A new prospective: Exploring variability of conditional risk factors for multimorbidity susceptibility among older adults in India

Abstract

Background

There is a lack of substantive evidence on the epidemiology of multimorbidity in LMICs. Simultaneously, India is also undergoing through the major demographic shift where population is rapidly aging followed by significantly elevated implications for multimorbidity risk. These implications include an increase in functional limitations, decline in quality of life, delayed mortality but expanding morbidity burden among older adults. This study aimed to characterize the distribution, pattern and further provide an understanding of the conditional role of risk factors for multimorbidity susceptibility among older adults in India.

Methods

We analyzed the national representative Longitudinal Ageing Study in India (LASI), Wave – 1, 2017–18, data of individuals aged 45 years and above. Primarily, to understand the distribution, prevalence and pattern of morbidities and multimorbidity we characterized and calculated the weighted frequency distribution, chi-square test for association and stacked area plot for relative prevalence share of multimorbidity over age. Finally, we constructed the CART model to further identify the optimal leading covariates and their conditional role for multimorbidity susceptibility among older adults in India.

Results

The CART model deducted that childhood health, place of residence, age, BMI, caste category and education level were the leading risk factors for multimorbidity susceptibility among older adults in India. The highest susceptibility of multimorbidity with a risk of 0.57 was observed among individuals with moderate to poor childhood health. Conversely, the adults who had good childhood health and lived in rural areas had a normal to underweight BMI and belonged to the Schedule tribe had the lowest risk of multimorbidity (0.19). Hypertension showed the highest prevalence (26.72%), followed by myopia (24.2%), hypermetropia (20.75%), gastrointestinal condition (17.98%), cataracts (14.18%), and diabetes (12.21%) confirmed a larger morbidity burden among older adults in India. Single morbidity prevalence was 23.78%, and multimorbidity was 50.94% and the relative prevalence share of multimorbidity over age expanded by 25.16 % from the 45–49 to 85+ age group.

Conclusion

Indian population endures high multimorbidity susceptibility on the account of acute and degenerative morbidities with highest burden of hypertension; nonetheless multimorbidity share expended significantly in the oldest of old age groups. Thus, early treatment and prognosis of acute and degenerative conditions, with a focus on preventive measures on modifiable risk factors, will significantly deviate the risk of higher multimorbidity susceptibility.

Introduction

Low and middle-income countries (LMICs) are facing a rapid increase in disease burden from chronic diseases (1), primarily driven by an aging population and changing lifestyle factors (2,3). Coextensively, India is also passing through a parallel phase of demographic and epidemiological transition where the burden of diseases since the last decade is rapidly shifting from Communicable Diseases (CDs) to Non-communicable Diseases (NCDs) (4,5). This epidemiological transition has been accompanied by sequential rising levels of multimorbidity, which the World Health Organization (WHO) defined as the coexistence of two or more morbidities or chronic conditions (6). Multimorbidity is a complex and evolving public health challenge and associated with higher levels of healthcare service utilization and out of-pocket expenditures (7,8), elevated mortality risks (9–11), low quality of life (12,13), reduced functional status, complex treatments, and behavioural risk factors with psychological antecedents and consequences (9,14) Moreover, the recent Longitudinal Ageing Study of India (LASI, Wave 1, 2017-18), reported that nearly one-third of the population aged 45 and above are suffering from one of the five common chronic morbidities (hypertension, diabetes, cardiovascular diseases, chronic respiratory diseases, arthritis)(15). Previous studies in India estimated the burden of multimorbidity to be over 50% among 45-year or above adults (16,17). This morbidity and thus multimorbidity burden in India is rapidly increasing due to increased unhealthy aging with longevity and early exposure to chronic disease risk factors ((18).

Despite the notable rise in the prevalence of multimorbidity in recent decades, there remains a significant gap in understanding the conditional role of socioeconomic, demographic and lifestyle risk factors to multimorbidity among older adults in India. Although early studies identified risk factors for multimorbidity were aging, higher number of previous diseases, and lower education level, whereas a large social network seemed to play a protective role (19,20). However, the approach of early studies in India for estimating the risk of multimorbidity primarily relied on odds ratios or relative risk models (18,21–23). Thus, those models were not well-suited for capturing the non-linear relationships and the conditional role of background characteristics on multimorbidity.

If we try to understand the association of socioeconomic, demographic and lifestyle factors on multimorbidity susceptibility we get a labyrinth full of adjusted and unadjusted linear association. So, to unwind and understand this labyrinth of linear associations, it seems vital and essential to meticulously discover the nonlinear and conditional association with leading factors for multimorbidity susceptibility. The aim of this study is therefor to characterize and calculate the distribution, prevalence and relative share of multimorbidity prevalence burden over age and finally to identify the optimal leading covariates for multimorbidity and their condition role for multimorbidity susceptibility among older adults in India.

Methods

Study Design

LASI is a longitudinal survey (Wave 1, 2017-18) that provides data on many morbidities in individuals 45 years and above and their spouses irrespective of age and their socio-economic and demographic details, covering 28 states and 8 UTs of India. LASI has adopted a multi-stage stratified areas probability cluster sampling design, with three stages in the rural and four stages in the urban areas, respectively. Firstly, a primary sampling unit (PSU) was selected from each state/union territory (UT), followed by a village (from rural) or ward (from urban) area in the second stage (Bloom et al., 2021). Finally, households were selected from the rural areas. However, in urban areas, census enumeration blocks (CEB) were selected randomly from each urban area, after which households were chosen from the selected CEB (International Institute for Population Sciences, 2020). The present study utilised merged

information from individual and biomarker datasets. The dataset contained samples of 73,396 individuals (all adults). In this research work, we primarily analysed.

Methodology*:*

Morbidities

The study encompasses a total of thirty-six morbidities: Arthritis, Rheumatism, Osteoporosis, Bone Joint other, Hypertension, Heart attack, Heart Blockage, Heart Failure, Arrhythmias, Heart rheumatic, Heart congenital or Structural disorder, Stroke, Heart other, Asthma, Bronchitis, COPD, Depression, Dementia, Neurological Disorders, Psychiatric Disorders, Cataract, Glaucoma, Hypermetropia, Myopia, Presbyopia, Diabetes and Thyroid, Jaundice or Hepatitis, Tuberculosis, Anaemia, Cancer, Cholesterol, Hearing disorders, Gastrointestinal disorders, Urogenital diseases and Skin diseases.

Outcome Variable: All thirty-six morbidities were classified into binary forms (absent & present) and morbidities score were generated. Further this score was categorised into three categories: Multimorbidity (individuals who had combinations of two or more morbidities or chronic health condition), Single morbidity (individuals with only one morbidity or chronic health conditions), and Zero morbidity (individuals with no morbidity or chronic health condition).

Independent Variables:

We have considered socioeconomic, demographic, behavioural, and self-induced risk factors to explore the differentials in the prevalence of multimorbidity. We have adopted Anderson's health care utilization framework (24) for the selection and categorising of the independent variables in three groups:

Predisposing factors are Age, Sex (Male /Female), Caste group (SCs/STs, OBC, Others)2, religion (Hindu, Muslim, Christian & Others), Marital status (Currently Married, Widowed, Divorced/Separated/N), Living arrangement (Alone, Spouse, Other), Impairment (No/ Yes).

Enabling factors are Level of education (No schooling, < 5 Years,5 -9 years, 10 + years), MPCE quintiles (poorest, poorer, middle, richer, richest), Residence (Rural, Urban), Regions (North, Central, East, Northeast, West, South), Working status (never worked, currently working, currently not working), Childhood health (Very good, Good, Fair, Poor, Very Poor), Self-rated health (Good, Moderate, Poor), Physical activity (Everyday, Weekly, Casual).

Risk factors are Tobacco consumption (Lifetime abstainer, Smokes tobacco, Smokeless tobacco, Both), Alcohol consumption (Lifetime abstainer, Infrequent non-heavy drinker, Frequent non-heavy drinker, Heavy episodic drinker), BMI (Underweight, Normal, Overweight, Obese).

Statistical method

We computed the weighted prevalence distribution of morbidities and multimorbidity of the target population. Further, weighted age-specific relative prevalence share of multimorbidity, single morbidity and zero morbidity were calculated. Finally, we hypothesized that the distribution of Zero morbidity, Single morbidity, and Multimorbidity may be similar or different by the covariates; for this purpose, the Chi-square test was applied to test the null hypothesis of the same distribution of morbidity statuses.

CART Model

The Classification and Regression Tree model (CART) is a method of regression or classification trees and used as growing method for the decision tree, run for the one outcome variable (Multimorbidity, Single morbidity and Zero morbidity).

The CART model splits the data with maximum homogeneity within the node. The degree of a non-homogeneous subset in a node, is an indication of impurity. In selecting the best splitter, CART attempted to maximize the average purity of the two child nodes. The way to measures of purity can be chosen freely, can be called a splitting criterion, or splitting functions. For this study this impurity is measured using the Gini index. Calculation of the Gini index was obtained by the below formula

$$Gini(t) = 1 - \sum_{i=1}^{c-1} [p(i|t)]^2$$

Where P (i | t) was the relative frequency of class i at node t, and c was the number of classes.

These calculations will achieve the highest value if the distribution of uniform class and has the smallest value if it contains all the records with the same class. Splitting of the data continues until homogeneity or stopping criteria are met in the node(25). The minimum of decrease in impurity was set at 0.0001. The growth limit was predetermined on a maximum tree depth of 5 and minimum leaf node observation of 5. Missing values were treated as missing values.

Three distinct strengths of CART that make it particularly applicable for analysing complex diseases models. First, the hierarchical structure of CART models is often more intuitive than traditional regression models because it mimics the heuristics of decision making with conditional risks. Second, CART can outperform standard regression models when predicting outcomes in the presence of nonlinear relationships and interactions thresholds may vary with direct and intermediating risk factors. For example, the risk of diagnosis with CVDs in the individuals decreases if they have later onset of cholesterol and increases in the case of early onset of cholesterol. Third, CART affords the data greater freedom to speak for themselves. Whereas regression models are refined by comparing across a limited number of possible specifications, CART performs an exhaustive search over all possible cut-points and predictors. As a result, the precise form of the relationship between a predictor and outcome is not delimited by the inclusion/exclusion of higher order terms.

Results

Prevalence, distribution and patterns of multimorbidity

Table 1 shows the burden of morbidities and the Zero morbidity prevalence among the older adult population aged 45 and above in India was 25.29%, single morbidity prevalence was 23.78%, and multimorbidity was 50.90%. Amongst 36 diseases, hypertension showed the highest prevalence (26.72%), followed by myopia (24.2%), and the lowest prevalence was for bone-joint & other diseases (0.01%). Most morbidities showed prevalence in the range of 1 to 7%, with a mean value of 5% prevalence. Therefore, morbidity with a high prevalence of hypertension, myopia, hypermetropia (20.75%), gastrointestinal condition (17.98%), cataracts (14.18%), and diabetes (12.21%) confirmed a larger morbidity burden in the Indian population compared to other morbidities. It indicates dominance of few diseases responsible for large consequences of illness, hospitalization, and diseases burden, unhealthy aging among older adults in India.

Multimorbidity	Weighted Frequency	Weighted Percentage (N = 66,606)
Zero Morbidity	16842	25.29
Single Morbidity	15837	23.78
Multimorbidity	33927	50.94
Single Morbidities		
Hypertension	17796	26.72
Myopia	16090	24.16
Hypermetropia	13823	20.75
Gastrointestinal Condition	11978	17.98
Cataract	9448	14.18
Diabetes	8130	12.21
Arthritis	5978	8.97
Hearing Disorder	4593	6.9
Presbyopia	4595	6.9
Urogenital Diseases	4303	6.46
Rheumatism	4100	6.16
Skin Diseases	3475	5.22
Asthma	3096	4.65
Anaemia	3061	4.6
Heart Attack	2505	3.76
Osteoporosis	2213	3.32
Thyroid	1871	2.81
Jaundice/Hepatitis	1858	2.79
Cholesterol	1484	2.23
Glaucoma	1264	1.9
Stroke	1262	1.89
Neurological	915	1.37
COPD	902	1.35
Bronchitis	798	1.2
Arrhythmias Heart	746	1.12
Tuberculosis	681	1.02
Heart Blockage	671	1.01
Rheumatic Heart	558	0.84
Heart Failure	512	0.77
Cancer	425	0.64
Depression	402	0.6
Dementia	388	0.58
Psychiatric	251	0.38
Heart Other [b]	116	0.17
Congenital| Structural Disorder	65	0.1
Bone Joint Other [a]	5	0.01
Footnote: a - Bone fracture, bone swelling, gout and haemophilia etc. b - Heart functioning, coronary thrombosis, myasthenia graves- post thymectomy and pericardial effusion etc.		

Table 1: Thirty-six morbidity and multimorbidity prevalence among older adults, Longitudinal Ageing Study in India (LASI), wave-1, 2017–2018

Fig 1 depicts the relative prevalence share of Multimorbidity, Single morbidity and Zero morbidity over the age group. The share of multimorbidity expanded by 25.16% when comparing individuals aged 45-49 to those aged 85 and older. This indicates that as the population ages, particularly into the oldest age group, they are significantly more likely to experience multiple chronic conditions. On the contrary single morbidity proportion remained constant and relative share remained plateaued across all age groups, while zero morbidity share shirked in later ages.

Fig 2 highlights a clear and significant increase in multimorbidity as individuals age, underscoring a progressive burden on older adults. Younger age groups (45–54) predominantly exhibit zero or single morbidity, but this shifts dramatically as age advances. By the 60–64 age group, there is a marked rise in individuals with 2–4 multimorbidity, signaling a critical transition phase in health deterioration. This trend accelerates further in those aged 70 and above, where multimorbidity, particularly with 2–4 conditions, becomes the norm. The share of individuals with more than four morbidities steadily grows in the oldest age groups (75+), emphasizing the escalating severity of health challenges in late life. Notably, the proportion of older adults with zero morbidity sharply declines, making clear the near-universal presence of health complications in advanced age.

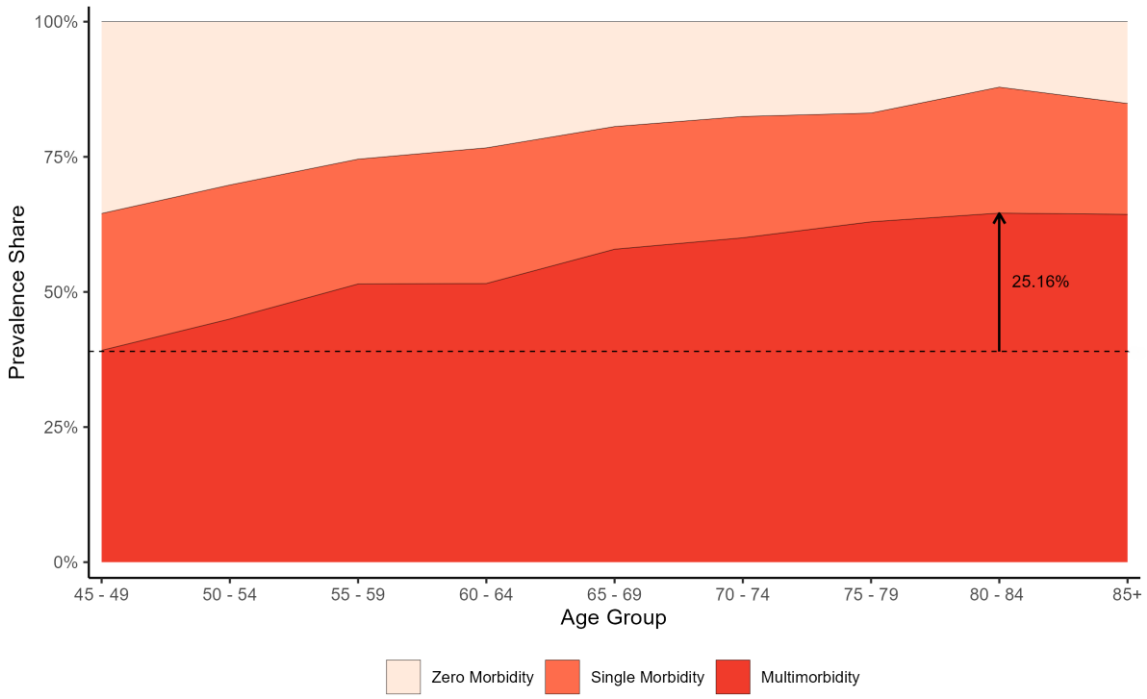


Fig. 1: Share of Zero morbidity, Single morbidity and Multimorbidity, LASI-Wave 1 (2017-18), India

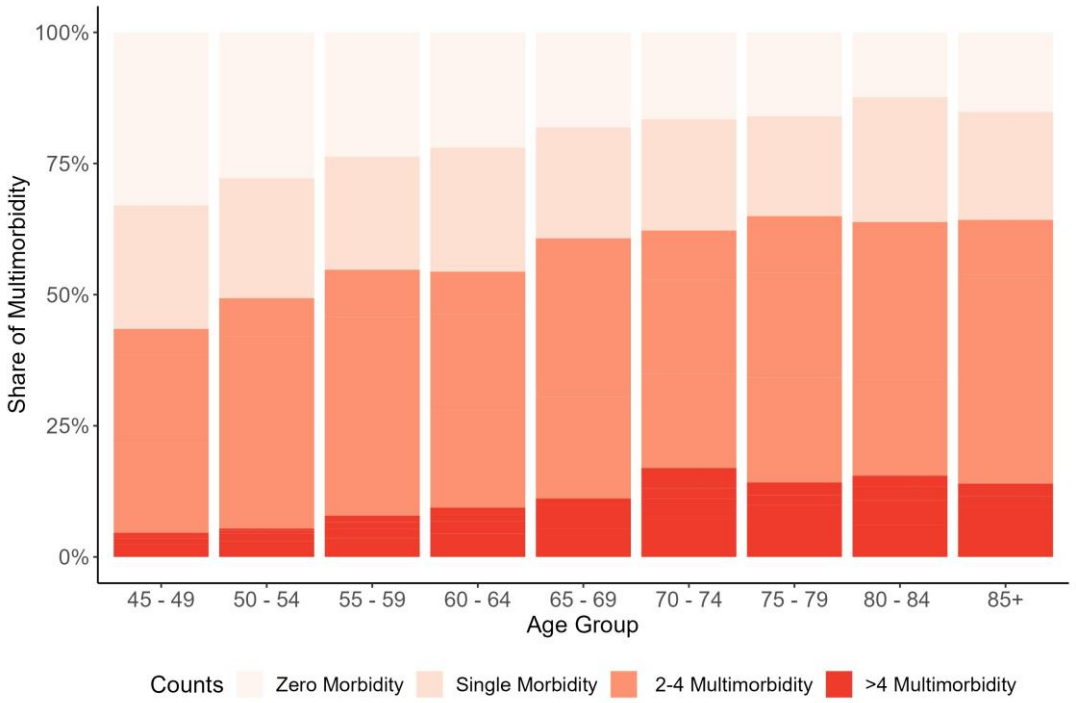


Fig 2: Relative proportional distribution of multimorbidity counts among older adults by age groups, LASI Wave-1, 2017-18, India

Table 2 presents the percent distribution of the three categories of morbidity status, by background characteristics in the Indian population. The background variables were categorised as predisposing, enabling, and risk factors. Amongst the predisposing factors, the oldest of the old (80-84 and 85 plus age groups) showed a large share, i.e. 64% of the older adult's population in the multimorbidity category versus 15% in the zero-morbidity category. In comparison, the 45–49 year age group exhibited a share of 39% in multimorbidity versus 35% in zero morbidity category; this age group of 45-49 years show very similar distribution across the categories of morbidity status. An increase in the share of multimorbidity by age in the Indian population is evident. By gender, multimorbidity was 51.86% in women compared to 49.85% in men. Compared to men, women show a marginally higher share in the multimorbidity category. By place of residence, multimorbidity was 62.99% in the urban population compared to 45.4% in the rural population. Social groups are of differential importance in Indian society; among social groups, the upper caste category showed a large share of 60.19% in the multimorbidity category. On the other hand, the most socially vulnerable STs category showed a small share of 31.12% in the multimorbidity category. It indicates a lack of medical infrastructure can be a factor for assessing medicine and drug facilities as when required in a society.

Amongst religions, Hindus with the largest base showed a share of 49.71%, Christians with the smallest sample size showed a share of 47.71%, and others with a small sample size showed the largest share of 63.42% in the multimorbidity category. By marital status, the share of multimorbidity was 57.03% in widowed, followed by a share of 49.34% in the currently married person category. The share of multimorbidity was higher in persons living alone (56.18%) than in persons living with spouses (49.35%). Also, persons living with disability or impairment show a larger share in the multimorbidity category compared to normal persons. The predisposing factors explain a large share of the Indian population in the multimorbidity category, except in the young-adult age group of 45-49 years.

Amongst enabling factors, the share of multimorbidity was 60.63% in persons with schooling for more than ten years versus 44.49% in persons without schooling. As measured by the MPCE class, the affluent class showed a large share of 62.93% in the multimorbidity category, whereas the poorest class showed a share of 39.87%. By work status, persons currently not working showed a larger share of 60.56% in the multimorbidity category compared to those currently working with 43.82%.

Childhood health has long-term implications in the later years of an individual's life. Individuals who had very poor childhood health endured a large share of 75.34% in the multimorbidity category in comparison to individuals who had better childhood health showing a share of ~50%. Amongst better childhood health conditions, persons with very good childhood health statuses showed a share of 51.74% in multimorbidity and the remaining 24.21% in single morbidity and 24.05% in zero morbidity. It implies that serious illness in childhood is the early origin of multimorbidity. A similar distribution of morbidity status was also apparent for self-rated health status. Individuals with poor self-rated health status reported a large share of 70.22% in the multimorbidity category compared to persons with good self-rated health status showing 38.37%. It points out an affirmative relationship between low self-rated health status and the prevalence of multimorbidity in the population. By region, the western, northern, and southern regions showed a larger percentage of the population enduring multimorbidity compared to the eastern, central, and north-eastern regions. Regional diversity in multimorbidity is expected as many states of India experience variations in weather and monsoons, which affects the level of mortality and morbidity. Most of these enabling factors reveal a large proportion of multimorbidity in populations with lower levels of health conditions and lower socio-economic status compared to their counterparts.

A large percentage of the obese (71.52%) and overweight (61.79%) population had multimorbidity; contrarily, a small percentage of the underweight population (39.61%), another facet of malnutrition, had multimorbidity. Finally, by applying the chi-square test of independence concludes a statistically significant association between the outcome variable (morbidity status) and covariates, as the P-value at the 5% level of significance was less than 0.001 for each covariate.

Covariates	**Zero Morbidity**	**Single Morbidity**	**Multimorbidity (two or more)**	**Frequency**	**Weighted Percentage**	**P - Value**
Age Group						
45 - 49	35.48	25.33	39.18	12565	18.86	< 0.001
50 - 54	30.21	24.8	44.99	13679	20.54	
55 - 59	25.43	23.1	51.47	6907	10.37	
50 - 64	23.34	25.1	51.55	10002	15.02	
65 - 69	19.4	22.7	57.9	9572	14.37	
70 - 74	17.54	22.45	60.01	6271	9.42	
75 - 79	16.9	20.13	62.97	4855	7.29	
80 - 84	12.11	23.31	64.58	1152	1.73	
85 +	15.13	20.52	64.35	1603	2.41	
Sex						
Male	25.94	24.21	49.85	30600	45.94	< 0.001
Female	24.73	23.41	51.86	36006	54.06	
Residence						
Rural	28.57	26	45.4	45648	68.53	< 0.001
Urban	18.13	18.88	62.99	20958	31.47	
MPCE quintile [a]						
Poorest	32.88	27.25	39.87	13896	20.86	< 0.001
Poorer	26.65	24.72	48.64	14144	21.24	

Middle	26.24	24	49.76	13646	20.49	
Richer	21.99	22.53	55.48	12937	19.42	
Richest	17.34	19.73	62.93	11984	17.99	
Highest level of Schooling						
No Schooling	29.69	25.82	44.49	33722	50.63	< 0.001
< 5 Years	21.95	22.37	55.68	7266	10.91	
5 - 9 Years	21.01	23.17	55.82	13594	20.41	
10 + Years	19.79	19.58	60.63	12023	18.05	
Religion						
Hindu	25.95	24.35	49.71	54590	81.96	< 0.001
Muslim	22.03	21.21	56.77	7667	11.51	
Christian	30.81	21.48	47.71	2023	3.04	
Other	15.71	20.88	63.42	2327	3.49	
Caste Category						
ST	41.93	26.95	31.12	5732	8.61	< 0.001
SC	26.66	25.17	48	12759	19.16	
OBC	25.57	24.02	50.4	30272	45.45	
Other	18.47	21.34	60.19	17843	26.79	
Working Status						
Never worked	22.35	21.9	55.75	17357	26.09	< 0.001
Currently working	30.7	25.47	43.82	33248	50	
Currently not working	17.13	22.31	60.56	15914	23.92	
Current Marital Status						
Currently married	26.5	24.16	49.34	48855	73.35	< 0.001
Widowed	20.34	22.62	57.03	15799	23.72	
Divorced/separated/other	34.93	23.52	41.56	1952	2.93	
Region						
North	21.36	22.94	55.70	8170	12.27	< 0.001
Central	35.84	27.17	36.99	13699	20.57	
East	24.91	25.24	49.85	15420	23.15	
Northeast	30.92	25.09	44	2320	3.48	
West	18.43	20.96	60.6	10990	16.5	
South	22.51	21.63	55.86	16008	24.03	
Alcohol Consumption						
Lifetime abstainer	24.4	23.6	52.00	55369	89.3	< 0.001
Infrequent non-heavy drinker	22.34	22.98	54.69	4146	6.69	
Frequent non-heavy drinker	29.24	26.31	44.45	1601	2.58	
Heavy episodic drinker	33.32	26.92	39.76	885	1.43	
Tabacco Consumption						
Lifetime abstainer	24.41	22.71	52.89	42108	63.22	< 0.001
Smokes tobacco	26.74	24.85	48.41	9273	13.92	
Smokeless tobacco	27.24	25.81	46.95	13243	19.88	
Both	24.11	27.93	47.96	1982	3	
SRH [b]						
Good	34.36	27.27	38.37	24735	37.66	< 0.001
Moderate	22.98	23.31	53.72	28864	43.94	
Poor	11.29	18.49	70.22	12089	18.40	
Childhood Health						

Very good	24.05	24.21	51.74	31875	48.56	< 0.001
Good	25.94	24.1	49.96	25535	38.90	
Fair	27.38	21.91	50.72	7205	10.98	
Poor	22.73	21.71	55.56	943	1.44	
Very Poor	10.79	13.86	75.34	84	0.13	
BMI [c]						
Underweight	32.28	28.11	39.61	12815	21.39	< 0.001
Normal	26.83	24.97	48.21	30870	51.52	
Overweight	17.29	20.93	61.79	12152	20.28	
Obese	11.37	17.11	71.52	4081	6.81	
Living Arrangement						
Alone	21.24	22.57	56.19	2454	3.68	< 0.001
Spouse	26.51	24.14	49.35	48179	72.33	
Others	22.21	22.88	54.91	15973	23.98	
Physical Activity						
Everyday	31.09	26.01	42.90	16634	25.19	< 0.001
Weekly	30.48	25.83	43.69	6746	10.22	
Casual	21.71	22.77	55.53	42647	64.59	
Impairment [d]						
No	26.15	24.13	49.71	61082	91.72	< 0.001
Yes	15.68	19.83	64.49	5516	8.28	

Footnote:
a - Wealth index, b - Self Related health, c - Body mass index, Underweight (BMI≤ 18.4 kg/m2), Normal (18.5 kg/m2 ≤ BMI ≤ 24.9 kg/m2), Overweight (25.0 kg/m2 ≤ BMI ≤ 29.9 kg/m2), Obese (BMI ≥ 30 kg/m2, d - Any form of physical or mental impairment

Table 2: Descriptive statistics of morbidity and multimorbidity by covariates among older adults, Longitudinal Ageing Study in India (LASI), wave-1, 2017–2018

Conditional role of covariates on multimorbidity

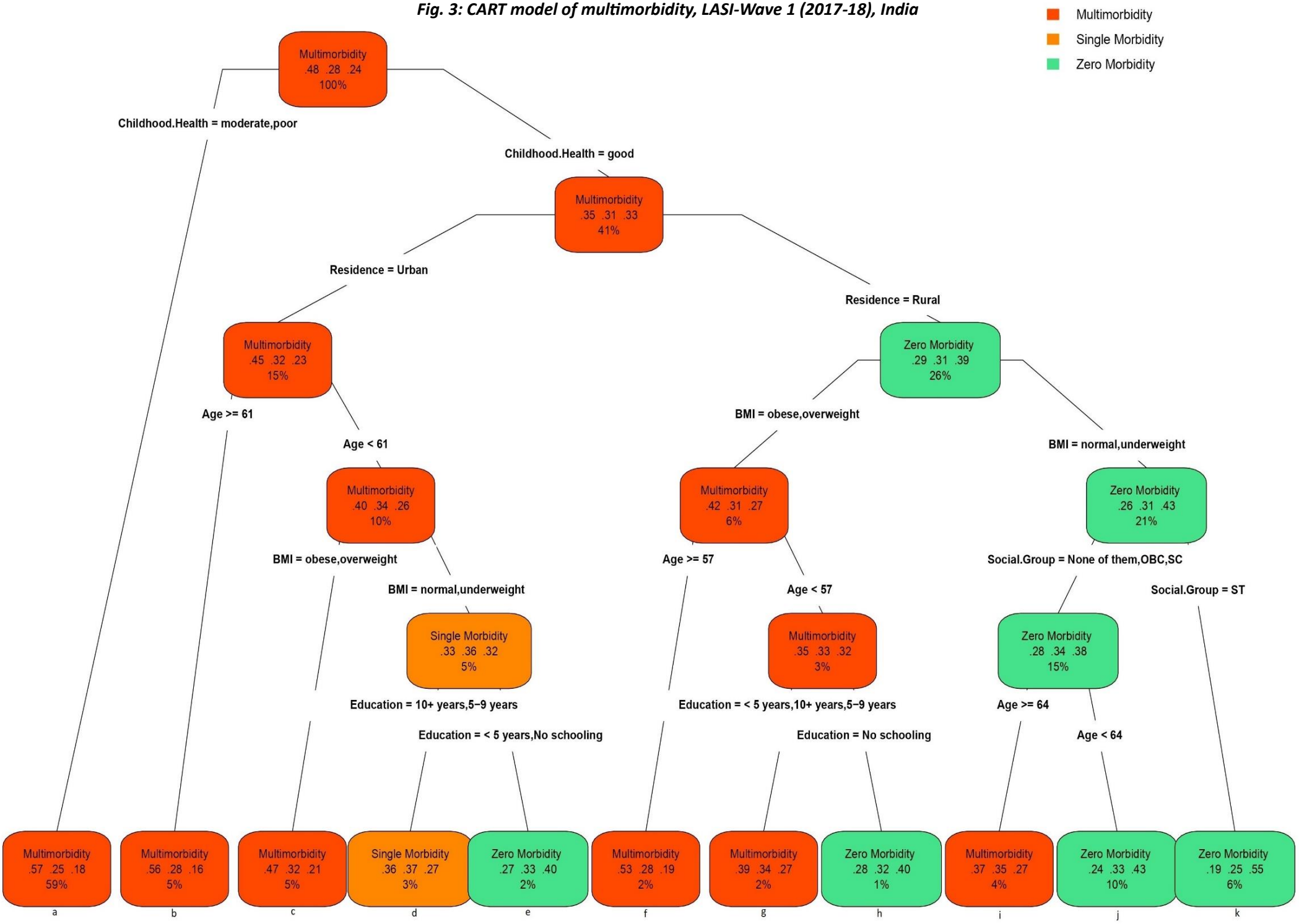
To further identify the optimal leading covariates and their joint conditional role for multimorbidity susceptibility among older adults in India, we constructed the CART model. Fig 3 depicts the conditional risk and sample size of each of the three outcomes in each box respectively: Zero morbidity (right digit), Single morbidity (middle digit) and Multimorbidity (left digit). CART model deducted that childhood health, place of residence, age, BMI, caste category and education level are the leading optimal covariates (Supplementary table 1) for multimorbidity risk among older adults in India.

The leftist terminal node (a) showed the highest risk of multimorbidity (0.57) was among those individuals who had moderate or poor childhood health. This risk probability is followed by the insignificant differential of risk (0.56) among those individuals whose age > 60(b), who resides in urban areas and had good childhood health. While this risk shifted to 0.47 in addition to above leaf nodes among those individuals who were obese or overweight and less than 61 years old(c). Conversely, individuals who were ST, had normal or underweight BMI and resided in rural (k) were on least risk of multimorbidity (0.19). In the same arm of BMI, a similar risk patter (0.24) was also observed among those individuals whose age was less than 64 and didn't belong to ST group(j). However, multimorbidity risk was elevated manifold for those who were more than 63 years of age(i).

Level of education played a vital significant role in both single and multimorbidity risk. The risk of single morbidity was highest (0.37) among those individuals who had 10 plus years of education, had normal or underweight BMI, resided in rural and had good childhood health (d). However, this risk shrined to (0.33) for those who had no schooling or less than 5 years of schooling(e). Parallelly for multimorbidity, this risk shifted from 0.36 to 0.27.

A distinctive pattern in conditional risk shift was observed for multimorbidity among rural residents. The risk of multimorbidity is 0.53 among those Individuals whose age was greater than 56, obese or overweight, who reside in rural and had good childhood health (f). Moreover, this risk decreases to 0.39 for those individuals whose age was less than 57 and who had education (g). However, this risk further decreases to 0.28 for those individuals who had no schooling(h).

Fig. 3: CART model of multimorbidity, LASI-Wave 1 (2017-18), India



Discussion

In this study using the comprehensive nationally representative survey data of India, we extensively explored the relative distribution, pattern and conditional role of risk factors for multimorbidity susceptibility among older adults in India. Additionally, this study had broad inclusion criteria of NCDs, CDs and endemic morbidities to provide both in-depth and comprehensive understanding of morbidities and multimorbidity. The overall findings highlighted that over the aging period, the spectrum of multimorbidity and acute morbidities burden had undergone a dramatic transition from middle to oldest of old age groups, coupled with sequential multiplicity of multimorbidity burden in the oldest of old age groups. Moreover, in this study the higher multimorbidity susceptibility risk was frequently paired with early childhood health along with conditional role of modifiable risk factors.

This study has several key findings. First, morbidities prevalence was consistent with other parallel studies (26–28), while the multimorbidity prevalence (50.94%) estimate was significantly reached to the threshold in this study is contrary to previous studies in India which ranges from 7.2% to 45.3% ((29–33). The plausible reason for such a high burden is an extensive number of NCDs, CDs and endemic morbidities were included in this study, where degenerative and acute diseases, which can go on for years, captured the major share of the disease burden among older adults in India.

However, it is essential to note that in the broad spectrum of morbidities burden among older adults in India, eye disorders and gastrointestinal condition (17.98%) showed a predominance diseases burden, however with lowest fatality, hypertension had the highest burden of 26.72% across all age groups, indicating a salient role of either mediator, moderator or confounder. Nonetheless, recent complemented these findings by indicated the role of hypertension as the modifiable risk factor for other morbidities (34–37). Moreover, the burden of chronic and communicable disease was significantly low but these patterns substantiated by coherent of high mortality patterns (33). Among chronic morbidities asthma and heart attack had the highest burden, while cancer with the highest mortality risk had a prevalence of only 0.64%. Additionally, we also complemented this study analysis by showing how the disease burden profile transition over age among older adults in India. Moreover, a sequential expanding share of multimorbidity burden by 25.2% was observed from older to oldest of old age groups, on the contrary the single morbidity proportion remained constant and the relative share remained plateaued across all age groups, while zero morbidity share shirked in later ages.

Nonetheless, our results were complemented with extended evidence on the role of socioeconomic, demographic, modifiable and unmodifiable risk factors in multimorbidity composition. Oldest of old group experience disproportionality higher rates of multimorbidity, while older groups show more balanced distributions between multimorbidity and good health. In line with the previous studies gender differences are subtle but present, while urban dwellers consistently exhibit higher prevalence than their rural counterparts (26,33,38). Higher income and education levels surprisingly correlate with increased rates, possibly due to better better living, diagnostic access or lifestyle factors. Lower socioeconomic groups, particularly Scheduled Tribes, show lower rates, potentially indicating underreporting or barriers to healthcare. Religious and regional variations suggest cultural and geographical influences, with some groups, like Hindus and upper castes, showing higher rates. Lifestyle factors like smoking, alcohol use, and physical activity also contribute, with non-smokers and alcohol abstainers displaying higher multimorbidity rates. We extended the previous studies' findings that the place of residence and age play a very significant factor in multimorbidity risk (18,39). Furthermore, there were a few parallel collateral effects, including the education level of the individuals, which include higher education levels associated with higher multimorbidity risk, particularly in urban areas. These findings collectively underscore the complexity of multimorbidity, driven by a combination of biological, social, and environmental factors.

Finally, with the contention that multimorbidity risk is not solely driven by isolated factors, this study used the comprehensive CART model to provide a fundamental baseline understanding for future studies by examining the underlying multimorbidity susceptibility within the context of conditional risk factors among older adults in India. Childhood health, place of residence, age, BMI, caste category, and education level were identified as the leading factors for multimorbidity susceptibility.
Surprisingly contrary to conventional previous studies, behavioural and self-induced risk factors like smoking and alcohol consumption did not emerge as the leading contributors to multimorbidity, highlighting the limitation of confounder or mediator effect in prior studies (40–42).
Moreover, a recent study of India and Brazil highlighted those individuals who perceived their childhood health as poor had the highest level of multimorbidity with (APR: (India: 1.38, 1.16 to 1.65) and (Brazil: 1.19, 1.09 to 1.30) (43) and indicated a clear association between aging and the accumulation of conditions. In our study also, the highest multimorbidity risk was observed among those individuals who had poor childhood health, followed closely by those over 60 years old living in urban areas with good childhood health (0.56). Conversely, the lowest risk (0.19) was among rural residents from ST with normal or underweight BMI.

This study has a few limitations, although our analysis and approach were novel, as it integrates evidence from robust and new statistical methods with a unique approach. Our study included a more comprehensive list of morbidities that has not been considered in previous studies of multimorbidity in India, yet it was not possible to include function limitation, Activities of daily living (ADL) and Instrumental activities of daily living (IADL) variables as these have a bidirectional relationship with multimorbidity. Morbidities and conditions were self-reported and retrospective in nature, which may provide inaccurate prevalence. Moreover, 45 years and above adults are considered in our study, which may have reduced variability and potentially increase the difficulty of identifying an association between factors and multimorbidity.

Conclusion

This study for the first time incorporated thirty-six morbidities for evaluating the composition, multiplicity and examines the underlying multimorbidity susceptibility within the context of conditional risk factors among older adults in India. Nonetheless this study also specifies the relative share of multimorbidity burden over age. The study highlighted that acute and degenerative morbidities had a huge burden across all age groups, while complex multimorbidity share expanded significantly in the oldest of old age groups. Furthermore, our results are complemented with extended evidence on the role of socioeconomic, demographic and modifiable or unmodifiable risk factors in multimorbidity composition. Childhood health was the key leading determinant of multimorbidity susceptibility and enhanced our understanding of healthy aging and place of residence, age, BMI and caste category were identified as the leading key factors for multimorbidity susceptibility among older adults in India.

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