International Journal of Population Studies

RESEARCH ARTICLE

Living longer: For better or worse? Changes in life expectancy with and without mobility limitation among older persons in India between 1995–1996 and 2004

Sreerupa[1], S. Irudaya Rajan[1], Shweta Ajay[2], Yasuhiko Saito[2,3], Rahul Malhotra[2,4]*

[1]Centre for Development Studies, Thiruvananthapuram - 695011, Kerala, India,
[2]Centre for Ageing Research and Education, Duke-NUS Medical School, 169857, Singapore
[3]Nihon University, Tokyo 101-8360, Japan,
[4]Health Services and Systems Research, Duke-NUS Medical School, 169857, Singapore

ARTICLE INFO

Received: August 28, 2018
Accepted: February 26, 2019
Published: March 18, 2019

***CORRESPONDING AUTHOR**

Rahul Malhotra
Centre for Ageing Research and Education, Duke-NUS Medical School, 8 College Road, 169857, Singapore. rahul.malhotra@duke-nus.edu.sg

CITATION

Sreerupa, Rajan SI, Shweta Ajay, Saito Y, Malhotra R (2018). Living longer: For better or worse? Changes in life expectancy with and without mobility limitation among older persons in India between 1995–1996 and 2004. *International Journal of Population Studies*, 4(2):23-34. doi: 10.18063/ijps.v4i2.761

Abstract: This study estimates changes in life expectancy with and without mobility limitation to test whether older persons in India experienced compression or expansion of morbidity from the period 1995–1996 to 2004. Age-specific death rates and the prevalence of mobility limitation were obtained from the Sample Registration System and two rounds (1995–1996/2004) of the National Sample Survey. Sullivan's method was employed to compute life expectancy with and without mobility limitation by gender and by place of residence. From 1995–1996 to 2004, at ages 60, 70, and 80, older men and older rural persons in India experienced a significant increase in life expectancy without mobility limitation and a significant reduction in the proportion of remaining life with mobility limitation, suggesting a compression of morbidity. However, over this same period, older women and older urban persons seem to have experienced an expansion of morbidity with an increase in life expectancy with mobility limitation and an increase in the proportion of remaining life with mobility limitation. These results call for the promotion and maintenance of physical mobility among all older persons in India, with special attention to older women and older urban persons.

Keywords: *health expectancy; India: life expectancy; mobility limitation; morbidity*

1. Introduction

According to the 2011 census, nearly one in 10 persons (8.6%) in India were aged 60 and above (hereafter older persons) (Census of India, 2011). This proportion translates to 104 million individuals in India's burgeoning population (Census of India, 2011), making India home to the world's second largest population of older persons. Moreover, by 2051, the number of older persons is expected to reach 298 million, nearly 20% of India's total projected population (Rajan, Risseeuw, and Perera, 2008). A key contributor to the large and increasing population of older persons in India is the rise in life expectancy at older ages; while in 1990 an Indian aged 60 was expected to live another 15 years, in 2013 an Indian aged 60 was expected to live another 17 years (World Health Organization, 2015). The increase in life expectancy at older ages is a significant development and public health achievement for India. However, whether this increase in life expectancy is associated with a better or worse state of health during the additional years of life has received little attention.

This important yet unanswered question can be addressed by assessing changes over time in the health expectancy of older persons in India. Health expectancy refers to the

average number of remaining years of life a person at a given age is expected to spend in various states of health. Calculating health expectancy allows the decomposition of total remaining years of life, at a given age, into those lived in a state of good health (healthy life expectancy) and those lived in one or more states of ill health (unhealthy life expectancy) (Saito, Robine, and Crimmins, 2014). While the concept of health expectancy is unique, different measures have been used to define "health." Commonly used measures are the absence or presence (or the extent therein) of mobility limitation, disability, activities of daily living (ADL) limitations, instrumental ADL limitations, any non-communicable disease (NCD), or specific NCDs (Saito, Robine, and Crimmins, 2014). Health expectancy combines information about mortality and morbidity. Thus, a comparison of changes in health expectancy over time directly addresses whether the duration of remaining life spent with morbidity or disability is shortening or lengthening relative to changes in life expectancy.

The extant literature provides two main hypotheses for the relationship of longer life with changes in health. The first hypothesis argues that improvements in life expectancy evolve from a delay in the onset and progression of diseases and disability, and morbidity is generally reduced (Fries, 1980). This hypothesis is called compression of morbidity, as it proposes that an increase in life expectancy is accompanied by a decrease in the proportion of remaining life lived with morbidity and disability. In other words, it posits a decrease in relative unhealthy life expectancy (the ratio of unhealthy life expectancy to life expectancy) over time. Conversely, the expansion of morbidity hypothesis states that as mortality declines through improved medical care, an increase in life expectancy is accompanied by an increase in the proportion of remaining life lived with morbidity and disability. That is, there is improved survival among frail individuals who have higher expected incidence rates of disability (Gruenberg, 1977; Kramer, 1980). In other words, it suggests an increase in relative unhealthy life expectancy over time.

Studies from several countries support the presence of both hypotheses (Doblhammer and Kytir, 2001, Graham, Blakely, Davis *et al.*, 2004, Crimmins and Beltrán-Sánchez, 2011, Fries, Bruce, and Chakravarty, 2011). However, to the best of our knowledge, only one recent study, operationalizing "health" as self-reported absence (or presence) of NCDs, assesses NCDs among older persons in India (Arokiasamy and Yadav, 2014). This 2014 study supports the expansion of morbidity hypothesis.

While informative, the said study has its limitations. First, the use of self-reported disease status to define "health" is sensitive to changes in awareness or literacy about diseases and to changes in health-care accessibility over time. Thus, a change in health expectancy may simply reflect a change in awareness, or it may reflect a change in awareness and/or access to health care. Over time, this can lead to a change in the diagnosis of diseases in otherwise undiagnosed individuals. Alternatively, changes in health expectancy may reflect a change over time in the criteria used for diagnosing diseases (Crimmins and Saito, 2000). Second, the list of NCDs and the referent time period varied across the rounds of National Sample Surveys (NSS) considered for health expectancy calculations in the study. Thus, any observed change in health expectancy, rather than real, could have been due to this variation in NCD criterion across the rounds. Third, it has been shown in studies, though not from India, that while the prevalence of diseases among older persons has consistently increased over the past few decades, the prevalence of functional or activity limitations consistently declined in the 1980s and 1990s (Freedman, Crimmins, Schoeni *et al*., 2004) and remained stable in the 2000s (Freedman, Spillman, Andreski *et al.*, 2013). Thus, it is of interest to see if the expansion of morbidity observed for NCDs in India holds in the context of functional or activity limitations.

In this paper, we use mobility limitation to define health, such that the absence of mobility limitation is considered healthy (and its presence, unhealthy). A mobility limitation is a functional impairment which limits a person's ability to move her- or him-self independently and safely. Mobility limitation leads to social isolation, depression, and other adverse mental health outcomes (Lampinen and Heikkinen, 2003), contributes to poor quality of life (Netuveli, Wiggins, Hildon *et al*., 2006), and is associated with a higher risk of health service use (Penninx, Ferrucci, Leveille *et al*., 2000), institutionalization (von Bonsdorff, Rantanen, Laukkanen *et al.*, 2006), and mortality (Rolland, Lauwers-Cances, Cesari *et al*., 2006). Further, mobility limitation may lead to dependency, a need for assistance, and an increased risk for disability (Lawrence and Jette, 1996; Stuck, Walthert, Nikolaus *et al*., 1999). Given the pivotal role of mobility for older persons, we thus utilize changes over time in life expectancy with and without mobility limitation among the population of older persons in India to assess whether increases in total life expectancy at older ages are associated with better or worse states of "health" during the years of life added. In other words, are increases in total life expectancy at older ages associated with the compression or expansion of morbidity?

In a largely patriarchal society like India with sharp gender disparities, across age groups, in access to nutrition, health, education, and economic resources (Agarwal, 1994; Singh, 2012; Saha, 2013; Maharana and Ladusingh, 2014), older women become disproportionately vulnerable to disability (Sengupta and Agree, 2003, Sreerupa and Rajan, 2010), and disease and poor health-care utilization (Sreerupa and Rajan, 2010). In a similar vein, older rural persons face a

disproportionately higher prevalence of disease and disability and lower access to and availability of health care, relative to their urban counterparts (Alam, 2000). It is important to keep in mind that nearly three-fourths of older people in India live in rural areas. Therefore, it is of interest to assess how changes over time in life expectancy with and without mobility limitation differ among older Indian men and women and among older persons residing in rural and urban areas of India.

Thus, utilizing data from two cross-sectional national surveys conducted in 1995–1996 and 2004, we test for the presence of expansion or compression of morbidity among older men and women and among older rural and urban persons in India. We do so by estimating changes over a decade in absolute and relative life expectancy with and without mobility limitation by gender and by place of residence.

2. Data and Methods

2.1. Data sources

Information on age-specific death rates (ASDR) from the Sample Registration System (Office of the Registrar General) was used to construct abridged life tables. The average values of ASDR from 1995 to 1998 and 2002 to 2005 were used as the ASDR of 1995–1996 and 2004, respectively, to avoid inconsistencies. Information on the age-specific prevalence of mobility limitation, by gender, and by place of residence, was obtained from publically available de-identified data of two survey rounds: The NSS on Morbidity and Treatment of Ailments, 52nd Round (National Sample Survey Organization, 1998), conducted from July 1995 to June 1996, and the NSS on Morbidity, Health Care, and the Conditions of the Aged, 60th Round (National Sample Survey Organisation, 2006), conducted from January to June 2004. The prevalence estimates were weighted using appropriate round-specific survey weights. The NSS are nationally representative cross-sectional household surveys conducted by the National Sample Survey Organization (NSSO), a branch of the Department of Statistics of the Government of India.

The sample for either round was selected using a two-stage stratified design, with census villages and urban blocks as the first-stage units for the rural and urban areas, respectively, and households as the second-stage units. The surveys had a sample of 34,084 older persons from 120,942 households in the 52nd NSS Round and 34,831 older persons from 73,868 households in the 60th NSS Round. Data were collected using structured questionnaires in face-to-face interviews at the homes of the respondents.

2.2. Mobility limitation

The physical mobility statuses of the respondents of both NSS rounds were recorded, with the options being (1) physically immobile and confined to bed (persons unable to move around the house and, in particular, to use the washroom on their own), (2) physically immobile and confined to their homes (persons able to move within the house but unable to move outside the house), and (3) physically mobile (National Sample Survey Organization, 1998, National Sample Survey Organization, 2006). The proportion of individuals categorized in option (1) was <2% in either round. Thus, for our analysis, those categorized in options (1) and (2) were combined so as to dichotomize physical mobility status into "with mobility limitation" and "without mobility limitation."

Our decision to focus on mobility limitation as the measure of health and not on other variables such as disability or NCDs, was in part due to comparability issues of such variables between the two NSS rounds. While questions and/or response options relating to disability or NCDs varied, the question on physical mobility status and its response categories remained unchanged between the rounds.

2.3. Statistical analysis

Using the method devised by Sullivan (1971), data on the prevalence of mobility limitation were combined with abridged life table data to compute life expectancy with and without mobility limitation for older persons in India, by gender and by place of residence. With this method, it is possible to see the current mobility health structure of a population adjusted for mortality by partitioning life expectancy at a given age into two mobility states: Expected years lived without mobility limitation (~healthy) and with mobility limitation (~unhealthy). Weighted age-specific prevalence rates were used to divide the life table stable population for each age group into specific mobility states. The total stable population above age x by mobility states was divided by survivors at age x to compute life expectancy with and without mobility limitation. Differences, by gender and by place of residence, in absolute and relative estimates of life expectancy with and without mobility limitation were tested using the approach described by Jagger *et al.* (2014).

3. Results

From 1995–1996 to 2004, the prevalence of mobility limitation decreased by 0.2–3.0% points among older men, older women, and older rural and urban persons [Table 1]. At both time points, the prevalence was higher among women, and the gender-gap widened over time (1.7% points [1995–1996] to 2.4% points [2004]). While in 1995–1996 the prevalence of mobility limitation was higher (by 2.1% points) among older rural persons, in 2004 it was higher (by 0.7% points) among older urban persons.

Table 1. Weighted prevalence (%) of mobility limitation among older persons in India, by gender and by place of residence, 1995–1996 and 2004.

Year	Gender		Place of residence	
	Men	Women	Rural	Urban
1995–1996	9.6	11.3	10.9	8.8
N	(16514)	(16148)	(20141)	(12521)
2004	6.9	9.3	7.9	8.6
N	(17750)	(17081)	(22265)	(12566)
Change from 1995–1996 to 2004	−2.7	−2.0	−3.0	−0.2

Note: N refers to the unweighted sample size.

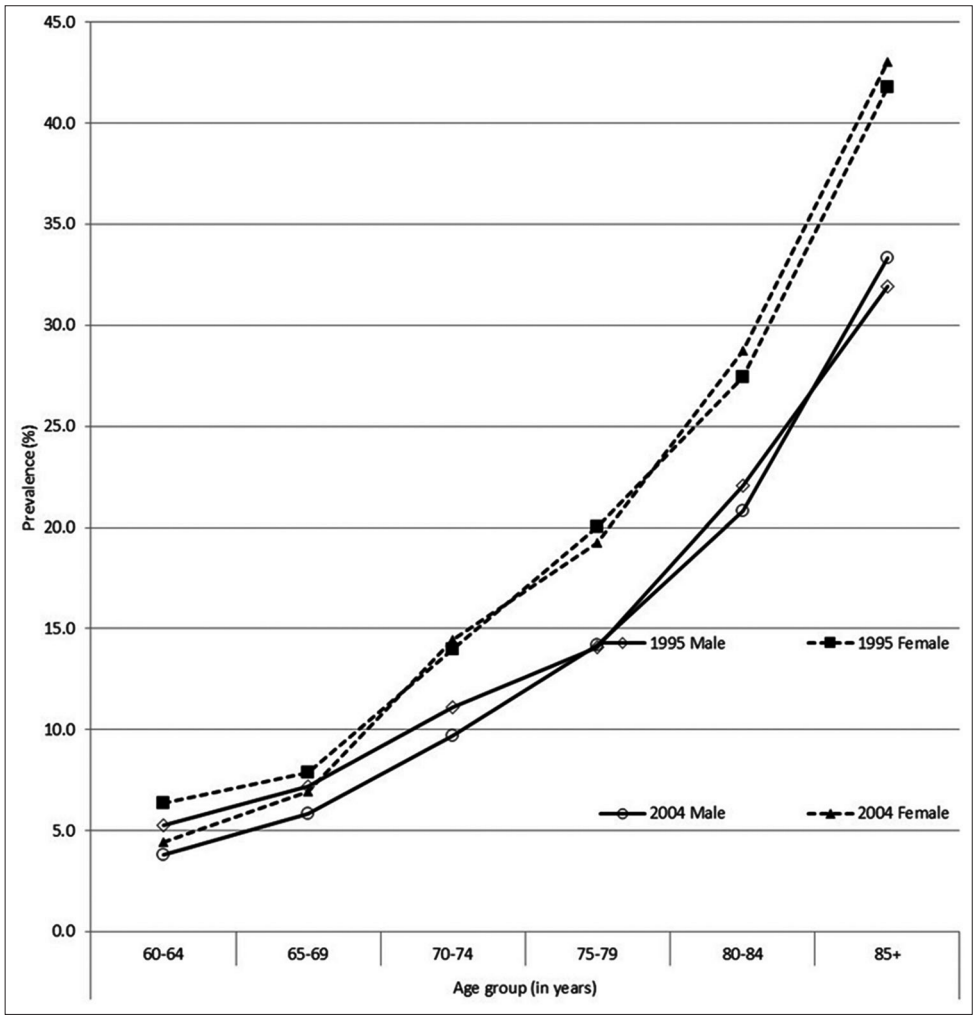

Figure 1. Prevalence of mobility limitation by 5-year age groups and gender, 1995–1996 and 2004.

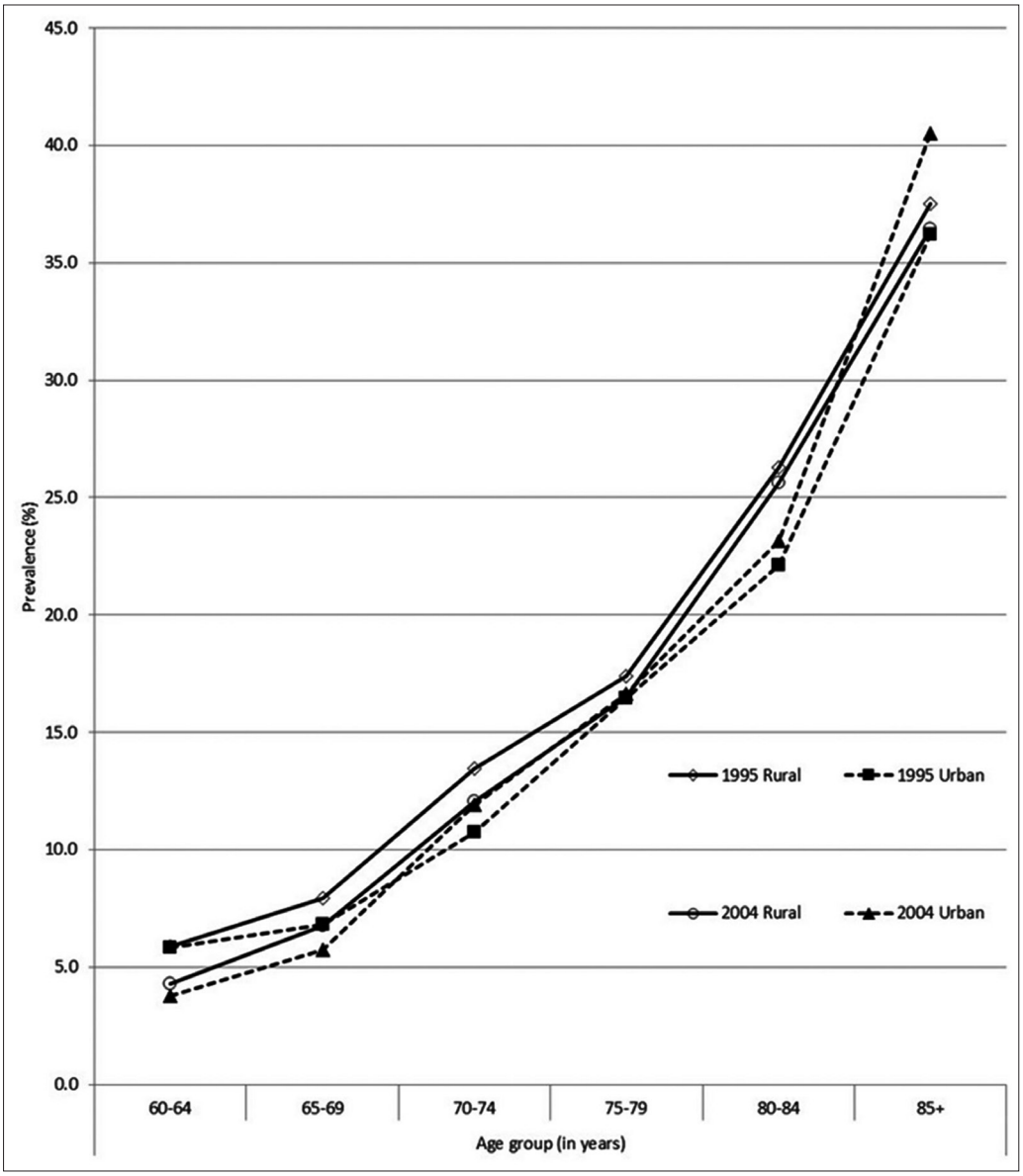

Figure 2. Prevalence of mobility limitation by 5-year age groups and place of residence, 1995–1996 and 2004

For both genders, in 1995–1996 and 2004, the prevalence of mobility limitation increased with age [Figure 1]. Further, at both time points, the prevalence was higher among women than men, particularly so after the age of 65–69 years. Among men, over the course of 10 years, the prevalence decreased slightly, especially for those aged 60–74. Among women, over the decade, the prevalence remained largely unchanged. There was a slight decrease in the prevalence for those aged 60–64, but then the prevalence marginally increased for those aged 80 and above.

Irrespective of the place of residence [Figure 2], there was an increase in the prevalence of mobility limitation with age in 1995–1996 as well as 2004. In 1995–1996, the rural-urban difference in prevalence varied by age group; the prevalence was higher for those residing in rural rather than urban areas, especially for respondents aged 65–84. However, in 2004, while there was a convergence in the prevalence for those aged <80, it was slightly higher for those aged 80–84 in rural areas and in urban areas for those aged 85 and above in urban areas. Among older rural persons, over the course of 10 years, the prevalence of mobility limitation decreased for all age groups, though it was only marginally for those aged 75 and above. However, among older urban persons, over the course of the decade, the prevalence increased for those aged 70–74 and those aged 80 and above.

Table 2. Life expectancy (in years), total and with and without mobility limitation, by age and gender, 1995–1996 and 2004.

Age	Life expectancy	Men			Women		
		1995–1996	2004	Change from 1995–1996 to 2004	1995–1996	2004	Change from 1995–1996 to 2004
60	Total	15.6	16.7	1.1	17.5	18.7	1.2
	Without mobility limitation	13.9	15.3	1.3**	15.0	16.2	1.1**
	With mobility limitation	1.7	1.5	-0.2*	2.4	2.5	0.1
70	Total	10.2	11.0	0.8	11.3	12.2	0.9
	Without mobility limitation	8.5	9.4	1.0**	8.8	9.5	0.7**
	With mobility limitation	1.7	1.6	-0.2	2.5	2.7	0.2
80	Total	6.5	7.0	0.6	7.1	7.7	0.6
	Without mobility limitation	4.7	5.3	0.6**	4.7	5.0	0.2
	With mobility limitation	1.8	1.7	0.0	2.3	2.7	0.4*

Note: Sum of life expectancy with and without mobility limitation may not add to total life expectancy due to rounding; Values under "Change from 1995–1996 to 2004" may not match exactly those obtained by subtracting 1995–1996 values from 2004 values listed above due to rounding. Differences in total life expectancy with and without mobility limitation were tested using the approach described by Jagger *et al*. (2014). *Significant at $p<0.05$ level; **Significant at $p<0.01$ level.

Table 3. The proportion of life expectancy with mobility limitation by age and gender, 1995–2004.

Age	Life expectancy with mobility limitation					
	Men			Women		
	1995–1996 (%)	2004 (%)	Change from 1995–1996 to 2004 (% points)	1995–1996 (%)	2004 (%)	Change from 1995–1996 to 2004 (% points)
60	10.6	8.8	−1.9**	13.9	13.5	−0.4
70	16.9	14.2	−2.6**	21.9	22.0	0.1
80	27.2	24.3	−2.9	33.0	35.1	2.1

Note: Values under "Change from 1995–1996 to 2004" may not match exactly those obtained by subtracting 1995–1996 values from 2004 values listed above due to rounding. Differences in the proportion of life expectancy with and without mobility limitation were tested using the approach described by Jagger *et al*. (2014). **Significant at 0.01 level.

Table 4. Life expectancy (in years), total and with and without mobility limitation, by age and place of residence, 1995–1996 and 2004.

Age	Life expectancy	Rural			Urban		
		1995-1996	2004	Change from 1995-1996 to 2004	1995-1996	2004	Change from 1995-1996 to 2004
60	Total	16.3	17.5	1.2	17.1	18.2	1.1
	Without mobility limitation	14.3	15.6	1.3**	15.3	16.2	0.8**
	With mobility limitation	2.1	1.9	−0.2*	1.8	2.0	0.2*
70	Total	10.6	11.5	0.9	11.1	11.9	0.8
	Without mobility limitation	8.5	9.4	0.9**	9.4	9.8	0.4**
	With mobility limitation	2.2	2.1	−0.1	1.8	2.1	0.4**
80	Total	6.7	7.4	0.7	7.1	7.3	0.3
	Without mobility limitation	4.6	5.2	0.6**	5.2	5.1	−0.1
	With mobility limitation	2.1	2.2	0.1	1.8	2.2	0.3

Note: Sum of life expectancy with and without mobility limitation may not add to total life expectancy due to rounding; Values under "Change from 1995–1996 to 2004" may not match exactly those obtained by subtracting 1995–1996 values from 2004 values listed above due to rounding. Differences in total life expectancy with and without mobility limitation were tested using the approach described by Jagger *et al*. (2014). *Significant at 0.05 level. **Significant at 0.01 level.

Table 5. The proportion of life expectancy with mobility limitation by age and place of residence, 1995–2004.

Age	Life expectancy with mobility limitation					
	Rural			Urban		
	1995–1996 (%)	2004 (%)	Change from 1995–1996 to 2004 (% points)	1995-1996 (%)	2004 (%)	Change from 1995–1996 to 2004 (% points)
60	12.7	10.9	−1.8**	10.5	11.2	0.7
70	20.3	17.9	−2.3**	15.9	17.9	2.0
80	31.2	29.4	−1.8	25.9	29.5	3.6

Note: Values under "Change from 1995–1996 to 2004" may not match exactly those obtained by subtracting 1995–1996 values from 2004 values listed above due to rounding. Differences in the proportion of life expectancy with and without mobility limitation were tested using the approach described by Jagger *et al*. (2014). **Significant at 0.01 level.

Table 2 shows total life expectancy and estimates of life expectancy with and without mobility limitation at selected ages by gender in 1995—1996 and 2004. From 1995–1996 to 2004, total life expectancy and life expectancy without mobility limitation increased for both older men and women in each age group, although more slowly in older age groups. The increase in life expectancy without mobility limitation was statistically significant, except for women aged 80. While life expectancy with mobility limitation fell slightly or remained unchanged from 1995–1996 to 2004 for men, it increased for women over this period; the change was significant only among men aged 60 and women aged 80. For men, over the decade, the gains made in total life expectancy at the considered ages were due to a significant increase in life expectancy without mobility limitation, balanced by a marginal reduction in life expectancy with mobility limitation. On the other hand, for women, over the decade, the gains in total life expectancy were due to an increase in life expectancy both with and without mobility limitation, their relative contributions varying across the considered ages. For women aged 60 and 70, the predominant increase was in life expectancy without mobility limitation, whereas for women aged 80, the increase in life expectancy with mobility limitation prevailed.

Examination of the proportion of life expectancy with mobility limitation is central for determining whether expansion or compression of morbidity was operational from 1995–1996 to 2004 among older Indian men and women [Table 3]. For men, over the decade, the proportion of life expectancy with mobility limitation fell for all the considered ages, suggesting a compression of morbidity. The drop was highest (−2.9% points), though not statically significant, among men aged 80. A 0.4% point reduction in this proportion was also observed for women aged 60. However, for women aged 70 and 80, from 1995–1996 to 2004, the proportion of life expectancy with mobility limitation increased, marginally for those aged 70 (+0.1% point) and more for those aged 80 (+2.1% points), indicating an expansion of morbidity. However, none of the changes for women were statically significant.

The various life expectancy estimates for 1995–1996 and 2004 by place of residence are shown in Table 4. From 1995–1996 to 2004, the total life expectancy increased at the considered ages for both older rural and urban persons, the increase tempering with age. For those residing in rural areas, over the decade, the gains in the total life expectancy at the considered ages were entirely or predominantly due to a significant increase in expected years of life without mobility limitation, with relatively minor contributions from a slight decrease (for those aged 60 and 70) or increase (for those aged 80) in expected years of life with mobility limitation. For those residing in urban areas, from 1995–1996 to 2004, the gains in total life expectancy at the considered ages were due to an increase in expected years of life both with and without mobility limitation, their contributions varying across the considered ages. For older urban persons aged 60, there was a significant and predominant increase in expected years of life without mobility limitation, whereas, for those aged 70, there were similar and significant increases in expected years of life with and without mobility limitation, and for those aged 80, a non-significant increase in expected years of life with mobility limitation predominated.

Table 5 shows that from 1995–1996 to 2004 the proportion of life with mobility limitation decreased for older rural persons, and significantly so for those aged 60 and 70, suggesting a compression of morbidity. For older urban persons, there was an increase, though non-significant, in this proportion over time, pointing to an expansion of morbidity.

4. Discussion

The current paper, to the best of our knowledge, is among the few to examine changes in health expectancy over time among older persons in India. Moreover, utilizing nationally representative data, it is the first in India to examine compression or expansion of morbidity in the context of mobility limitation. In the decade spanning 1995–1996 to

2004, older men and older rural persons in India experienced increases in life expectancy without mobility limitation, a reduction or no change in life expectancy with mobility limitation, as well as a reduction in the proportion of remaining life with mobility limitation. These changes were mostly statistically significant, thus strongly suggesting a compression of morbidity among these sub-groups of older persons. From 1995–1996 to 2004, older women and older urban persons likewise experienced increases in life expectancy without mobility limitation. However, they also experienced increases in life expectancy with mobility limitation and in the proportion of remaining life with mobility limitation. It is important to point out that these changes, especially those for the proportion of remaining life with mobility limitation, were not consistently statistically significant. Thus, while they are suggestive, they are not conclusive of, an expansion of morbidity among older women and older urban persons in India.

There could be several reasons for the observed urban-rural difference. One reason could be that Indian urban areas, driven by developmental and industrial objectives, have been expanding in an unplanned manner. This has resulted in unhealthy residential areas (Bentinck and Chikara, 2001) and restricted opportunities for older persons to move freely outside their homes. In a recent study from India (United Nations Population Fund, 2012), concern for safety was an important reason for older people not leaving their homes; and the proportion of older people citing this reason was higher in urban than rural areas. Another possible reason is that from the 1990s to 2000s there has been a greater increase in the concentration of sicker, less mobile older persons in urban areas than in rural areas, and there has been an increase in the movement of such older persons from rural to urban areas in search of health and medical care. While there is no direct data to support this conjecture, there is some indirect support through numbers portraying a greater increase in the older population and in medical care infrastructure in urban, versus rural, India. The increase in India, from 1991 to 2001, in the proportion of older persons in the urban population (5.8–6.7%) was marginally higher than that in the rural population (7.1–7.8%) (Chakrabarti and Sarkar, 2011). Concurrently, there was an increase in the population residing in urban slums (Prakash, 1999), and older people residing in urban slums are more vulnerable to chronic diseases than their counterparts in other urban areas (Anand, Shah, Yadav *et al.*, 2007). Greater availability of medical services, especially specialist services, in urban areas may be contributing to the growth in the older urban population (Chakrabarti and Sarkar, 2011). While there was a considerable expansion in medical care infrastructure in India from 1991 to 2001, the expansion was greater in urban than in rural areas. For example, growth from 1991 to 2001 in hospitals, hospital beds, and doctors per 100,000 people, was 43%, 28%, and 27%, respectively, in urban areas compared to 37%, 19%, and 23%, respectively, in rural areas (Bhatia, 2013). The greater availability in urban versus rural areas of advanced medical care may have led to sicker, less mobile older people remaining alive for longer in urban than in rural areas, contributing to the observed increase in absolute and relative life expectancy with mobility limitation in older urban persons.

At the same time, it appears that in rural India the increase in medical care infrastructure (as stated above) as well as in primary health-care facilities (the number of functioning sub-centers and primary health centers, specific to rural India, increased by 6.6% and 1%, respectively, from 1991 to 2001) (Ministry of Health and Family Welfare, 2005) has been beneficial, as indicated by the compression of morbidity seen among older rural persons in our study.

Similar to our study, previous studies, though not from India, have also documented the expansion of morbidity (using different "health" indicators) among older women (Tu and Chen, 1994, Gu, Dupre, Wamer *et al*., 2009). It has been suggested that with the progression of the epidemiologic transition, life span increases and the survival gap favoring women over men have led to women being at a higher risk of becoming disabled at older ages and of spending a greater time of their remaining life with disability (Myers, Lamb, and Agree, 2003). This may very well explain our finding. The potential reasons for the gender differences in life expectancy and life expectancy with a disability could be that women tend to have more non-life-threatening but disabling conditions, whereas men have a higher prevalence of life-threatening conditions (Case and Paxson, 2005). Previous studies have also found that women are more likely to experience a decline in functional status and are less likely to recover than men (Becket, Brock, Lemke *et al*., 1996). Thereby, women may simply accumulate more disability throughout the life course (Laditka and Laditka, 2002).

In India, it is well known that gender disparities in health (in infancy, childhood, and adulthood) favor men (Pande and Yazbeck, 2003, Tiwari, 2013). Our study points to the continuation of the gender disparity well into old age, as reflected in the gender disparity in absolute and relative life expectancy without mobility limitation favoring older men. Our study confirms the existence of the gender gap in health and mortality, generally termed "the male-female health-survival paradox," as observed elsewhere (Oksuzyan, Brønnum-Hansen, Jeune *et al*., 2010; Van Oyen, Nusselder, Jagger *et al*., 2013), wherein women live longer than men but spend a larger proportion of their life with a disability.

Certain limitations of this study must be acknowledged. First, our study focuses on the decade from 1995–1996 to 2004, and not thereafter. Other than the data available through the NSS, there is a lack of national-level data on older Indians collected through either repeated cross-sectional or longitudinal/panel surveys. Recent data collection efforts, such

as the Longitudinal Study of Ageing in India (LASI), will be useful in addressing this lack; we plan to use data from LASI in future analyses on health expectancy when they are available. Second, this study employs a vital yet a single measure of health, that is, mobility status. This, as mentioned before, was due to the lack of comparability of other measures of disease and disability between the two NSS rounds. Going forward, the NSSO, and other organizations and researchers conducting repeated cross-sectional and/or longitudinal surveys, should be mindful of maintaining consistency in all aspects (such as wording, referent time period, and response options) of included questions over time. Utilization of additional indicators of "health" over a longer period of time in future analyses using data, when available, from studies like the LASI, will be useful in determining whether there is a compression or expansion of morbidity among older persons in India. Third, health expectancy computed with the Sullivan method does not take into account the expected life cycle events of individuals exposed to current morbidity conditions (Saito, Robine, and Crimmins, 2014). Thus, it may underestimate (or overestimate) healthy life expectancy because it produces estimates based on past (as opposed to current) probabilities of becoming unhealthy. Finally, the NSS does not capture information on the environmental characteristics of older persons. Environmental characteristics play a role in defining functional ability (World Health Organization, 2015). We cannot, therefore, categorically comment on the role played by environmental characteristics in enabling or restricting mobility for older persons in our sample and thereby in the observed compression or expansion of morbidity. Having said that, mobility is less likely to be affected by environmental changes than other measures like instrumental ADL used to define "health" (Crimmins and Beltrán-Sánchez, 2011).

5. Conclusions

While the prevalence of mobility limitation fell among older men, older women, and older urban and rural persons from 1995–1996 to 2004, this did not translate into an absolute and relative reduction in the duration of remaining life without mobility limitation for all older people in India. Older men and older rural persons did experience a compression of morbidity, whereas older women and older urban persons seem to have experienced an expansion of morbidity over this decade. This suggests that current national programs in India, such as the National Health Mission and the National Program for Health Care of the Elderly, which aim to address health issues in general or, specifically, among older persons, need to focus on addressing mobility limitation among older women and older urban persons. At the same time, one cannot ignore the high absolute numbers of older persons (6.2 million, comprising 2.6 million older men and 3.6 million older women, or 4.5 million older rural persons and 1.7 million older urban persons [based on the observed prevalence estimates in 2004 and the 2001 India population census]) who are confined either to their beds or their homes and who need assistance with mobility. Clearly, there is a need for a policy focus on promoting and maintaining mobility and functional capacity among all older persons in India, concurrently with development and support for formal and informal long-term care services.

Authors' Contributions

Sreerupa, S Irudaya Rajan, and Yasuhiko Saito conceptualized and conducted the data analyses, interpreted the results of the analyses, and contributed in drafting the manuscript. Shweta Ajay and Rahul Malhotra interpreted the results of the analyses and contributed to drafting the manuscript.

Ethics

Secondary analysis of the available de-identified data was done. The de-identified data are publicly available. Therefore, we did not seek any ethical approval.

Availability of Supporting Data

Secondary analysis of the available de-identified data was done. The de-identified data are publicly available, i.e., ASDR from the Sample Registration System and two rounds of the NSS on Morbidity and Treatment of Ailments, 52nd Round (National Sample Survey Organisation, 1998), conducted from July 1995 to June 1996, and on Morbidity, Health Care, and the Conditions of the Aged, 60th Round (National Sample Survey Organisation, 2006), conducted from January to June 2004.

Conflicts of Interest

No conflicts of interest were reported by the authors.

Funding

None.

Appendix

None.

References

Agarwal B. (1994). Gender and command over property: A critical gap in economic analysis and policy in South Asia. *World Development*, 22(10): 1455–1478. https://doi.org/10.1016/0305-750X(94)90031-0.

Alam M. (2000). Ageing in India: A country profile. *Bold*, 10(3): 5–22.

Anand K, Shah B, and Yadav K, *et al*. (2007). Are the urban poor vulnerable to non-communicable diseases? A survey of risk factors for non-communicable diseases in urban slums of Faridabad. *The National Medical Journal of India*, 20(3): 115–120.

Arokiasamy P and Yadav S. (2014). Changing age patterns of morbidity vis-à-vis mortality in India. *J Biosoc Sci*, 46(4): 462–479. https://doi: 10.1017/S002193201300062X.

Becket LA, Brock DB, and Lemke JH, *et al.* (1996). Analysis of change in self-reported physical function among older persons in four population studies. *American Journal of Epidemiology*, 143: 766–778. https://doi.org/10.1093/oxfordjournals.aje.a008814.

Bentinck J and Chikara S. (2001). Illegal Factories in Delhi: The Controversy, the Causes, and the Expected Future. *International Workshop on Coping with Informality and Illegality in Human Settlements in Developing Cities*. Leuven and Brussels, Belgium. Available from: https://www.ucl.ac.uk/dpu-projects/drivers_urb_change/urb_economy/pdf_infor_econo/ESFN_AERUS_Bentinck_Illegal%20factor.pdf. [Last accessed on 2018 Jul 15].

Bhatia S. (2013). *Public Health Expenditure and Health Status in India: An Inter State Analysis*.Thesis, Guru Nanak Dev University.

Case A and Paxson C. (2005). Sex differences in morbidity and mortality. *Demography*, 42(2): 189–214. https://doi.org/10.1353/dem.2005.0011.

Census of India. (2011). *Five Year Age Group Data by Residence and Sex, Population Enumeration Data 2011 Census.* Office of the Registrar General and Census Commissioner, India. New Delhi.

Chakrabarti S and Sarkar A. (2011). Pattern and trend of population ageing in India. *Indian Journal of Spatial Science*, 2(2): 1–11. Available from: http://www.indiansss.org/pdf/pdfset-5/issueset-7/Art_012.pdf.

Crimmins EM and Beltrán-Sánchez H. (2011). Mortality and morbidity trends: Is there compression of morbidity? *The Journals of Gerontology. Series B, Psychological Sciences*, 66(1): 75–86. https://doi: 10.1093/geronb/gbq088.

Crimmins EM and Saito Y. (2000). Change in the prevalence of diseases among older Americans: 1984–1994. *Demographic Research*, 3(9): 1–20. Available from: https://www.demographic-research.org/volumes/vol3/9.

Doblhammer G and Kytir J. (2001). Compression or expansion of morbidity? Trends in healthy-life expectancy in the elderly Austrian population between 1978 and 1998. *Social Science and Medicine*, 52(3): 385–391. https://doi.org/10.1016/S0277-9536(00)00141-6.

Freedman VA, Crimmins E, and Schoeni RF, *et al.* (2004). Resolving inconsistencies in trends in old-age disability: Report from a technical working group. *Demography*, 41(3): 417–441. https://doi.org/10.1353/dem.2004.0022.

Freedman VA, Spillman BC, and Andreski PM, *et al.* (2013). Trends in late-life activity limitations in the United States: An update from five national surveys. *Demography*, 50(2): 661–671. https://doi.org/10.1007/s13524-012-0167-z.

Fries JF, Bruce B, and Chakravarty E. (2011). Compression of morbidity 1980–2011: A focused review of paradigms and progress. *Journal of Aging Research*, 2011: 261702. https://doi: 10.4061/2011/261702.

Fries JF. (1980). Aging, natural death, and the compression of morbidity. *The New England Journal of Medicine*, 303(3): 130–135. https://doi: 10.1007/s13524-012-0167-z.

Graham P, Blakely T, and Davis P, *et al.* (2004). Compression, expansion, or dynamic equilibrium? The evolution of health expectancy in New Zealand. *Journal of Epidemiology and Community Health*, 58(8): 659–666. https://doi: 10.1136/jech.2003.014910.

Gruenberg EM. (1977). The failures of success. *The Milbank Memorial Fund Quarterly Health and Society*, 55(1): 3–24. https://doi.

org/10.2307/3349592.

Gu D, Dupre ME, and Warner DF, *et al.* (2009). Changing health status and health expectancies among older adults in China: Gender differences from 1992 to 2002. *Social Science and Medicine*, 68(12): 2170–2179. https://doi: 10.1016/j.socscimed.2009.03.031.

Jagger C, Oyen H, and Robine JM. (2014). *Health expectancy calculation by the Sullivan Method: A Practical Guide. E. H. E. M. Unit*. Europe: European Health Expectancy Monitoring Unit.

Kramer M. (1980). The rising pandemic of mental disorders and associated chronic diseases and disabilities. *Acta Psychiatr Scand,* 62(S285): 382-397. https://doi.org/10.1111/j.1600-0447.1980.tb07714.x.

Laditka SB and Laditka JN. (2002). Recent perspectives on active life expectancy for older women. *Journal of Women and Aging*, 14(1-2), 163–184. https://doi.org/10.1300/J074v14n01_11.

Lampinen P and Heikkinen E. (2003). Reduced mobility and physical activity as predictors of depressive symptoms among community-dwelling older adults: An eight-year follow-up study. *Aging Clinical and Experimental Research*, 15(3): 205–211. https://doi.org/10.1007/BF03324501.

Lawrence RH and Jette AM. (1996). Disentangling the disablement process. *The Journals of Gerontology Series B, Psychological Sciences*, 51(4): S173–S182.

Maharana B and Ladusingh L. (2014). Gender disparity in health and food expenditure in india among elderly. *International Journal of Population Research*, 2014: 150105. https://doi.org/10.1155/2014/150105.

Ministry of Health and Family Welfare. (2005). *Bulletin on Rural Health Statistics in India*. New Delhi: Ministry of Health and Family Welfare.

Myers G, Lamb V, and Agree E. (2003). Patterns of disability change associated with the epidemiologic transition. In: Robine JM, Jagger C, Mathers CD, Crimmins E, and Suzman R, editors. *Determining Health Expectancies*. Chichester: John Wiley and Sons, Ltd. p59–74.

National Sample Survey Organisation. (1998). Morbidity and Treatment of Ailments, NSS 52nd Round: July 1995-June 1996. New Delhi: *Ministry of Statistics and Programme Implementation*. Government of India.

National Sample Survey Organisation. (2006). Morbidity, Health Care and Condition of the Aged, NSS 60th Round: January 2004-June 2004, *Ministry of Statistics and Programme Implementation.* New Delhi: Government of India.

Netuveli G, Wiggins RD, and Hildon Z, *et al.* (2006). Quality of life at older ages: Evidence from the English longitudinal study of aging (wave 1). *Journal of Epidemiology and Community Health*, 60(4): 357–363. http://dx.doi.org/10.1136/jech.2005.040071.

Office of the Registrar, General Sample Registration System 1995-2005. (2010). *Sample Registration*. New Delhi: Government of India.

Oksuzyan A, Brønnum-Hansen H and Jeune B. (2010). Gender gap in health expectancy. *European Journal of Ageing*, 7(4): 213–218. https://doi.org/10.1007/s10433-010-0170-4.

Pande RP and Yazbeck AS. (2003). What's in a country average? Wealth, gender, and regional inequalities in immunization in India. *Social Science and Medicine*, 57(11): 20752088. https://doi.org/10.1016/S0277-9536(03)00085-6.

Penninx BW, Ferrucci L, and Leveille SG, *et al.* (2000). Lower extremity performance in nondisabled older persons as a predictor of subsequent hospitalization. *The Journals of Gerontology. Series B, Psychological Sciences*, 55(11): M691–M697. https://doi.org/10.1093/gerona/55.11.M691.

Prakash IJ. (1999). *Ageing in India*. Geneva: World Health Organization.

Rajan SI, Risseeuw C, and Perera M. (2008), *Institutional Provisions and Care for the Aged*: *Perspectives from Asia and Europe*. New Delhi: Anthem Press India.

Rolland Y, Lauwers-Cances V, and Cesari M, *et al.* (2006). Physical performance measures as predictors of mortality in a cohort of community-dwelling older French women. *European Journal of Epidemiology*, 21(2): 113–122. https://doi.org/10.1007/s10654-005-5458-x.

Saga A. (2013). An assessment of gender discrimination in household expenditure on education in India. *Oxford Development Studies*, 41(2): 220–238. https://doi.org/10.1080/13600818.2013.786694.

Saito Y, Robine JM, and Crimmins EM, (2014). The methods and materials of health expectancy. *Statistical Journal of the IAOS*, 30: 209–223. https://doi: 10.3233/SJI-140840.

Sengupta M and Agree EM. (2003). Gender, health, marriage and mobility difficulty among older adults in India. *Asia Pacific Population Journal*, 18(4): 53–65.

Singh A. (2012). Gender based within-household inequality in childhood immunization in India: Changes over time and across regions. *PLoS One*, 7(4): e35045. https://doi.org/10.1371/journal.pone.0035045.

Sreerupa and Rajan SI. (2010). Gender and widowhood: Disparity in health status and health care utilization among the aged in India. *Journal of Ethnic and Cultural Diversity in Social Work*, 19(4): 287304. https://doi.org/10.1080/15313204.2010.523650.

Stuck AE, Walthert JM, and Nikolaus T, *et al.* (1999). Risk factors for functional status decline in community-living elderly people: A systematic literature review. *Social Science and Medicine*, 48(4): 445–469. https://doi.org/10.1016/S0277-9536(98)00370-0.

Sullivan DF. (1971). A single index of mortality and morbidity. *HSMHA Health Reports*, 86(4): 347. https://doi.org/10.2307/4594169.

Tiwari A. (2013). Gender inequality in terms of health and nutrition in India: Evidence from National Family Health Survey-3. *Pacific Business Review International*, 5: 24–34.

Tu EJ and Chen K. (1994). Changes in active life expectancy in Taiwan: Compression or expansion? *Social Science and Medicine*, 39(12): 1657–1665. https://doi.org/10.1016/0277-9536(94)90080-9.

United Nations Population Fund. (2012). *Report on the Elderly in Select States of India. Building a Knowledge Base on Population Ageing in India*. New Delhi: United Nations Population Fund.

Van Oyen H, Nusselder W, and Jagger C, *et al*. (2013). Gender differences in healthy life years within the EU: An exploration of the "health survival" paradox. *International Journal of Public Health*, 58(1): 143–155. https://doi.org/10.1007/s00038-012-0361-1.

von Bonsdorff M, Rantanen T, and Laukkanen P. (2006). Mobility limitations and cognitive deficits as predictors of institutionalization among community-dwelling older people. *Gerontology*, 52(6): 359–365. https://doi.org/10.1159/000094985.

World Health Organization. (2015). *Integrating Equity, Gender, Human Rights and Social Determinants into the Work of WHO-Roadmap for Action (2014-2019)*. Geneva: World Health Organization.

World Health Organization. (2015). *World Report on Ageing and Health*. Geneva: World Health Organization.