |
| 70-74 | 13.2 | 10.4 | 2.8 | 78.9 |
| 75-79 | 10.4 | 7.6 | 2.8 | 73.1 |
| 80-84 | 8.2 | 5.6 | 2.6 | 68.7 |
| 85+ | 6.3 | 4.0 | 2.3 | 64.2 |

***Note**: TLE: Total Life Expectancy; CIFLE: Cognitive Impairment-Free Life Expectancy; CILE: Life Expectancy with Cognitive Impairment*

**Figure 2** shows the proportion of life expectancy with cognitive impairment (CILE) among older adults in India, stratified by gender and place of residence. Females consistently have a higher CILE proportion than males across all age groups, with the gap widening in later years. By age 85, females reach 55.4% CILE compared to 27.9% for males. Moreover, older adults reside in rural areas show higher CILE proportions than those from urban areas at all ages. The disparity grows with age, reaching 45.9% for rural and 35.8% for urban residents by age 85.

**Table 5** shows the difference in cognitive impairment free-life expectancy among middle aged and older adults in India by gender and place of residence. It is evident that males had higher cognitive impairment free life expectancy (CIFLE) compared to females. Males consistently show higher CIFLE than females across all age groups. The gender gap in CIFLE widens with age, ranging from 0.59 years at ages 45-49 to 1.58 years (SE = 0.147, $p<0.001$) at 80-84 age. Urban-rural differences in CIFLE are even more pronounced, with urban residents enjoying significantly higher CIFLE across all age groups. This urban advantage is most substantial in younger age groups, peaking at 3.46 years (SE=0.119, $p<0.001$) for ages 45-49, and gradually narrows with age to 1.40 years (SE=0.212, $p< 0.001$) for those 85 and older, but remains statistically significant throughout the lifespan. Interestingly, while urban-rural differences decrease with age, gender differences generally increase.

**Table 5**: Differences in cognitive impairment free life expectancy (CIFLE) among middle aged and older adults in India by gender and place of residence, 2017-18

| Age groups (years) | Difference in CIFLE between Male and Female* | Standard Error | P- value [a] | Difference in CIFLE between Rural and Urban** | Standard Error | P- value [b] |
|---|---|---|---|---|---|---|
| 45-49 | 0.59 | 0.108 | <0.001 | 3.46 | 0.119 | <0.001 |
| 50-54 | 0.80 | 0.108 | <0.001 | 3.38 | 0.118 | <0.001 |
| 55-59 | 0.82 | 0.108 | <0.001 | 3.05 | 0.119 | <0.001 |
| 60-64 | 1.15 | 0.109 | <0.001 | 2.70 | 0.122 | <0.001 |
| 65-69 | 1.27 | 0.113 | <0.001 | 2.41 | 0.127 | <0.001 |
| 70-74 | 1.32 | 0.121 | <0.001 | 2.18 | 0.137 | <0.001 |
| 75-79 | 1.45 | 0.134 | <0.001 | 1.65 | 0.155 | <0.001 |
| 80-84 | 1.58 | 0.147 | <0.001 | 1.60 | 0.175 | <0.001 |
| 85+ | 1.34 | 0.176 | <0.001 | 1.40 | 0.212 | <0.001 |

** Difference in CIFLE (Male-Female); **Difference in CIFLE (Urban-Rural)*

*[a] Z test significance level of male and female difference; [b] Z test significance level p value of rural and urban difference*

**Discussion**

The results from this analysis are important in that provide the first estimates of the life expectancy with cognitive impairment and without cognitive impairment in India based on a nationally representative survey. In India, on average an older adult spends 3.1 years with cognitive impairment. This burden is significantly higher among women, who live with cognitive impairment for 3.0 to 5.2 years, compared to 1.4 to 2.2 years among men. This represents the average current burden of this condition for each older person in the population. Our analysis clarifies how increases in life expectancy, unaccompanied by major reductions in the prevalence of cognitive impairment, can lead to increases in the duration of life with cognitive impairment and the number of years of care that must be provided for this condition for each older person.

The findings of this research reveal significant gender and domicile differences in life expectancy with and without cognitive impairment among older adults in India. The age-specific prevalence of cognitive impairment for males and females differs significantly. Consistent with prior research, our results show that females live longer than males, but they spend a greater proportion of their remaining years with cognitive impairment (Suthers et al., 2003). The rapid decline in the percentage of life free from cognitive impairment for female older adults aligns with global evidence that women tend to have longer life expectancy but bear a higher burden of age-related diseases, including cognitive impairment (Dhak & R, 2009; Murtagh & Hubert, 2004; Singh et al., 2018). The longevity paradox may explain the evident phenomenon that women had a longer CILE and had a lower proportion of remaining CIFLE than men counterparts (Zheng et al., 2020). In contrast, males maintain a higher proportion of life free from cognitive impairment (72.1% at age 85+), despite having lower total life expectancy. Previous studies support our findings on gender disparities in cognitive impairment. Research conducted in Europe and the U.S. shows similar patterns, where women generally experience more years with cognitive decline, likely due to their longer lifespan and differences in biological vulnerability, such as hormonal changes post-menopause and other health factors that influence cognitive decline (Ardila et al., 2011; Levine et al., 2021).

Our results show urban residents consistently had higher cognitive impairment-free life expectancy (CIFLE) and fewer years with cognitive impairment (CILE) compared to rural residents. For instance, at age 45-49, urban residents have 90.6% of their life expectancy free from cognitive impairment, while rural residents have 86.5%. The findings revealed that the older adults reside in rural areas had significant higher prevalence of cognitive impairment instead of in urban region, which was compatible with other studies in the literature (Bae et al., 2015; Jia et al., 2014; Nakamura et al., 2016; Nunes et al., 2010). A possible explanation for this result is that low education has been a long-held risk factor of dementia and indicates a poor cognitive reserve, less resistant to neuropathological insults of dementia (Meng & D'Arcy, 2012; Stern et al., 1994). It has been found that low educational attainment may lead to low-skill occupations with less cognitively-stimulating environment, which then increased risk of cognitive impairment (Chuang et al., 2021; Helmer et al., 2001; Scazufca et al., 2010). This rural disadvantage persists across all age groups, which may be attributable to differential access to healthcare, educational opportunities, and social determinants of health between rural and metropolitan areas (Chen et al., 2019; Muhammad, 2023). The disparities are especially stark in older age groups, where rural residents have significantly more years with cognitive impairment, indicating poorer health outcomes (Rahemi et al., 2024).

Our study highlights the importance of addressing these gender and geographic disparities in cognitive health. Policymakers should focus on targeted interventions, especially in rural areas and among older women, to reduce the burden of cognitive impairment. Initiatives such as improving access to geriatric care, cognitive health screenings, and educational programs in rural settings could help mitigate the growing divide in cognitive health outcomes between different population groups.

**Strengths and limitations of the study**

Our study has several strengths. First, this study represents a significant advancement in apprehending health expectancies among the Indian population, particularly addressing cognitive impairment. Its strengths lie in utilizing nationally representative data from the LASI survey and mortality data from the Sample Registration System (SRS). The use of Sullivan's method for estimating health expectancies adds methodological rigour. By focusing on cognitive impairment-free life expectancy across a wide age range (45 and older) and providing detailed breakdowns by gender and rural-urban residence, the study offers valuable insights into demographic disparities in cognitive health. Finally, this research contributes to the nascent field of health expectancy estimation in India, setting a foundation for informed policy decisions and future studies in this crucial area of public health.

Our study also has several limitations. First, our estimates of prevalence rates are based on data from self-respondents only; proxy respondents were excluded to maintain consistency in cognitive assessment, in line with most population-level studies of cognitive impairment. Second, the use of the Sullivan method with cross-sectional data assumes that the current age-specific prevalence of cognitive impairment remains constant over time, which may not reflect future trends in the rapidly changing demographic and health landscape in India. Moreover, this method does not capture transitions between cognitive states (e.g., from normal cognition to impairment or recovery) or account for competing mortality risks, potentially limiting the accuracy of estimated cognitive health trajectories. In addition, the Sullivan approach provides only population averages and does not reflect individual-level variation. It does not clarify how many individuals ever experience cognitive impairment before death, the distribution of the duration of impairment across the population, or differences in life expectancy between those with and without cognitive impairment. These important questions require longitudinal data and multistate life table methods, which can provide more nuanced estimates. Future investigations should consider these approaches to better project the cognitive health burden among India's ageing population.

**Conclusion**

This study highlights mostly gender and rural-urban disparities in cognitive impairment-free life expectancy (CIFLE) among older adults in India. Although women live longer than men, they tend to spend a greater proportion of their later years with cognitive impairment (CILE). Similarly, older adults in rural areas experience fewer years of life free from cognitive impairment and more years with cognitive decline compared to their urban counterparts. These findings emphasize the urgent need for gender- and region-specific strategies to promote healthy cognitive aging. Based on our results and existing evidence, we recommend several policy measures tailored to the Indian context. First, early detection of cognitive impairment should be prioritized by integrating routine cognitive screening into primary healthcare services, explicitly in rural and underserved areas. Leveraging the existent network of community health workers (such as ASHAs and ANMs) can support outreach and awareness efforts in low-resource settings. Second, targeted interventions addressing modifiable risk factors such as adult education, improved nutrition, physical activity, social participation, and mental stimulation are essential, especially for rural women and socioeconomically disadvantaged groups. Health promotion campaigns and educational initiatives must be accessible, inclusive, and culturally appropriate for older adults, including those with low literacy. Third, given the limited formal long-term care infrastructure in India, there is a pressing need to invest in community-based services such as adult day-care centres, respite care, and caregiver training programs. Strengthening support for informal caregivers, who provide the majority of elder care, is critical to ensuring the well-being of mutually older adults and their families. Finally, we acknowledge the broader societal and economic implications of longer lives lived with cognitive impairment. Future research should utilize longitudinal data and multistate life table methods to better capture cognitive health transitions and to support more accurate forecasting and planning. Proactive, evidence-based policies are essential to meet the cognitive health needs of India's rapidly aging population.

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**Declaration of competing interest**

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

**Data availability**

The study is based on secondary data accessed on requests from https://www.iipsdata.ac.in/datacatalog_detail/5. Mortality data can be accessed from https://censusindia.gov.in/census .

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**CRediT authorship contribution statement**

MS: Conceptualization, Data curation, Formal analysis, Software, Methodology, Writing – review & editing, Writing – original draft, Visualization, Validation, Software; AF: Conceptualization, Data analysis, writing- review & editing, validation; IG: Writing the Draft, Supervision, Review & Editing of the Draft. MS: Madhurima Sharma, AF: Abdul Fathah, IG: Indrajit Goswami.



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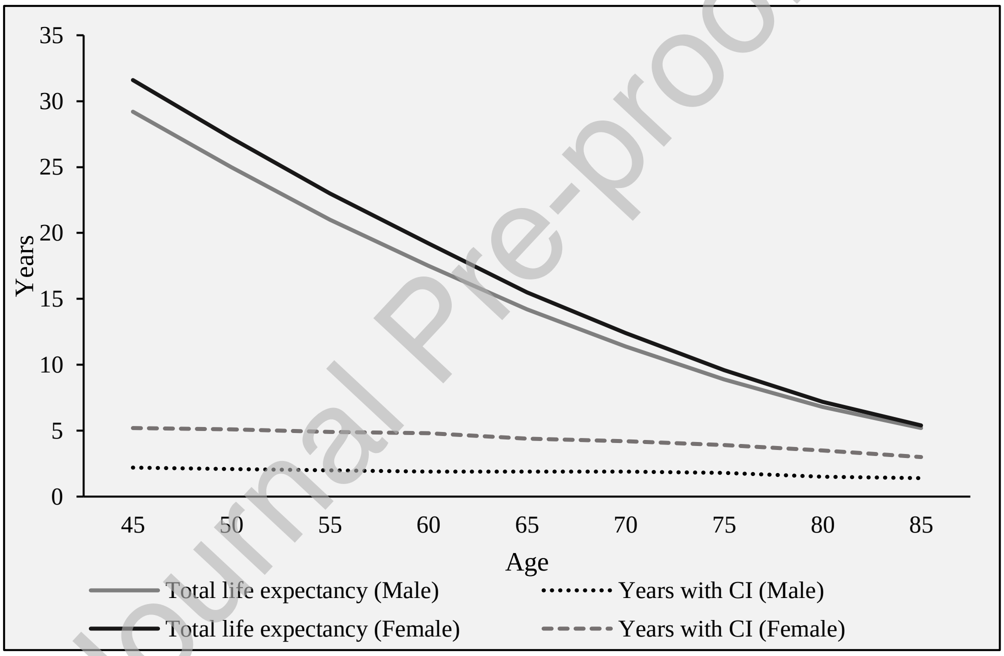
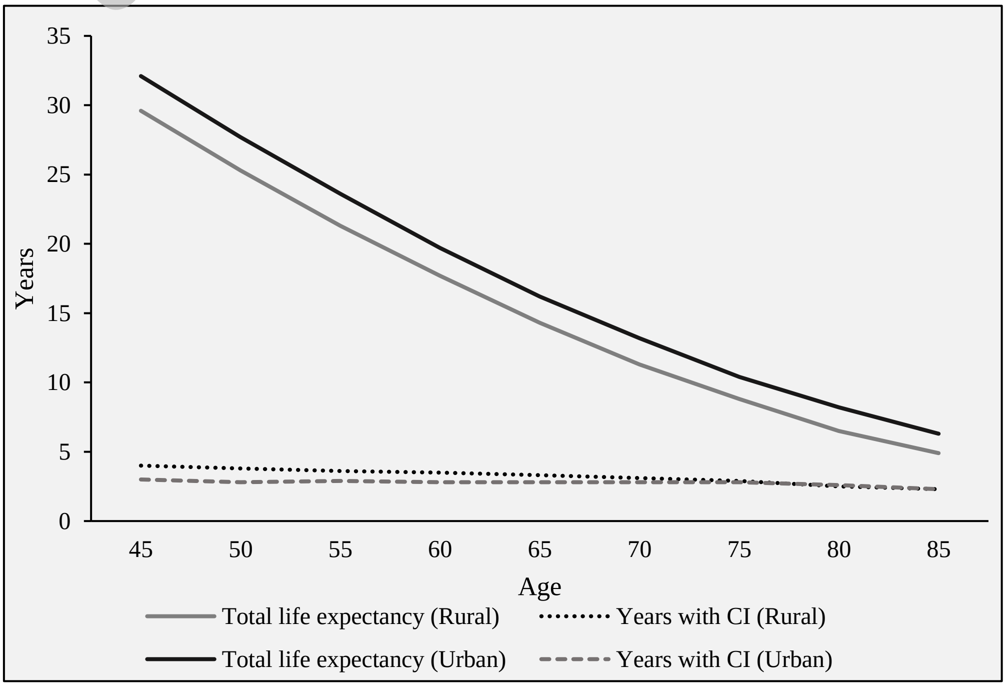
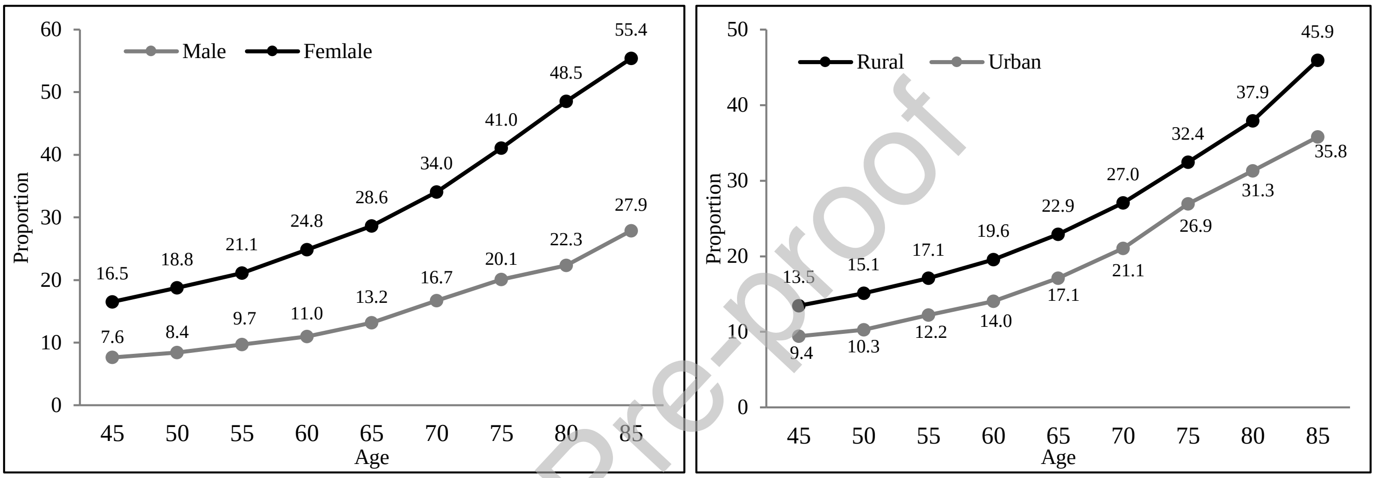



(a)



(b)

**Figure 1**: TLE by age and (a) gender, (b) place of residence with amount of time spent with CI. Figures are weighted to be representative of the middle aged and older population of in India. CI = Cognitive impairment; TLE = total life expectancy.




(a) (b)

**Figure 2**: Proportion of Life Expectancy with Cognitive Impairment (CILE) by gender (a) and place of residence (b) among older adults in India.



**Declaration of interests**

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐ The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: