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## Prevalence, determinants, and inequalities in chronic disease multi-morbidity among elderly in India: Insights from LASI data

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**Title Page**

**Prevalence, determinants, and inequalities in chronic disease multi-morbidity among elderly in India: Insights from LASI data**

**Shekhar Chauhan[1], Ratna Patel[2], Shubham Kumar[3]**

[1] Ph.D. Research Scholar, Department of Population Policies and Programmes, International Institute for Population Sciences, Mumbai, India

[2] Ph.D. Research Scholar, Department of Public Health and Mortality Studies, International Institute for Population Sciences, Mumbai, India

[3] Ph.D. Research Scholar, Department of Mathematical Demography & Statistics, International Institute for Population Sciences, Mumbai, India

**Corresponding author:**
**Shubham Kumar**
**Affiliation**: Ph.D. Research Scholar, Department of Mathematical Demography & Statistics, International Institute for Population Sciences, Mumbai, India
Email: shubhamk98@gmail.com
ORCID: 0000-0003-0421-5677

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**Prevalence, determinants, and inequalities in chronic disease multi-morbidity among elderly in India: Insights from LASI data**

**Abstract**

**Objective:** This study intends to examine the prevalence, patterns, and determinants of chronic disease-related multi-morbidity. Also, this study examines the inequality in the prevalence of multi-morbidity among the elderly in India.

**Design:** Cross-sectional study; large representative survey data

**Setting and Participants:** We have used the first wave of a Longitudinal Ageing Study in India (LASI) conducted in 2017-18 across all the 35 states (excluded Sikkim) and union territories (UTs) in India. This study is based on 31,373 older people aged 60+ years in India.

**Primary and secondary outcome measures:** The outcome variable for this study is multi-morbidity. The study utilized multinomial logistic regression to examine the risk factors for multi-morbidity among elderly. To measure the inequality in multi-morbidity, the slope of index inequality (SII) and relative index of inequality (RII) have been used to understand the ranked-based inequality.

**Results:** Almost one-fourth (24.1%) reported multi-morbidity. The relative risk ratio of multi-morbidity (RRR=2.12; C.I.=1.49-3.04) was higher among higher educated elderly than uneducated elderly. Furthermore, the relative risk ratio of multi-morbidity (RRR=2.35; C.I.=2.02-2.74) was higher among urban elderly than their rural counterparts. The elderly in richest wealth quintile were more likely to report multi-morbidities (RRR=2.86; C.I.=2.29-3.55) than the poorest elderly. Good self-rated health and No ADL disability were associated with a lower risk of multi-morbidities.

**Conclusions:** This study contributes to the comprehensive knowledge of the prevalence, determinants, and inequality of the chronic disease-related multi-morbidity among the elderly in India. Considering India's ageing population and high prevalence of multi-morbidity, the elderly must be preferred in disease prevention and health programs, however, without compromising other sub-populations in the country. There is a need to develop geriatric

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healthcare services in India on an urgent basis. Furthermore, there is a need to disseminate awareness and management of multi-morbidity among urban and highly educated elderly.

**Keywords:** Multi-morbidity; Chronic disease; Older population; India.

**Strength and limitations**

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1. This is a comprehensive study examining the prevalence, patterns, determinants, and inequality in the prevalence of multi-morbidity among elderly in India.

2. To form the variable of multi-morbidity, only nine chronic diseases were considered.

3. The cross-sectional nature of data limits our understanding of the causal relationship.

4. The study is based on country-representative data, and therefore findings can be generalized.

5. The study is based on recent released data; therefore providing current estimates.

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## Introduction:

Chronic disease is a worldwide phenomenon, and more elderly than ever are suffering from chronic diseases. In the last few decades, the combination of improved living conditions, better prevention and management of infectious diseases, ever-improving healthcare infrastructure, and rising trends of an ageing population have considerably increased the prevalence of chronic diseases [1]. Inevitably, multi-morbidity is frequently observed in individuals and can be regarded as an emerging health problem [2]. Multimorbidity, defined as two or more co-occurring chronic diseases, is frequent among the elderly, highly disabling, and costly [3–5]. Multimorbidity has become widely prevalent and is characterized by a decline in mortality rates resulting from improved healthcare systems worldwide, combined with an ageing population [5].

Increased life expectancy and decline in fertility rates have increased the elderly population [6]. Moreover, old age is associated with several chronic conditions [7]. It is already noted that the share of the older population is estimated to be higher in developing countries with an increased disease burden [8]. As the number of elderly in India is growing, there were around 104 million older persons in India during the count of the 2011 Census, which roughly translates into 8 percent of India's total population [9]. With this demographic transition, the disease burden of the population is shifting towards chronic conditions [10]. The growing concern of population ageing in India confronts many challenges, including multi-morbidity among older people [11].

If persist for a longer duration, chronic diseases can affect the ability of a person to function normally, and subsequently, multi-morbidity aggravates the situation to the extent that it induces profound adverse effects on quality of life and well-being [12,13]. Several risk factors predispose older people towards multi-morbidity, including increasing age [14–17], poor socioeconomic conditions [14,16,18,19], educational status [16,17], place of residence, gender [14–16,18], levels of physical activity [19], and poor self-rated health [15]. A few studies conducted recently in

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different community settings in India reported an increasing prevalence of multi-morbidity and suggested that older people are more prone to multi-morbidity [7,20,21].

Developing countries are currently undergoing an epidemiological transition, resulting from a decline in infectious diseases and a constant increase in non-communicable diseases or chronic diseases [22]. In recent years, increased longevity in life expectancy in India has increased the prevalence of chronic conditions among the elderly [7]. Despite a rising concern of chronic conditions in India, the issue of multi-morbidity has yet to be explored extensively in India [7]. A growing body of research substantiates the effects of multi-morbidity on health outcomes beyond risk attributable to individual disease [23] and pinned down specific determinants of multi-morbidities [7]. However, minimal research is available examining the inequalities in multi-morbidities by socioeconomic, health, and lifestyle characteristics of the elderly.

Furthermore, the increasing prevalence of multi-morbidity has secured growth in research on the epidemiology of multi-morbidity in many developed countries [24–26]; however, the same has been relatively a new concept in developing countries including India [7,22,27]. Multi-morbidity still is an under-researched entity in India, constituting a critical knowledge impasse for a country experiencing an unparalleled high rise of chronic diseases [10]. Therefore, this study intends to examine the prevalence, patterns, and determinants of chronic disease-related multi-morbidity. Also, this study examines the inequality in the prevalence of multi-morbidity among the elderly in India.

**Methods:**

**Data**

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We have used the first wave of a Longitudinal Ageing Study in India (LASI) conducted in 2017-18 across all the 35 states (excluded Sikkim) and union territories (UTs) in India. The LASI has designed comprehensive and internationally comparable national survey data on the ageing process health, economic, social, and psychological aspects. The survey was funded by the Ministry of Health and Family Welfare (MoHFW), the Government of India, the National Institute on Aging (NIA), and the United Nations Population Fund, India (UNFPA). The LASI has been coordinated by three partnering institutions: the International Institute for Population Sciences (IIPS), Harvard T.H. Chain School of Public Health (HSPH), and the University of Southern California (USC).

LASI is the world's biggest and India's first-ever longitudinal study which evaluates the scientific evidence base on demographics, household economic status, chronic health conditions, symptom-based health conditions, functional health, mental health (cognition and depression), biomarkers, health insurance, and healthcare utilization, family and social networks, social welfare programs, work and employment, retirement, satisfaction, and life expectations for elderly men and women age 45 years and above.

The primary objective of the survey is to study the overall health status and social and economic well-being of the elderly; therefore, a multistage stratified area probability cluster sampling design had applied to reach out a representative sample in each stage of sample selection. With each state and UT, a three-stage sampling design was adopted for rural areas, and a four-stage sampling design was adopted for urban areas. In the first stage, primary sampling units (PSUs) were selected in rural and urban areas, sub-districts (Tehsils/Talukas). The second stage involved selecting villages in rural areas and wards in urban areas from selected PSUs. In the third stage of sampling, the household was selected in rural areas, and census enumeration blocks (CEBs) were selected in urban areas; however, an additional stage was involved for urban areas. In the fourth stage, households were selected from CEBs in urban areas.

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The survey intends to follow a representative sample of the elderly population for every two years for the next 25 years with a revised sample size for attrition due to death, migration, non-reachable, and non-response. The LASI covered 72,250 older people aged 45 years and above in the first follow-up, including 31,464 elderly age 60 and above and 6,749 oldest-old persons aged 75 and above across all the states and UTs. Although, our study concerned with elderly with 60 years and above age group. This study is based on 31,373 older people aged 60+ years.

**Definition of multi-morbidity**

Multimorbidity can be defined as the simultaneous occurrence of two or more chronic conditions in an individual [28]. This was coming into focus after the third phase of epidemiological transition, as portrayed by Omran. Over the past decades, life expectancy has tremendously increased [6]. However, a more significant number of people are at risk of long-term chronic conditions like hypertension, diabetes, cancer, stroke, chronic lung and heart diseases, mental disorders [7,29]. Following are the definitions of some selected chronic diseases considered in the study:

*Hypertension:* commonly known as high blood pressure, it is a situation where the blood vessels have persistently raised pressure. Consequently, the heart has to pump harder against the walls of blood vessels. In the Indian context, the cut-off for blood pressure for hypertension is 130mmHg or more than systolic and 80mmHg or greater [30].

*Diabetes or high blood sugar:* Diabetes can be defined as a metabolic disease symbolized by hyperglycemia resulting from defects in insulin secretion, insulin action, or both [31].

*Cancer:* Cancer may be defined as the genetic changes that interfere with this orderly process. Consequently, cells start to grow uncontrollably, and formed cells may form a mass called a malignant tumour.

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*Chronic lung diseases:* chronic lung diseases include asthma, chronic obstructive pulmonary disease/Chronic bronchitis, or other chronic lung problems [32].

*Chronic heart diseases:* chronic heart diseases (CHDs) include coronary heart failure (heart attack or Myocardial Infarction), congestive heart failure, rheumatic heart disease, and cerebrovascular disease.

*Stroke:* A stroke can be defined as the interruption or reduction of blood is stopped to supply into the brain that prevents brain tissue from getting oxygen and nutrients.

*Arthritis:* Arthritis is symmetric polyarticular arthritis that primarily affects the small diarthrodial joints of the hands and feet.

*Psychiatric problems:* A psychiatric problem is a group of mental disorders that lead to abnormal thoughts, perceptions, emotions, depression, Alzheimer's/Dementia, unipolar/bipolar disorders, convulsions, Parkinson's.

*High cholesterol:* high cholesterol may be defined as a type of fat-like substance found in the bloodstream, while there are different etiological roles of different types of cholesterol, such as low cholesterol and high cholesterol.

**Study Variables**

*Outcome Variables*

The outcome variable for this study is multi-morbidity. The multi-morbidity condition was measured through the following health conditions: Hypertension or high blood pressure, diabetes or high blood sugar, Cancer or a malignant tumour, Chronic lung diseases such as asthma, chronic obstructive pulmonary disease/Chronic bronchitis or other chronic lung problems, Chronic heart diseases such as Coronary heart disease (heart attack or Myocardial Infarction), congestive heart failure, or other chronic heart problems, Stroke, Arthritis or

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rheumatism, Osteoporosis or other bone/joint diseases, any neurological, or psychiatric problems such as depression, Alzheimer's/Dementia, unipolar/bipolar disorders, convulsions, Parkinson's, and high cholesterol. All the chronic diseases have been asked in dichotomous form as "yes" and "no." Further, these morbidity conditions have been classified into three categories as "no morbidity," "one morbidity," and "multi-morbidity."

### *Explanatory variables*

Explanatory variables for this study are sex (male and female); age (60-69 and 70 years and above); marital status (currently married, never married, Divorced/Separated/Deserted/Widowhood); education (No education, below primary, primary, secondary, and higher); living arrangements (living alone, with spouse and with others); place of residence (rural and urban); currently working (yes and no); wealth index (poorest, poorer, middle, richer and richest); and self-rated health (poor and good); tobacco use (no and yes); alcohol use (yes and no); ADL disability (severe. Moderate and no ADL disability), and IADL disability (Severe, moderate and no IADL disability).

### **Statistical Measures**

The bi-variate analysis had been adopted to understand the proportion of morbidity conditions among the elderly. Furthermore, the study utilized multinomial logistic regression to examine the risk factors for multi-morbidity among elderly. To measure the inequality in multi-morbidity, the slope of index inequality (SII) and relative index of inequality (RII) have been used to understand the ranked-based inequality by sociodemographic and health characterizes. Both the SII and RII are regression-based measures that show outcomes with the relative position of social groups. The formula for the SII is given by:

$$SII = \frac{\sum_{i=1}^{n} w_i (y_i - \bar{y}_w)(x_i - x_w)}{\sum_{i=1}^{n} w_i (x_i - x_w)^2}$$

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Where xi is the ridit, $y_i$ the mortality rate, and $w_i$ the frequency of each class i = {1, …, n}, and $x_w$ and $y_w$ the frequency-weighted averages of xi and $y_i$ [33].

The RII can be obtained by extrapolating the regression line towards the extreme position of the x-axis. It explains the ratio of the value at the bottom of the social hierarchy to the value at the top of the hierarchy (Renard et al., 2019). The equation for RII is given by:

$$RII = \frac{Intercept}{Intercept + slope}$$

Where RII is the relative slope of the index, all the analysis has been done using the STATA 16th version.

**Patient and Public Involvement**

No patient was involved in this study. This study is based on secondary data source and therefore, patients were not involved in any way.

**Results:**

Figure 1 depicts the prevalence of chronic morbidities among the elderly in India. The results found that the prevalence of hypertension (35% vs. 31.2%), Cancer (0.8% vs. 0.7%), chronic lung diseases (10.7% vs. 6.9%), chronic heart diseases (6.1% vs.4.5%), stroke (3.4% vs. 2.2%), and arthritis (21.4% vs. 18.5%) was higher among elderly aged 70+ than older people belonging to 60-69 years age group. Almost one-third (32.8%) of the elderly reported hypertension, one-fifth (19.7%) reported arthritis, and around 14 percent elderly reported diabetes.

Figure 2 depicts the proportion of elderly by the number of chronic diseases. Results found that a little less than half of the elderly (46.6%) reported no chronic disease. Almost 30 percent of

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the elderly reported suffering from at least one chronic disease. Around 16 percent of the elderly reported suffering from at least two chronic diseases, and 6 percent reported suffering from at least three chronic diseases. Almost 2.4 percent of the elderly reported four and more chronic diseases.

Table 1 depicts the prevalence of multi-morbidity among the elderly by sociodemographic and health behaviours and lifestyle characteristics. A higher percentage of females (25.5% vs. 22.5%) reported multi-morbidity than their male counterparts. Similarly, multi-morbidity was higher among elderly aged 70+ years, divorced elderly, elderly with secondary and higher educated, and elderly living in urban areas than their respective counterparts. Currently, working elderly had a lower prevalence of multi-morbidity (13.6% vs. 27.3%) than non-working elderly. Furthermore, the prevalence of multi-morbidity increases with an increase in status related to the household wealth index. Almost one-third (35.9%) of the richest elderly reported multi-morbidity, and only one-sixth (16.7%) of the poorest elderly reported multi-morbidity. Multimorbidity was higher among those who reported poor self-rated health (40.2% vs. 21%) than those who reported good self-rated health. Similarly, the prevalence of multi-morbidity was higher among those with severe ADL (42.8% vs. 21.3%) and severe IADL (33.7% vs. 19.7%) than those without ADL and IADL, respectively.

**Table 1: Prevalence of multimorbidity among elderly by socio-demographic and health parameters**

| | No Morbidity | One Morbidity | Multi-morbidity | Total (N) |
|---|---|---|---|---|
| **Sex** | | | | |
| Male | 49.1 | 28.4 | 22.5 | 14,808 |
| Female | 44.4 | 30.2 | 25.5 | 16,565 |
| **Age** | | | | |
| 60-69 | 49.1 | 28.1 | 22.8 | 18,426 |
| 70+ | 43.2 | 31.1 | 25.8 | 12,947 |
| **Marital Status** | | | | |
| Currently married | 47.8 | 28.8 | 23.4 | 19,425 |
| Never Married | 54.3 | 29.8 | 16.0 | 225 |
| Divorced/Separated/Deserted | 44.5 | 30.2 | 25.3 | 11,723 |
| **Education** | | | | |

| | | | | |
|---|---|---|---|---|
| No education | 52.8 | 28.8 | 18.4 | 17,808 |
| Below primary | 41.5 | 32.2 | 26.4 | 3,602 |
| Primary | 39.7 | 30.1 | 30.2 | 3,525 |
| Secondary | 37.1 | 27.9 | 35.0 | 5,161 |
| Higher | 32.3 | 33.0 | 34.7 | 1,277 |
| **Living arrangements** | | | | |
| Living alone | 44.7 | 31.9 | 23.5 | 1,792 |
| With spouse | 47.9 | 28.8 | 23.3 | 19,063 |
| With others | 44.6 | 29.9 | 25.5 | 10,518 |
| **Place of residence** | | | | |
| Rural | 52.6 | 28.2 | 19.1 | 22,233 |
| Urban | 32.0 | 32.0 | 36.0 | 9,140 |
| **Currently working** | | | | |
| Yes | 60.1 | 26.3 | 13.6 | 9,501 |
| No | 41.2 | 31.5 | 27.3 | 13,105 |
| **Wealth Index** | | | | |
| Poorest | 55.1 | 28.3 | 16.7 | 6,835 |
| Poorer | 49.9 | 29.8 | 20.3 | 6,832 |
| Middle | 47.6 | 29.7 | 22.7 | 6,474 |
| Richer | 41.5 | 30.6 | 27.9 | 6,053 |
| Richest | 35.9 | 28.2 | 35.9 | 5,180 |
| **Self-rated health** | | | | |
| Poor | 29.6 | 30.3 | 40.2 | 4,627 |
| Good | 50.0 | 29.0 | 21.0 | 26,164 |
| **Tobacco Use** | | | | |
| No | 43.1 | 30.0 | 26.9 | 18,654 |
| Yes | 52.0 | 28.4 | 19.6 | 12,531 |
| **Alcohol use** | | | | |
| Yes | 52.7 | 27.5 | 19.9 | 4,553 |
| No | 45.6 | 29.7 | 24.7 | 26,638 |
| **ADL disability** | | | | |
| Severe ADL | 28.3 | 28.9 | 42.8 | 999 |
| Moderate ADL | 37.5 | 30.4 | 32.1 | 6,044 |
| No ADL | 49.6 | 29.1 | 21.3 | 24,276 |
| **IADL disability** | | | | |
| Severe IADL | 38.1 | 28.3 | 33.7 | 1,858 |
| Moderate IADL | 41.5 | 30.5 | 28.0 | 13,272 |
| No IADL | 51.8 | 28.5 | 19.7 | 16,157 |
| **Total** | **46.6** | **29.3** | **24.1** | **31,373** |

Table 2 depicts the results of multinomial odds regression for multi-morbidity among the elderly. In the analysis, no morbidity was considered as the base outcome. Occurrence of one morbidity and multi-morbidity was considered for relative risk ratio with respect to no morbidity as the reference category. Results found that the occurrence of multi-morbidity (RRR=0.43; C.I.=0.20-0.90) was lower among never-married elderly than currently married

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elderly. The relative risk ratio of one morbidity and multi-morbidity was higher among higher educated elderly than their uneducated counterparts. The relative risk ratio of one morbidity (RRR=1.57; C.I.=1.16-2.13) and multi-morbidity (RRR=2.12; C.I.=1.49-3.04) was higher among higher educated elderly than uneducated elderly. Furthermore, the relative risk ratio of one morbidity (RRR=1.60; C.I.=1.38-1.86) and multi-morbidity (RRR=2.35; C.I.=2.02-2.74) was higher among urban elderly than their rural counterparts. Higher wealth was associated with a higher risk of multi-morbidity. The elderly in the richest wealth quintile were more likely to report multi-morbidities (RRR=2.86; C.I.=2.29-3.55) than the poorest elderly. Good self-rated health and No ADL disability were associated with a lower risk of multi-morbidities among the elderly.

**Table 2: Multinomial logistic regression of multi-morbidity among elderly by socio-demographic and health parameters**

|  | One Morbidity | | Multi-morbidity | |
|---|---|---|---|---|
|  | **RRR** | **CI at 95%** | **RRR** | **CI at 95%** |
| **Sex** | | | | |
| Male | | | | |
| Female | 1.17** | 1.03-1.34 | 1.06 | 0.89-1.24 |
| **Age** | | | | |
| 60-69 | | | | |
| 70+ | 1.11 | 0.99-1.24 | 0.94 | 0.82-1.07 |
| **Marital Status** | | | | |
| Currently married | | | | |
| Never Married | 1.00 | 0.50-1.98 | 0.43** | 0.20-0.90 |
| Divorced/Separated/Deserted | 1.18 | 0.72-1.90 | 0.69 | 0.44-1.07 |
| **Education** | | | | |
| No education | | | | |
| Below primary | 1.40*** | 1.18-1.66 | 1.74*** | 1.40-2.15 |
| Primary | 1.43*** | 1.20-1.71 | 2.04*** | 1.67-2.48 |
| Secondary | 1.49*** | 1.26-1.76 | 2.26*** | 1.88-2.70 |
| Higher | 1.57*** | 1.16-2.13 | 2.12*** | 1.49-3.04 |
| **Living arrangements** | | | | |
| Living alone | | | | |
| With spouse | 1.14 | 0.68-1.89 | 0.63 | 0.38-1.02 |
| With others | 0.86 | 0.69-1.07 | 0.78 | 0.59-1.03 |
| **Place of residence** | | | | |
| Rural | | | | |
| Urban | 1.60*** | 1.38-1.86 | 2.35*** | 2.02-2.74 |
| **Currently working** | | | | |
| Yes | | | | |

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| | | | | |
|---|---|---|---|---|
| No | 1.47*** | 1.31-1.64 | 2.18*** | 1.90-2.51 |
| **Wealth Index** | | | | |
| Poorest | | | | |
| Poorer | 1.24*** | 1.07-1.44 | 1.53*** | 1.26-1.85 |
| Middle | 1.32*** | 1.13-1.55 | 1.79*** | 1.47-2.18 |
| Richer | 1.50*** | 1.26-1.78 | 2.06*** | 1.71-2.48 |
| Richest | 1.48*** | 1.23-1.78 | 2.86*** | 2.29-3.55 |
| **Self-rated health** | | | | |
| Poor | | | | |
| Good | 0.60*** | 0.51-0.70 | 0.33*** | 0.28-0.39 |
| **Tobacco Use** | | | | |
| No | | | | |
| Yes | 0.93 | 0.82-1.04 | 0.76*** | 0.67-0.87 |
| **Alcohol use** | | | | |
| Yes | | | | |
| No | 1.04 | 0.90-1.18 | 1.02 | 0.88-1.19 |
| **ADL disability** | | | | |
| Severe ADL | | | | |
| Moderate ADL | 0.73 | 0.46-1.13 | 0.68 | 0.42-1.09 |
| No ADL | 0.61** | 0.39-0.96 | 0.43*** | 0.27-0.70 |
| **IADL disability** | | | | |
| Severe IADL | | | | |
| Moderate IADL | 1.41** | 1.03-1.93 | 1.59** | 1.10-2.28 |
| No IADL | 1.07 | 0.77-1.47 | 1.00 | 0.68-1.45 |

*No morbidity is considered as base outcome

Table 3 depicts the absolute and relative inequality in chronic diseases among the elderly by their socio-demographic and health characteristics. The slope index of inequality (Column 2; table 3) depicts the absolute inequality in the prevalence of multi-morbidity (chronic diseases) among the elderly. If there is no inequality, the coefficient takes the value zero. Grater absolute values indicate higher levels of inequality. On the lines of the above interpretation, the higher absolute inequality was explained by female gender, 60-69 age group, divorced elderly, educated elderly, living with others, currently not working, good self-rated health, and ADL and IADL disabilities. Similarly, the relative index of inequality (Column 4, Table 3) depicts the relative contribution in the prevalence of multi-morbidity (chronic diseases) among the elderly. If there is no inequality, the coefficient of RII takes the value one. RII takes only positive values, where higher values (values above 1) are associated with the concentration of

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inequality in the sub-population, and lower values (lower than 1) indicate the concentration of the inequality in the disadvantaged sub-groups. The highest inequality in the prevalence of chronic disease multimorbidity was explained by ADL and IADL disability. Female gender, divorced, 60-69 age group, higher education, living with others were other significant predictors of inequality in the prevalence of chronic disease-related multi-morbidity.

**Table 3: Absolute (slope index of inequality-SII) and relative (relative index of inequality-RII) inequalities in chronic diseases among elderly by socio-demographic and health clusters**

| | Slope index of inequality (SII) | | Relative index of inequality (RII) | |
|---|---|---|---|---|
| | Coefficient | CI at 95% | Coefficient | CI at 95% |
| **Sex** | | | | |
| Male | 0.21*** | (0.15-0.27) | 2.52*** | (1.91-3.13) |
| Female | 0.22*** | (0.16.-0.29) | 2.60*** | (1.89-3.30) |
| **Age** | | | | |
| 60-69 | 0.23*** | (0.18.-0.27) | 2.83*** | (2.32-3.34) |
| 70+ | 0.20*** | (0.12-0.28) | 2.25*** | (1.59-2.91) |
| **Marital Status** | | | | |
| Currently married | 0.20*** | (0.16-0.24) | 2.45*** | (2.05-2.84) |
| Never Married | -0.08 | (-0.33-0.17) | 0.60*** | (-0.33-1.53) |
| Divorced/Separated/Deserted | 0.25*** | (0.16-0.35) | 2.85*** | (1.90-3.81) |
| **Education** | | | | |
| No education | 0.12*** | (0.08-0.15) | 1.93*** | (1.57-2.28) |
| Below primary | 0.12*** | (0.03-0.20) | 1.60*** | (1.08-2.13) |
| Primary | 0.28*** | (0.18-0.38) | 2.62*** | (1.73-3.51) |
| Secondary | 0.32*** | (0.18-0.46) | 2.63*** | (1.64-3.61) |
| Higher | 0.24* | (0.06-0.41) | 2.03*** | (0.813.26) |
| **Living arrangements** | | | | |
| Living alone | 0.13** | (0.01-0.24) | 1.76*** | (0.84-2.68) |
| With spouse | 0.20*** | (0.16-0.24) | 2.45*** | (2.05-2.86) |
| With others | 0.27*** | (0.17-0.38) | 3.06*** | (1.94-4.18) |
| **Place of residence** | | | | |
| Rural | 0.17*** | (0.14-0.20) | 2.48*** | (2.08-2.89) |
| Urban | 0.33*** | (0.23-0.42) | 2.60*** | (1.91-3.29) |
| **Currently working** | | | | |
| Yes | 0.13*** | (0.10-0.17) | 2.77*** | (2.02-3.51) |
| No | 0.20*** | (0.15-0.24) | 2.14*** | (1.77-2.51) |
| **Self-rated health** | | | | |
| Poor | 0.10* | (0.03-0.18) | 1.31*** | (1.05-1.57) |
| Good | 0.23*** | (0.19-0.28) | 3.22*** | (2.53-3.19) |
| **Tobacco Use** | | | | |
| No | 0.24*** | (0.18-0.30) | 2.52*** | (1.98-3.06) |
| Yes | 0.16*** | (0.12-0.20) | 2.38*** | (1.89-2.88) |

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| | | | | |
|---|---|---|---|---|
| **Alcohol use** | | | | |
| Yes | 0.23*** | (0.17-0.29) | 3.33*** | (2.27-4.39) |
| No | 0.21*** | (0.16-0.26) | 2.45*** | (2.00-2.90) |
| **ADL disability** | | | | |
| Severe ADL | 0.15 | (-0.03-0.34) | 1.44*** | (0.79-2.10) |
| Moderate ADL | 0.12*** | (0.05-0.20) | 1.49*** | (1.14-1.83) |
| No ADL | 0.25*** | (0.20-0.30) | 3.46*** | (2.71-4.20) |
| **IADL disability** | | | | |
| Severe IADL | 0.18* | (0.04-0.31) | 1.72*** | (0.99-2.44) |
| Moderate IADL | 0.23*** | (0.14-0.31) | 2.33*** | (1.69-2.96) |
| No IADL | 0.22*** | (0.19-0.26) | 3.29*** | (2.65-3.92) |

## Discussion:

The findings from this study show a higher prevalence of chronic diseases multi-morbidity among the elderly in India, where almost one-fourth (24.1%) of the elderly reported multi-morbidity. Another 29.3 percent elderly reported at least one chronic disease-related morbidity. The prevalence of one morbidity in this study was higher than previous studies conducted in Brazil [34] and China [35]. However, the prevalence of multi-morbidities reported in this study was much lower than previous studies conducted in China [35], Brazil [34], South Africa [36]. Few community-based studies in India also reported a higher prevalence of chronic multi-morbidity among the elderly [21,37,38]. A multi-country study conducted for high-income countries reported a higher prevalence of multi-morbidity [24]. Another study conducted in six low-and middle-income countries also reported a higher prevalence of multi-morbidity among the elderly [27]. However, it is not a good idea to compare the prevalence of multi-morbidity from different studies due to differences in the definitions of multi-morbidity, demographic characteristics of the sample, and difference in methodologies [12,39,40]. In agreement with previous studies, hypertension, diabetes, and arthritis were the most common diseases [37,41–45].

The results found that the risk of one morbidity and multi-morbidity was higher among female elderly than male elderly; however, results for multi-morbidity were not significant. This finding is consistent with several previous studies [4,46–48]. The higher prevalence of multi-

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morbidity among older women can be attributed to the fact that women generally use healthcare services more frequently than men [49]. Furthermore, studies have noted that women were more vulnerable to co-occurring diseases than their men counterparts, which might explain a higher risk of multi-morbidity among them [14,46,50]. Furthermore, treating women as socially inferior predicts a higher multi-morbidity than their male counterparts [7]. Gender inequalities in resource allocation, including income, healthcare, and nutrition, are associated with poor health and reduced well-being among the female gender [51].

Results noted a higher risk of multi-morbidity among higher educated elderly. Several previous studies agree with this finding [21,37,48,50,52]. However, few studies failed to notice any significant association between education and multi-morbidity [47,53]. A study in a community setting in India has noticed a lower risk of multi-morbidity; however, the study was conducted among adults [44]. Higher education can be linked to better socio-economic status [54], further linked to multi-morbidity among the elderly [55]. An increase in education can further be linked to health-related knowledge, affecting lifestyle behaviours and further lowering the risk of multi-morbidity [46].

In corroboration with previous studies [19,48,52,56–59], this study noted a high risk of multi-morbidity among richest elderly than their poor counterparts. Wealthier persons utilize healthcare services more than poorer people, leading to definitive diagnoses of chronic diseases [60]. People with high income may experience unhealthy behaviours such as lack of exercise, which could further be attributed to the high risk of multi-morbidity [53].

The risk of multi-morbidity was higher among the urban elderly than their rural counterparts. Several previous studies have highlighted the high risk of multi-morbidity among urban residents [7,61,62]. The possible explanation of the high risk of multi-morbidity among urban residents includes the low physical activity due to developed infrastructure and dependence on

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processed food [63,64]. Another study also noted a change in dietary habits and low physical activity as a probable reason for higher risk of multi-morbidity among urban elderly [65]. The higher risk of chronic diseases in urban areas has been attributed to inadequacy of physical exercise, high levels of alcohol consumption, and poor lifestyle-related factors [66,67].

In line with previous findings [47,68–70], the findings from this study significantly noticed the high risk of multi-morbidity among working elderly than their non-working counterparts. The Elderly currently working might be less engaged in physical activity due to their work profile which could be a plausible reason for higher multi-morbidity. A study noted that working status could be associated with high work-related physical activity, accompanied by poorer health outcomes [71]. Those working at an older age might be poor and engaged in unskilled work, which could be attributed to a higher risk of multi-morbidity among the working elderly [70]. The high risk of multi-morbidity among working elderly could also be attributed to occupation-related physical inactivity, higher sitting time, and dietary factors [69]. Good self-rated health and no ADL were associated with a lower risk of multi-morbidity among the elderly. The findings agree with several previous studies [72–75]. Severe ADL would be positively associated with physical inactivity, which could further undermine the multi-morbidity among the elderly with severe ADL [7].

**Limitations and strengths of the study:**

This study has certain noteworthy limitations. The chronic diseases included in the current study were not comprehensive since only nine chronic conditions were included in the survey. Furthermore, the data on multi-morbidity was based on self-reporting, which may have introduced some bias [35]. The causality could not be appropriately inferred as the data were cross-sectional. Despite the above limitations, the study has a few strengths too. This study is

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based on a nationally representative sample of the Indian elderly population. The data helps estimate the current prevalence of multi-morbidity among the elderly as the data were released in the year 2021 itself.

**Conclusion:**

Multimorbidity remains an underexplored area of research in India [7]. Despite the increasing prevalence of multi-morbidity, there are no specific proposals for its diagnosis and treatment. This study contributes to the comprehensive knowledge of the prevalence, determinants, and inequality of the chronic disease-related multi-morbidity among the elderly in India. Considering India's ageing population and high prevalence of multi-morbidity, the elderly must be preferred in disease prevention and health programs, however, without compromising other sub-populations in the country. Results noticed that almost one-fourth of the elderly reported multi-morbidity. Given the increasing prevalence of multi-morbidity, understanding the socio-economic differentials in multi-morbidity is important to address the issues among the elderly in India. Results from multinomial logistic regression show that education, place of residence, current working status, wealth index, self-rated health, and ADL disability were the most important predictors of multi-morbidity. Developing countries like India are least prepared to meet the challenges of ageing societies [29]. Therefore, there is a need to develop geriatric healthcare services in India on an urgent basis. Furthermore, there is a need to disseminate awareness and management of multi-morbidity among working, urban, and highly educated elderly.

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**Contributor statement**

Conceived and designed the research paper: SK and SC; analysed the data: SK; Contributed agents/materials/analysis tools: SK; Wrote the manuscript: SC and RP; Refined the manuscript: SC and RP.

**Competing interest**

The authors declare that there is no competing interest

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**Data sharing statement**

The datasets generated and/or analysed during the current study are available with the International Institute for Population Sciences, Mumbai, India repository and could be accessed from the following link: https://iipsindia.ac.in/sites/default/files/LASI_DataRequestForm_0.pdf. Those who wish to download the data have to follow the above link. This link leads to a data request form designed by International Institute for Population Sciences. After completing the form, it should be mailed to: datacenter@iips.net for further processing. After successfully sending the mail, individual will receive the data in a reasonable time.

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**Figure 1:** Prevalence of chronic morbidities among elderly by age groups.

**Figure 2:** Proportion of elderly by number of chronic disease.

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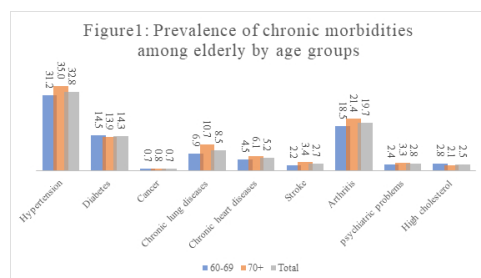
Figure 1: Prevalence of chronic morbidities among elderly by age groups.

316x122mm (96 x 96 DPI)

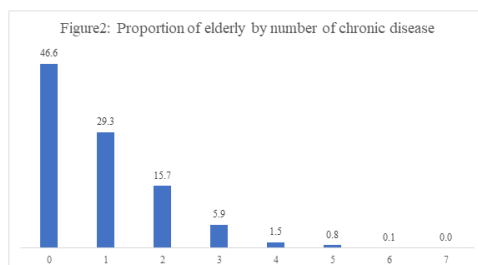Figure2: Proportion of elderly by number of chronic disease

Figure 2: Proportion of elderly by number of chronic disease.

316x122mm (96 x 96 DPI)

STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

| | Item No | Recommendation |
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| | | |
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| | | |
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| Generalisability | 21 | n/a |
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*Give information separately for exposed and unexposed groups.

# BMJ Open

# Prevalence, factors, and inequalities in chronic disease multi-morbidity among older adults in India: Analysis of cross-sectional data from the nationally representative Longitudinal Aging Study in India (LASI)

| | |
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## Title Page

**Prevalence, factors, and inequalities in chronic disease multi-morbidity among older adults in India: Analysis of cross-sectional data from the nationally representative Longitudinal Aging Study in India (LASI)**

**Shekhar Chauhan[1], Ratna Patel[2], Shubham Kumar[3]**

[1] Ph.D. Research Scholar, Department of Population Policies and Programmes, International Institute for Population Sciences, Mumbai, India

[2] Ph.D. Research Scholar, Department of Public Health and Mortality Studies, International Institute for Population Sciences, Mumbai, India

[3] Ph.D. Research Scholar, Department of Mathematical Demography & Statistics, International Institute for Population Sciences, Mumbai, India

**Corresponding author:**
**Shubham Kumar**
**Affiliation**: Ph.D. Research Scholar, Department of Mathematical Demography & Statistics, International Institute for Population Sciences, Mumbai, India
Email: shubhamk98@gmail.com
ORCID: 0000-0003-0421-5677

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# Prevalence, factors, and inequalities in chronic disease multi-morbidity among older adults in India: Analysis of cross-sectional data from the nationally representative Longitudinal Aging Study in India (LASI)

## Abstract

**Objective:** This study examines the prevalence, patterns, and factors of chronic disease-related multi-morbidity. Also, this study examines the inequality in the prevalence of multi-morbidity among older adults in India.

**Design:** Cross-sectional study; large nationally representative survey data

**Setting and Participants:** We have used the first wave of a Longitudinal Ageing Study in India (LASI) conducted in 2017-18 across all the 35 states (excluded Sikkim) and union territories (UTs) in India. This study utilized information from 31,373 older people aged 60+ years in India.

**Primary and secondary outcome measures:** The outcome variable for this study is multi-morbidity. The study utilized multinomial logistic regression to examine the risk factors for multi-morbidity among older adults. To measure the inequality in multi-morbidity, the slope of index inequality (SII) and relative index of inequality (RII) have been used to understand the ranked-based inequality.

**Results:** Almost one-fourth (24.1%) reported multi-morbidity. The relative risk ratio of multi-morbidity (RRR=2.12; C.I.=1.49-3.04) was higher among higher educated older adults than uneducated older adults. Furthermore, the relative risk ratio of multi-morbidity (RRR=2.35; C.I.=2.02-2.74) was higher among urban older adults than their rural counterparts. Older adults in the richest wealth quintile were more likely to report multi-morbidities (RRR=2.86; C.I.=2.29-3.55) than the poorest older adults. Good self-rated health and No ADL disability were associated with a lower risk of multi-morbidities.

**Conclusions:** This study contributes to the comprehensive knowledge of the prevalence, factors, and inequality of the chronic disease-related multi-morbidity among older adults in India. Considering India's ageing population and high prevalence of multi-morbidity, the older adults must be preferred in disease prevention and health programs, however, without compromising other sub-populations in the country. There is a need to develop geriatric

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healthcare services in India. Additionally, there is a need to disseminate awareness and management of multi-morbidity among urban and highly educated older adults.

**Keywords:** Multi-morbidity; Chronic disease; Older adults; India.

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**Strength and limitations**

1. This is a comprehensive study examining the prevalence, patterns, factors , and inequality in the prevalence of multi-morbidity among older adults in India.

2. To create the variable of multi-morbidity, only nine chronic diseases were considered.

3. The cross-sectional nature of data limits our understanding of the causal relationship.

4. The study is based on country-representative data, and therefore findings can be generalized.

5. The study is based on recently released data, therefore providing current estimates.

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**Prevalence, factors, and inequalities in chronic disease multi-morbidity among older adults in India: Analysis of cross-sectional data from the nationally representative Longitudinal Aging Study in India (LASI)**

## Introduction:

Chronic disease is a worldwide phenomenon, and more number of older adults than ever are suffering from chronic diseases. In last few decades, the combination of improved living conditions, better prevention and management of infectious diseases, ever-improving healthcare infrastructure, and rising trends of an ageing population have considerably increased the prevalence of chronic diseases [1]. Inevitably, multi-morbidity is frequently observed in individuals and can be regarded as an emerging health problem [2]. Multi-morbidity, defined as two or more co-occurring chronic diseases, is frequent among older adults, highly disabling, and costly [3–5]. Multi-morbidity has become widely prevalent and is characterized by a decline in mortality rates resulting from improved healthcare systems worldwide, combined with an ageing population [5].

Increased life expectancy and decline in fertility rates have increased the population of older adults [6]. Moreover, old age is associated with several chronic conditions [7]. It is already noted that the share of the older population is estimated to be higher in developing countries with an increased disease burden [8]. There were around 104 million older persons in India during the count of the 2011 Census, which roughly translates into 8 percent of India's total population [9]. With this demographic transition, the disease burden of the population is shifting towards chronic conditions [10]. The growing concern of population ageing in India confronts many challenges, including multi-morbidity among older people [11].

If persist for a longer duration, chronic diseases can affect the ability of a person to function normally. Subsequently, multi-morbidity aggravates the situation to the extent that it induces

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profound adverse effects on quality of life and well-being [12,13]. Several risk factors predispose older people towards multi-morbidity, including increasing age [14–17], poor socioeconomic conditions [14,16,18,19], educational status [16,17], place of residence, gender [14–16,18], levels of physical activity [19], and poor self-rated health [15]. A few recent studies in different community settings in India reported an increasing prevalence of multi-morbidity and suggested that older people are more prone to multi-morbidity [7,20,21].

Developing countries are undergoing an epidemiological transition, resulting from a decline in infectious diseases and a constant increase in non-communicable diseases or chronic diseases [22]. In recent years, increased longevity in life expectancy in India has increased the prevalence of chronic conditions among older adults [7]. Despite a rising concern of chronic diseases in India, the issue of multi-morbidity has yet to be explored extensively in India [7]. A growing body of research substantiates the effects of multi-morbidity on health outcomes beyond risk attributable to individual disease [23] and pinned down specific factors of multi-morbidities [7]. However, minimal research is available examining the inequalities in multi-morbidities by socioeconomic, health, and lifestyle characteristics of older adults.

Furthermore, the increasing prevalence of multi-morbidity has secured growth in research on the epidemiology of multi-morbidity in many developed countries [24–26]; however, the same has been relatively a new concept in developing countries, including India [7,22,27]. Multi-morbidity still is an under-researched entity in India, constituting a critical knowledge impasse for a country experiencing an unparalleled high rise of chronic diseases [10]. Therefore, this study examines the prevalence, patterns, and factors of chronic disease-related multi-morbidity. Also, this study examines the inequality in the prevalence of multi-morbidity among older adults in India.

**Methods:**

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**Data**

We have used the first wave of a Longitudinal Ageing Study in India (LASI) conducted in 2017-18 across all the 35 states (excluded Sikkim) and union territories (UTs) in India. The LASI has designed comprehensive and internationally comparable national survey data on health, economic, social, and psychological aspects of the aging process. The survey was funded by the Ministry of Health and Family Welfare (MoHFW), the Government of India, the National Institute on Aging (NIA), and the United Nations Population Fund, India (UNFPA). The LASI has been coordinated by three partnering institutions: the International Institute for Population Sciences (IIPS), Harvard T.H. Chain School of Public Health (HSPH), and the University of Southern California (USC).

LASI is the world's biggest and India's first-ever longitudinal study which evaluates the scientific evidence based on demographics, household economic status, chronic health conditions, symptom-based health conditions, functional health, mental health (cognition and depression), biomarkers, health insurance, and healthcare utilization, family and social networks, social welfare programs, work and employment, retirement, satisfaction, and life expectations for men and women age 45 years and above.

The survey intends to follow a representative sample of the population of older adults for every two years for the next 25 years with a revised sample size for attrition due to death, migration, non-reachable, and non-response. The LASI covered 72,250 older people aged 45 years and above in the first follow-up, including 31,464 older adults, aged 60 and above, and 6,749 oldest-old persons aged 75 and above across all the states and UTs. Although, our study concerned older adults with 60 years and above age group. This study utilized information from 31,373 older people aged 60+ years.

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Indian Council of Medical Research (ICMR) extended the ethical approval required to carry out the LASI survey. The interviewer sought the informed consent of each respondent before undertaking the LASI survey. Furthermore, the authors involved in this study do not require any ethical approval for the present analysis because the analysis is based on the existing secondary data available to everyone upon request.

**Study Variables**

*Outcome Variables*

The outcome variable for this study is multi-morbidity. The multi-morbidity condition was measured through the following health conditions: Hypertension or high blood pressure, diabetes or high blood sugar, Cancer or a malignant tumour, Chronic lung diseases such as asthma, chronic obstructive pulmonary disease/Chronic bronchitis or other chronic lung problems, Chronic heart diseases such as Coronary heart disease (heart attack or Myocardial Infarction), congestive heart failure, or other chronic heart problems, Stroke, Arthritis or rheumatism, Osteoporosis or other bone/joint diseases, any neurological, or psychiatric problems such as depression, Alzheimer's/Dementia, unipolar/bipolar disorders, convulsions, Parkinson's, and high cholesterol. The specific question asked in relation to chronic morbidity was: Has any health professional ever diagnosed you with the following chronic conditions or diseases? All the chronic diseases have been asked in dichotomous form as "yes" and "no." Further, these morbidity conditions have been classified into three categories as "no morbidity," "one morbidity," and "multi-morbidity."

*Explanatory variables*

Explanatory variables for this study are sex (male and female); age (60-69 and 70 years and above); marital status (currently married, never married,

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Divorced/Separated/Deserted/Widowhood); education (No education, below primary, primary, secondary, and higher); living arrangements (living alone, with spouse and with others); place of residence (rural and urban); currently working (yes and no); wealth index (poorest, poorer, middle, richer and richest); self-rated health (poor and good); tobacco use (no and yes); alcohol use (yes and no); ADL disability (severe. Moderate and no ADL disability), and IADL disability (Severe, moderate and no IADL disability).

**Statistical Measures**

The bi-variate analysis had been adopted to understand the proportion of morbidity conditions among older adults. Furthermore, the study utilized multinomial logistic regression to examine the risk factors for multi-morbidity among older adults. To measure the inequality in multi-morbidity, the slope of index inequality (SII) and relative index of inequality (RII) have been used to understand the ranked-based inequality by sociodemographic and health characterizes. Both the SII and RII are regression-based measures that show outcomes with the relative position of social groups. The formula for the SII is given by:

$$SII = \frac{\sum_{i=1}^{n} w_i (y_i - \bar{y}_w)(x_i - x_w)}{\sum_{i=1}^{n} w_i (x_i - x_w)^2}$$

Where xi is the ridit, $y_i$ the mortality rate, and $w_i$ the frequency of each class i = {1, …, n}, and $x_w$ and $y_w$ the frequency-weighted averages of xi and $y_i$[28].

The RII can be obtained by extrapolating the regression line towards the extreme position of the x-axis. It explains the ratio of the value at the bottom of the social hierarchy to the value at the top of the hierarchy (Renard et al., 2019). The equation for RII is given by:

$$RII = \frac{Intercept}{Intercept + slope}$$

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Where RII is the relative slope of the index, all the analysis has been done using the STATA 16th version.

**Patient and Public Involvement**

No patient was involved in this study. This study is based on a secondary data source and therefore, patients were not involved in any way.

**Results:**

Figure 1 depicts the prevalence of chronic morbidities among older adults in India. The results found that the prevalence of hypertension (35% vs. 31.2%), Cancer (0.8% vs. 0.7%), chronic lung diseases (10.7% vs. 6.9%), chronic heart diseases (6.1% vs.4.5%), stroke (3.4% vs. 2.2%), and arthritis (21.4% vs. 18.5%) was higher among older adults aged 70+ than older people belonging to 60-69 years age group. Almost one-third (32.8%) of the older adults reported hypertension, one-fifth (19.7%) reported arthritis, and around 14 percent older adults reported diabetes.

Figure 2 depicts the proportion of older adults by the number of chronic diseases. Results found that less than half of the older adults (46.6%) reported no chronic disease. Almost 30 percent of the older adults reported suffering from at least one chronic disease. Around 16 percent of the older adults reported suffering from at least two chronic diseases, and 6 percent reported suffering from at least three chronic diseases. Almost 2.4 percent of the older adults reported four and more chronic diseases.

Table 1 depicts the prevalence of multi-morbidity among older adults by sociodemographic and health behaviours and lifestyle characteristics. A higher percentage of females (25.5% vs. 22.5%) reported multi-morbidity than their male counterparts. Similarly, multi-morbidity was higher among older adults aged 70+ years, divorced/separated/deserted older adults, older

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adults with secondary and higher educated, and older adults living in urban areas than their respective counterparts. Currently, working older adults had a lower prevalence of multi-morbidity (13.6% vs. 27.3%) than non-working older adults. Furthermore, the prevalence of multi-morbidity increases with an increase in status related to the household wealth index. Almost one-third (35.9%) of the richest older adults reported multi-morbidity, and only one-sixth (16.7%) of the poorest older adults reported multi-morbidity. Multi-morbidity was higher among those who reported poor self-rated health (40.2% vs. 21%) than those who reported good self-rated health. Similarly, the prevalence of multi-morbidity was higher among those with severe ADL (42.8% vs. 21.3%) and severe IADL (33.7% vs. 19.7%) than those without ADL and IADL, respectively.

**Table 1: Prevalence of multi-morbidity among older adults by socio-demographic and health parameters**

| | No Morbidity | One Morbidity | Multi-morbidity | Total (N) |
|---|---|---|---|---|
| **Sex** | | | | |
| Male | 49.1 | 28.4 | 22.5 | 14,808 |
| Female | 44.4 | 30.2 | 25.5 | 16,565 |
| **Age** | | | | |
| 60-69 | 49.1 | 28.1 | 22.8 | 18,426 |
| 70+ | 43.2 | 31.1 | 25.8 | 12,947 |
| **Marital Status** | | | | |
| Currently married | 47.8 | 28.8 | 23.4 | 19,425 |
| Never Married | 54.3 | 29.8 | 16.0 | 225 |
| Divorced/Separated/Deserted | 44.5 | 30.2 | 25.3 | 11,723 |
| **Education** | | | | |
| No education | 52.8 | 28.8 | 18.4 | 17,808 |
| Below primary | 41.5 | 32.2 | 26.4 | 3,602 |
| Primary | 39.7 | 30.1 | 30.2 | 3,525 |
| Secondary | 37.1 | 27.9 | 35.0 | 5,161 |
| Higher | 32.3 | 33.0 | 34.7 | 1,277 |
| **Living arrangements** | | | | |
| Living alone | 44.7 | 31.9 | 23.5 | 1,792 |
| With spouse | 47.9 | 28.8 | 23.3 | 19,063 |
| With others | 44.6 | 29.9 | 25.5 | 10,518 |
| **Place of residence** | | | | |
| Rural | 52.6 | 28.2 | 19.1 | 22,233 |
| Urban | 32.0 | 32.0 | 36.0 | 9,140 |
| **Currently working** | | | | |
| Yes | 60.1 | 26.3 | 13.6 | 9,501 |

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| | | | | |
|---|---|---|---|---|
| No | 41.2 | 31.5 | 27.3 | 13,105 |
| **Wealth Index** | | | | |
| Poorest | 55.1 | 28.3 | 16.7 | 6,835 |
| Poorer | 49.9 | 29.8 | 20.3 | 6,832 |
| Middle | 47.6 | 29.7 | 22.7 | 6,474 |
| Richer | 41.5 | 30.6 | 27.9 | 6,053 |
| Richest | 35.9 | 28.2 | 35.9 | 5,180 |
| **Self-rated health** | | | | |
| Poor | 29.6 | 30.3 | 40.2 | 4,627 |
| Good | 50.0 | 29.0 | 21.0 | 26,164 |
| **Tobacco Use** | | | | |
| No | 43.1 | 30.0 | 26.9 | 18,654 |
| Yes | 52.0 | 28.4 | 19.6 | 12,531 |
| **Alcohol use** | | | | |
| Yes | 52.7 | 27.5 | 19.9 | 4,553 |
| No | 45.6 | 29.7 | 24.7 | 26,638 |
| **ADL disability** | | | | |
| Severe ADL | 28.3 | 28.9 | 42.8 | 999 |
| Moderate ADL | 37.5 | 30.4 | 32.1 | 6,044 |
| No ADL | 49.6 | 29.1 | 21.3 | 24,276 |
| **IADL disability** | | | | |
| Severe IADL | 38.1 | 28.3 | 33.7 | 1,858 |
| Moderate IADL | 41.5 | 30.5 | 28.0 | 13,272 |
| No IADL | 51.8 | 28.5 | 19.7 | 16,157 |
| **Total** | **46.6** | **29.3** | **24.1** | **31,373** |

Table 2 depicts the results of multinomial odds regression for multi-morbidity among older adults. In the analysis, no morbidity was considered as the base outcome. Occurrence of one morbidity and multi-morbidity was considered for relative risk ratio with respect to no morbidity as the reference category. Results found that the occurrence of multi-morbidity (RRR=0.43; C.I.=0.20-0.90) was lower among never-married older adults than currently married older adults. The relative risk ratio of one morbidity and multi-morbidity was higher among higher educated older adults than their uneducated counterparts. The relative risk ratio of one morbidity (RRR=1.57; C.I.=1.16-2.13) and multi-morbidity (RRR=2.12; C.I.=1.49-3.04) was higher among higher educated older adults than uneducated older adults. Furthermore, the relative risk ratio of one morbidity (RRR=1.60; C.I.=1.38-1.86) and multi-morbidity (RRR=2.35; C.I.=2.02-2.74) was higher among urban older adults than their rural counterparts. Higher wealth was associated with a higher risk of multi-morbidity. The older

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adults in the richest wealth quintile were more likely to report multi-morbidities (RRR=2.86; C.I.=2.29-3.55) than the poorest older adults. Good self-rated health and No ADL disability were associated with a lower risk of multi-morbidities among older adults.

**Table 2: Multinomial logistic regression of multi-morbidity among older adults by socio-demographic and health parameters**

| | One Morbidity | | Multi-morbidity | |
|---|---|---|---|---|
| | RRR | CI at 95% | RRR | CI at 95% |
| **Sex** | | | | |
| Male | | | | |
| Female | 1.17** | 1.03-1.34 | 1.06 | 0.89-1.24 |
| **Age** | | | | |
| 60-69 | | | | |
| 70+ | 1.11 | 0.99-1.24 | 0.94 | 0.82-1.07 |
| **Marital Status** | | | | |
| Currently married | | | | |
| Never Married | 1.00 | 0.50-1.98 | 0.43** | 0.20-0.90 |
| Divorced/Separated/Deserted | 1.18 | 0.72-1.90 | 0.69 | 0.44-1.07 |
| **Education** | | | | |
| No education | | | | |
| Below primary | 1.40*** | 1.18-1.66 | 1.74*** | 1.40-2.15 |
| Primary | 1.43*** | 1.20-1.71 | 2.04*** | 1.67-2.48 |
| Secondary | 1.49*** | 1.26-1.76 | 2.26*** | 1.88-2.70 |
| Higher | 1.57*** | 1.16-2.13 | 2.12*** | 1.49-3.04 |
| **Living arrangements** | | | | |
| Living alone | | | | |
| With spouse | 1.14 | 0.68-1.89 | 0.63 | 0.38-1.02 |
| With others | 0.86 | 0.69-1.07 | 0.78 | 0.59-1.03 |
| **Place of residence** | | | | |
| Rural | | | | |
| Urban | 1.60*** | 1.38-1.86 | 2.35*** | 2.02-2.74 |
| **Currently working** | | | | |
| Yes | | | | |
| No | 1.47*** | 1.31-1.64 | 2.18*** | 1.90-2.51 |
| **Wealth Index** | | | | |
| Poorest | | | | |
| Poorer | 1.24*** | 1.07-1.44 | 1.53*** | 1.26-1.85 |
| Middle | 1.32*** | 1.13-1.55 | 1.79*** | 1.47-2.18 |
| Richer | 1.50*** | 1.26-1.78 | 2.06*** | 1.71-2.48 |
| Richest | 1.48*** | 1.23-1.78 | 2.86*** | 2.29-3.55 |
| **Self-rated health** | | | | |
| Poor | | | | |
| Good | 0.60*** | 0.51-0.70 | 0.33*** | 0.28-0.39 |
| **Tobacco Use** | | | | |
| No | | | | |
| Yes | 0.93 | 0.82-1.04 | 0.76*** | 0.67-0.87 |
| **Alcohol use** | | | | |

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| | | | | |
|---|---|---|---|---|
| Yes | | | | |
| No | 1.04 | 0.90-1.18 | 1.02 | 0.88-1.19 |
| **ADL disability** | | | | |
| Severe ADL | | | | |
| Moderate ADL | 0.73 | 0.46-1.13 | 0.68 | 0.42-1.09 |
| No ADL | 0.61** | 0.39-0.96 | 0.43*** | 0.27-0.70 |
| **IADL disability** | | | | |
| Severe IADL | | | | |
| Moderate IADL | 1.41** | 1.03-1.93 | 1.59** | 1.10-2.28 |
| No IADL | 1.07 | 0.77-1.47 | 1.00 | 0.68-1.45 |

*No morbidity is considered as the base outcome

Table 3 depicts the absolute and relative inequality in chronic diseases among older adults by their socio-demographic and health characteristics. The slope index of inequality (Column 2; table 3) depicts the absolute inequality in the prevalence of multi-morbidity (chronic diseases) among older adults. If there is no inequality, the coefficient takes the value zero. Grater absolute values indicate higher levels of inequality. On the lines of the above interpretation, the higher absolute inequality was explained by female gender, 60-69 age group, divorced older adults, educated older adults, living with others, currently not working, good self-rated health, and ADL and IADL disabilities. Similarly, the relative index of inequality (Column 4, Table 3) depicts the relative contribution in the prevalence of multi-morbidity (chronic diseases) among older adults. If there is no inequality, the coefficient of RII takes the value one. RII takes only positive values, where higher values (values above 1) are associated with the concentration of inequality in the sub-population, and lower values (lower than 1) indicate the inequality concentration in the disadvantaged sub-groups. The highest inequality in the prevalence of chronic disease multi-morbidity was explained by ADL and IADL disability. Female gender, divorced, 60-69 age group, higher education, living with others were other significant predictors of inequality in the prevalence of chronic disease-related multi-morbidity.

**Table 3: Absolute (slope index of inequality-SII) and relative (relative index of inequality-RII) inequalities in chronic diseases among older adults by socio-demographic and health clusters**

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| | Slope index of inequality (SII) | | Relative index of inequality (RII) | |
|---|---|---|---|---|
| | Coefficient | CI at 95% | Coefficient | CI at 95% |
| **Sex** | | | | |
| Male | 0.21*** | (0.15-0.27) | 2.52*** | (1.91-3.13) |
| Female | 0.22*** | (0.16.-0.29) | 2.60*** | (1.89-3.30) |
| **Age** | | | | |
| 60-69 | 0.23*** | (0.18.-0.27) | 2.83*** | (2.32-3.34) |
| 70+ | 0.20*** | (0.12-0.28) | 2.25*** | (1.59-2.91) |
| **Marital Status** | | | | |
| Currently married | 0.20*** | (0.16-0.24) | 2.45*** | (2.05-2.84) |
| Never Married | -0.08 | (-0.33-0.17) | 0.60*** | (-0.33-1.53) |
| Divorced/Separated/Deserted | 0.25*** | (0.16-0.35) | 2.85*** | (1.90-3.81) |
| **Education** | | | | |
| No education | 0.12*** | (0.08-0.15) | 1.93*** | (1.57-2.28) |
| Below primary | 0.12*** | (0.03-0.20) | 1.60*** | (1.08-2.13) |
| Primary | 0.28*** | (0.18-0.38) | 2.62*** | (1.73-3.51) |
| Secondary | 0.32*** | (0.18-0.46) | 2.63*** | (1.64-3.61) |
| Higher | 0.24* | (0.06-0.41) | 2.03*** | (0.813.26) |
| **Living arrangements** | | | | |
| Living alone | 0.13** | (0.01-0.24) | 1.76*** | (0.84-2.68) |
| With spouse | 0.20*** | (0.16-0.24) | 2.45*** | (2.05-2.86) |
| With others | 0.27*** | (0.17-0.38) | 3.06*** | (1.94-4.18) |
| **Place of residence** | | | | |
| Rural | 0.17*** | (0.14-0.20) | 2.48*** | (2.08-2.89) |
| Urban | 0.33*** | (0.23-0.42) | 2.60*** | (1.91-3.29) |
| **Currently working** | | | | |
| Yes | 0.13*** | (0.10-0.17) | 2.77*** | (2.02-3.51) |
| No | 0.20*** | (0.15-0.24) | 2.14*** | (1.77-2.51) |
| **Self-rated health** | | | | |
| Poor | 0.10* | (0.03-0.18) | 1.31*** | (1.05-1.57) |
| Good | 0.23*** | (0.19-0.28) | 3.22*** | (2.53-3.19) |
| **Tobacco Use** | | | | |
| No | 0.24*** | (0.18-0.30) | 2.52*** | (1.98-3.06) |
| Yes | 0.16*** | (0.12-0.20) | 2.38*** | (1.89-2.88) |
| **Alcohol use** | | | | |
| Yes | 0.23*** | (0.17-0.29) | 3.33*** | (2.27-4.39) |
| No | 0.21*** | (0.16-0.26) | 2.45*** | (2.00-2.90) |
| **ADL disability** | | | | |
| Severe ADL | 0.15 | (-0.03-0.34) | 1.44*** | (0.79-2.10) |
| Moderate ADL | 0.12*** | (0.05-0.20) | 1.49*** | (1.14-1.83) |
| No ADL | 0.25*** | (0.20-0.30) | 3.46*** | (2.71-4.20) |
| **IADL disability** | | | | |
| Severe IADL | 0.18* | (0.04-0.31) | 1.72*** | (0.99-2.44) |
| Moderate IADL | 0.23*** | (0.14-0.31) | 2.33*** | (1.69-2.96) |
| No IADL | 0.22*** | (0.19-0.26) | 3.29*** | (2.65-3.92) |

**Discussion:**

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The findings from this study show a higher prevalence of chronic diseases multi-morbidity among older adults in India, where almost one-fourth (24.1%) of the older adults reported multi-morbidity. Another 29.3 percent older adults reported at least one chronic disease-related morbidity. The prevalence of one morbidity in this study was higher than previous studies conducted in Brazil [29] and China[30]. However, the prevalence of multi-morbidities reported in this study was much lower than previous studies conducted in China [30], Brazil [29], South Africa [31]. Few community-based studies in India also reported a higher prevalence of chronic multi-morbidity among older adults [21,32,33]. A multi-country study conducted for high-income countries reported a higher prevalence of multi-morbidity [24]. Another study conducted in six low-and middle-income countries also reported a higher prevalence of multi-morbidity among older adults [27]. However, it is not advised to compare the prevalence of multi-morbidity from different studies due to differences in the definitions of multi-morbidity, demographic characteristics of the sample, and difference in methodologies [12,34,35]. In agreement with previous studies, hypertension, diabetes, and arthritis were the most common diseases [32,36-40].

The results found that the risk of one morbidity and multi-morbidity was higher among female older adults than male older adults; however, results for multi-morbidity were not significant. This finding is consistent with several previous studies [4,41-43]. The higher prevalence of multi-morbidity among older women can be attributed to the fact that women generally use healthcare services more frequently than men [44]. Moreover, studies have noted that women were more vulnerable to co-occurring diseases than their men counterparts, which might explain a higher risk of multi-morbidity among them [14,41,45]. Moreover, treating women as socially inferior predicts a higher multi-morbidity than their male counterparts [7]. Gender inequalities in resource allocation, including income, healthcare, and nutrition, are associated with poor health and reduced well-being among the female gender [46].

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Results noted a higher risk of multi-morbidity among higher educated older adults. Several previous studies agree with this finding [21,32,43,45,47]. However, few studies failed to notice any significant association between education and multi-morbidity [42,48]. A study in a community setting in India has noticed a lower risk of multi-morbidity; however, the study was conducted among adults [39]. Higher education can be linked to better socio-economic status [49], further linked to multi-morbidity among older adults [50]. An increase in education can further be linked to health-related knowledge, affecting lifestyle behaviours and further lowering the risk of multi-morbidity [41].

In corroboration with previous studies [19,43,44,51-54], this study noted a high risk of multi-morbidity among richest older adults than their poor counterparts. Wealthier persons utilize healthcare services more than poorer people, leading to definitive diagnoses of chronic diseases [55]. People with high income may experience unhealthy behaviours such as lack of exercise, which could further be attributed to the high risk of multi-morbidity [48].

The risk of multi-morbidity was higher among the urban older adults than their rural counterparts. Several previous studies have highlighted the high risk of multi-morbidity among urban residents [7,56,57]. The possible explanation of the high risk of multi-morbidity among urban residents includes the low physical activity due to developed infrastructure and dependence on processed food [58,59]. Another study also noted a change in dietary habits and low physical activity as a probable reason for higher risk of multi-morbidity among urban older adults [60]. The higher risk of chronic diseases in urban areas has been attributed to inadequate physical exercise, high levels of alcohol consumption, and poor lifestyle-related factors [61-62].

In line with previous findings [42,63-65], the findings from this study significantly noticed the high risk of multi-morbidity among working older adults than their non-working counterparts. Older adults currently working might be less engaged in physical activity due to their work profile

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which could be a plausible reason for higher multi-morbidity. Physical activity has widely been correlated as a measure of multi-morbidity, and working at an older age might be associated with lower physical activity, thereby leading to multi-morbidity among older adults. A study noted that working status could be related to high work-related physical activity, accompanied by poorer health outcomes [66]. It largely depends upon the kind of work older adults are engaged in; working as unskilled labour might initiate multi-morbidity among them. Those working at an older age might be poor and engaged in unskilled work, which could be attributed to a higher risk of multi-morbidity among the working older adults [65]. The high risk of multi-morbidity among working older adults could also be attributed to occupation-related physical inactivity, higher sitting time, and dietary factors [64]. Good self-rated health and no ADL were associated with a lower risk of multi-morbidity among older adults. The findings agree with several previous studies [67-70]. Severe ADL would be positively associated with physical inactivity, further undermining the multi-morbidity among older adults with severe ADL [7].

**Limitations and strengths of the study:**

This study has certain noteworthy limitations. The chronic diseases included in the current study were not comprehensive since only nine chronic conditions were included in the survey. In addition, the data on multi-morbidity was based on self-reporting, which may have introduced some bias [30]. The causality could not be appropriately inferred as the data were cross-sectional. Despite the above limitations, the study has a few strengths too. This study is based on a nationally representative sample of the Indian older adults' population and study findings can be generalized at national level. The data helps estimate the current prevalence of multi-morbidity among older adults as the data were released in the year 2021.

**Conclusion:**

Despite the increasing prevalence of multi-morbidity, there are no specific diagnoses and treatment proposals. This study contributes to the comprehensive knowledge of the prevalence, factors, and inequality of the chronic disease-related multi-morbidity among older adults in India. Considering India's ageing population and high prevalence of multi-morbidity, the older adults must be preferred in disease prevention and health programs, however, without compromising other sub-populations in the country. Results noticed that almost one-fourth of the older adults reported multi-morbidity. Given the increasing prevalence of multi-morbidity, understanding the socio-economic differentials in multi-morbidity is important to address the issues among older adults in India. Results from multinomial logistic regression show that education, residence, current working status, wealth index, self-rated health, and ADL disability were the most important predictors of multi-morbidity. Developing countries like India are least prepared to meet the challenges of ageing societies. Therefore, there is a need to establish geriatric healthcare services in India on an urgent basis. Additionally, there is a need to disseminate awareness and management of multi-morbidity among working, urban, and highly educated older adults.

**Contributor statement**

Conceived and designed the research paper: SK and SC; analysed the data: SK; Contributed agents/materials/analysis tools: SK; Wrote the manuscript: SC and RP; Refined the manuscript: SC and RP.

**Competing interest**

The authors declare that there is no competing interest

**Funding**

No funding was received for the study

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**Data sharing statement**

The datasets generated and/or analysed during the current study are available with the International Institute for Population Sciences, Mumbai, India repository and could be accessed from the following link: https://iipsindia.ac.in/sites/default/files/LASI_DataRequestForm_0.pdf. Those who wish to download the data have to follow the above link. This link leads to a data request form designed by International Institute for Population Sciences. After completing the form, it should be mailed to: datacenter@iips.net for further processing. After successfully sending the mail, the individual will receive the data in a reasonable time.

**Ethics statement:** The authors used existing data source and therefore do not require any ethical approval from any authority. The data was sought by following all the required protocols mentioned above in the sub-heading titled "data sharing statement." The agencies that collected data sought consent from each respondent.

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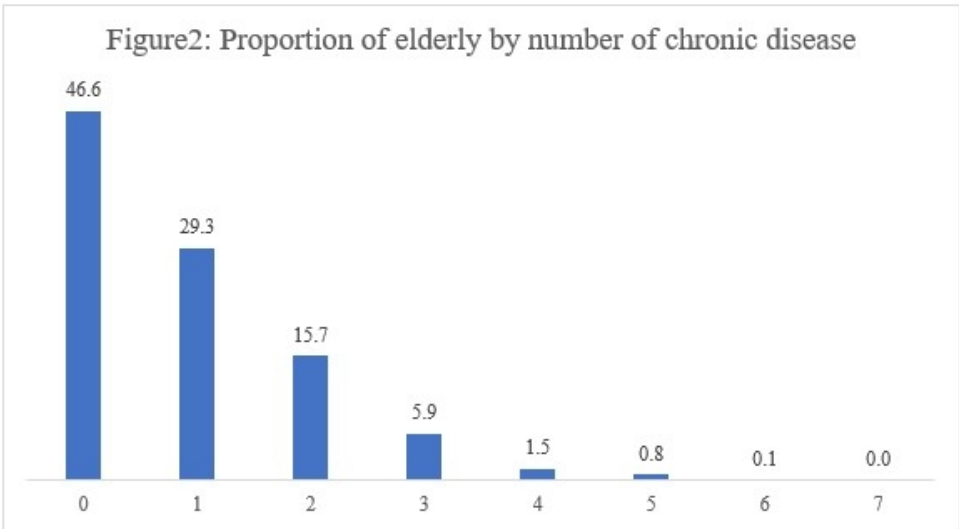
**Figure 1:** Prevalence of chronic morbidities among elderly by age groups.

**Figure 2:** Proportion of elderly by number of chronic disease.

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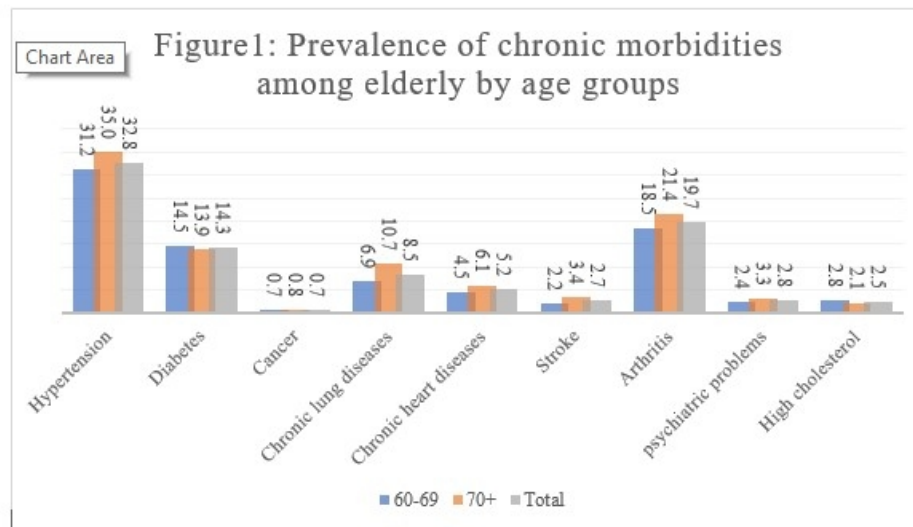
Prevalence of chronic morbidities among elderly by age groups

53x29mm (300 x 300 DPI)

Figure2: Proportion of elderly by number of chronic disease

Proportion of elderly by number of chronic disease

50x32mm (300 x 300 DPI)

STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

| | Item No | Recommendation |
|---|---|---|
| **Title and abstract** | 1 | Page-2 |
| | | |
| **Introduction** | | |
| Background/rationale | 2 | Page 5-6 |
| Objectives | 3 | Page 7 |
| **Methods** | | |
| Study design | 4 | Page- 7-8 |
| Setting | 5 | Page-7 |
| Participants | 6 | Page-8 |
| Variables | 7 | Page 10-11 |
| Data sources/ measurement | 8* | Page 7 |
| Bias | 9 | n/a    The study is based on secondary data source and therefore authors did not presented any biases in the manuscript. |
| Study size | 10 | Page-8 |
| Quantitative variables | 11 | Page 10-11 |
| Statistical methods | 12 | Page 11-12 |
| **Results** | | |
| Participants | 13* | n/a    the study is based on a secondary data source and the authors did not recruit any participants for this study. |
| Descriptive data | 14* | Page- 13-14    Descriptive information is provided in table 1; based on LASI data. |
| Outcome data | 15* | Page- 13-16 |
| Main results | 16 | Page 13-16 |
| Other analyses | 17 | n/a    Results are provided using various statistical techniques and page numbers are depicted above. Other analyses were not carried out. |
| **Discussion** | | |
| Key results | 18 | Page 13-17 |
| Limitations | 19 | Page 21 |
| Interpretation | 20 | 19-20 |
| Generalisability | 21 | 21 |
| **Other information** | | |
| Funding | 22 | Page- 22 |

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