Measuring the Risk of Multimorbidity in India: Application of Network Analysis and Random Survival Forest Method

Abstract:

Abstract: India has shown an escalating burden of NCDs together with a sizeable burden of CDs since the early 1990s. The disadvantage of the enormous burden of NCDs is analogous to high inequality in mortality and morbidity. While most research on multimorbidity has been in Western countries, a developing country like India may experience different patterns of multimorbidity clusters, morbidity onsets and survival conditions. The study uses information on 73,396 individuals 45 years and above surveyed in the LASI (Wave 1, 2017-18) data to retrieve the cluster pattern and survival pattern of 36 morbidities over age. The study applies (1) the Kaplan-Meier survival method to examine the changing survival gradient of morbidities and survival probability of multimorbidity clusters over age, (2) Network analysis to examine the degree of interaction (centrality, closeness, and betweenness) and relationship among 36 morbidities, (3) Time-series hierarchical clustering analysis to examine the normative and dynamic clusters of multimorbidity, and (4) Random Survival Forest (RSF) method to examine the risk of multimorbidity in Indian population by socio-economic backgrounds and demographic factors. The study finds that the significant gradient of multimorbidity is in the age group of 55 – 75 years. Among 36 morbidities, the median survival probability is lowest for hypertension (74 years), followed by myopia (79 years) and hypermetropia (80 years). Seven multimorbidity clusters were identified and the degree of centrality was highest for Hypertension followed by Diabetes and Joint & bone diseases in the network. The RSF method reveals that the median expected risk of multimorbidity in female (66 years) is significantly higher than in male. The results also provide empirical evidence that individuals with the highest level of education, obesity, and poor childhood health are the crucial factors for the highest risk of multimorbidity at an early age.

Introduction:

Multimorbidity is defined as the presence or diagnosis of two or more diseases in a person/population. The dual burden of noncommunicable diseases (NCDs) and communicable diseases (CDs) in a developing country India (Alvarez-Galvez & Vegas-Lozano, 2022; Kumar, 1993; Yadav et al., 2022) points to complexity in analysing the pattern of multimorbidity, i.e., association and effects between diseases and changing severity of multimorbidity over age. The prevalence of multimorbidity is higher with a large burden of chronic or killer diseases. The gradient of multimorbidity slopes with age and therefore, shows a strong association with the ageing process, especially in the later years of life. The burden of non-communicable diseases (NCDs) is higher in old ages. Consequently, many chronic diseases constitute to large multimorbidity in old ages. Moreover, the duration of degenerative/chronic diseases over a wide age range increases the burden of multimorbidity.

Numerous works of literature point gradient of degenerative diseases such as hypertension and diabetes slopes in the later adult or middle age group. Moreover, the aetiology of these degenerative diseases ratifies themselves as causation or high-risk factors for many chronic diseases and leads to multimorbidity. The clusters of diseases also decide the gradient, size, and severity of multimorbidity. Notably, the severity of multimorbidity affects disease composition, especially in old age groups.

India has shown an escalating burden of NCDs since the early 1990s (Arokiasamy, 2018). The significant disadvantage of the large burden of NCDs is analogue to high inequality in mortality and morbidity. By and large, the focus has remained on the killer diseases. Perhaps, the repercussion of multimorbidity has remained underneath the priority of reducing the burden of killer diseases for a

long time. The Western countries have been much focusing on the need or risk for diseases; however, in a developing country India, with 20% of the world's population, high inequality in health care access & utilization and wide differentials in caste and income, the predisposing factors such as age, sex, caste, regions and enabling factors such as education, occupation, wealth, health service utilization (Andersen & Newman, 1973; Andersen, 1995; Babitsch et al., 2012; Li et al., 2016) has major roles in explaining the burden of multimorbidity.

MoHFW (2017) has prioritised the reduction in the premature mortality caused by NCDs; however, at the same time, it is also important to recognise that the prevalence of multimorbidity is still at large in India. While chronic diseases have been proven killer diseases, degenerative diseases and other chronic ailments constitute a large portion of multimorbidity at middle and old ages. Acknowledging a large burden of NCDs accompanied with high inequality, multimorbidity becomes more complex in LMIC such as India than in developed nations. The study aims

(1) to examine the prevalence and Kaplan-Meier estimates of 36 morbidities
(2) to explore the association between these 36 morbidities
(3) to examine the cluster of these morbidities
(4) to examine the risk of multimorbidity by socioeconomic and demographic backgrounds

Methods and Materials:

Data: 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 information from merged information from individual and biomarker datasets. The dataset contained samples of 73,396 individuals (all adults). In this research work, we primarily deal with the 36 morbidities with a focus on the pattern and severity of multimorbidity over age..

Methodology: The study (1) applies the Kaplan-Meier method to examine the gradient, survival probability and clusters of 36 morbidities by age, (2) applies Network analysis to examine interaction (centrality, closeness, and betweenness), to identify the morbidity with higher betweenness centrality which act as a bridge between other morbidities thorough common risk factors and relationship among 36 morbidities. Network analysis helps to find out the connectedness of morbidities and to vizualize the most influential morbidity which is connected with the greater number of morbidities in the network.

(3) applies Time-series hierarchical clustering analysis to examine the normative and dynamic clusters of multimorbidity, and (4) applies the Random Survival Forest (RSF) method to examine the risk of multimorbidity in the Indian population by socio-economic backgrounds and demographic factors. From the 73,396 individuals, a sample of 66,606 individuals between the age of 45 to 95 years is included in this study. Further 16,842 individuals were identified as having "zero morbidity", 15,837 individuals were identified as having "one morbidity" and 33,927 individuals were identified as having "multimorbidity".

Outcome Variable: We calculated the prevalence of 36 morbidities based on the given response and diagnosis. All 36 morbidities are classified into the binary form: absent (0) and present (1). The generated morbidity score was further categorised into three:

▪ No morbidity (individuals with no morbidity/chronic disease)

▪ Single morbidity (individual with exactly one morbidity/chronic disease)

▪ Multimorbidity (combinations of two or more morbidities/chronic diseases)

Independent Variables: We have considered the self-rated health and childhood health as two of the independent variables in addition to socio-economic and demographic variables such as Age, Sex, Residence, Marital status, Wealth index (MPCE quintiles), Caste group, Religion, Level of education, working status, etc. We have adopted Anderson's health care utilization framework (Andersen, 1995) for the selection and categorising of the independent variables in three groups:

(1) Predisposing factors such as Age, Sex (Male /Female), Caste group (SCs/STs, OBC, Others)2, religion (Hindu, Muslim, Christian & Others), Level of education (No schooling, < 5 Years,5 -9 years, 10 + years), Marital status (Currently Married, Widowed, Divorced/Separated/N), Living arrangement (Alone, Spouse, Other), Impairment (No/ Yes).

(2) Enabling factors such as 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).

(3) Risk factors such as 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).

Results:

Survival Analysis: Survival Analysis: Fig1 Kaplan-Meier curve, represents the survival probability pattern of 36 morbidities over the age of diagnosis and the median morbidity survival age were calculated using this model

The median survival probability of diagnosis multimorbidity is at the age of 66 years. Among chronic diseases, hypertension has shown a significant gradient in the age group of 45-49 years, and diabetes shows a gradient in the age group of 50-54 years. The median survival probability is lowest for hypertension (74 years), followed by myopia (79 years) and hypermetropia (80 years). Whereas Rheumatic and Congenital heart diseases show the highest diagnosis survival probability over age.

The survival age pattern reveals that the gradient of hypertension is much sharper and steeper than that of diabetes. Also, hypertension is a disease most associated with other 36 diseases, analysed in network analysis. Furthermore hypertension, diabetes and arthritis cluster have significantly steeper survival patterns to its level over other clusters.

Cluster Analysis: The cluster analysis identified seven clusters of multimorbidity. The first cluster consists of Hearing Disorder and Cataract , second (Hypertension, Arthritis and Diabetes), third(Cholesterol, Asthma, COPD, Bronchitis, Rheumatic Heart , Heart failure , Skin Diseases, Arrhythmias, Osteoporosis , Heart Attack and Stoke), fourth (Glaucoma, Cancer and Urogenital Diseases) , fifth(Tuberculosis, Hypermetropia, Thyroid, Anemia, Gastrointestinal Condition, Jaundice/Hepatitis) sixth(Rheumatism and Presbyopia), seventh(Heart Blockage, Depression Dementia, Neurological Disorder, Myopia, Psychiatric Disorder, Heart Other, Bone Joint Other and Congenital/ Structural Disorder) The survival pattern of seven multimorbidity clusters shows a steep diverging gradient in the age group of 80 to 95 years. Fourth and third cluster have the same survival probability distribution curve, while the second cluster have the lowest survival probability.

Network Analysis: At first glance, the Network analysis revealed that the degree of centrality was highest for Hypertension followed by Diabetes and Joint & bone diseases. The betweenness centrality was highest for myopia and closeness centrality was highest for many diseases namely, anemia, arthritis, cataract, diabetes, Gastrointestinal, hearing disorder, hypermetropia, hypertension, myopia, osteoporosis, presbyopia, rheumatism, skin diseases, and stroke.

RSF Analysis: The expected risk of having multimorbidity is higher in female than male in all age groups with the highest gap in the age group of 65 to 70 years. Both childhood health and self-rated health play a significant role in the risk of multimorbidity over age. "Poor childhood health" and "poor self-rated health "lead to the higher expected risk of having multimorbidity with median expected risk at the age of 66 years and 67 years. The median expected risk of having multimorbidity for "currently working" "never worked" and currently working are 66, 69 and 72 years respectively.

The expected risk of having multimorbidity is higher among "frequent non–heavy drinkers" than lifetime abstainers with a median expected risk of 67 and 69 years. Both tobacco consumption habits and living arrangement status play the least significant role among categories of multimorbidity risk. "10 + years" of schooling have a higher expected risk than "no schooling" with median survival age 65 and 71 years respectively.

Conclusion: The study finds that the median survival probability of multimorbidity is at the age of 66 years. The dominant diseases constituting multimorbidity are hypertension, eye disorders (myopia, hypermetropia and cataract), gastrointestinal, and diabetes. The degree of centrality was highest for Hypertension followed by Diabetes and Joint & bone diseases. The betweenness centrality was highest for myopia and closeness centrality was highest for many diseases namely, anemia, arthritis, cataract, diabetes, Gastrointestinal, hearing disorder, hypermetropia, hypertension, myopia, osteoporosis, presbyopia, rheumatism, skin diseases, and stroke. The hierarchical clustering reveals age pattern of Bone & joint pain is very similar to Congenital diseases in the seventh cluster. In the same (seventh) cluster, Depression and Dementia are similar but many other diseases vary with each other. Also, many heart and lung diseases are similarly clustered in the third cluster. The second cluster consisting of Hypertension, Diabetes and Arthritis show similarity between Diabetes and Arthritis but differs from that of Hypertension. It signifies that although the burden of Hypertension and Diabetes is large, their age pattern and concentration in the population are not similar. Given these differences, hypertension and diabetes are to be explored differently. The RSF method reveals female have a higher risk of having multimorbidity than male and the risk gap is highest at the age of 70 years. It also reveals that obesity and overweight as the factors with the highest risk for multimorbidity. Divorced or separated also show a higher risk of multimorbidity.

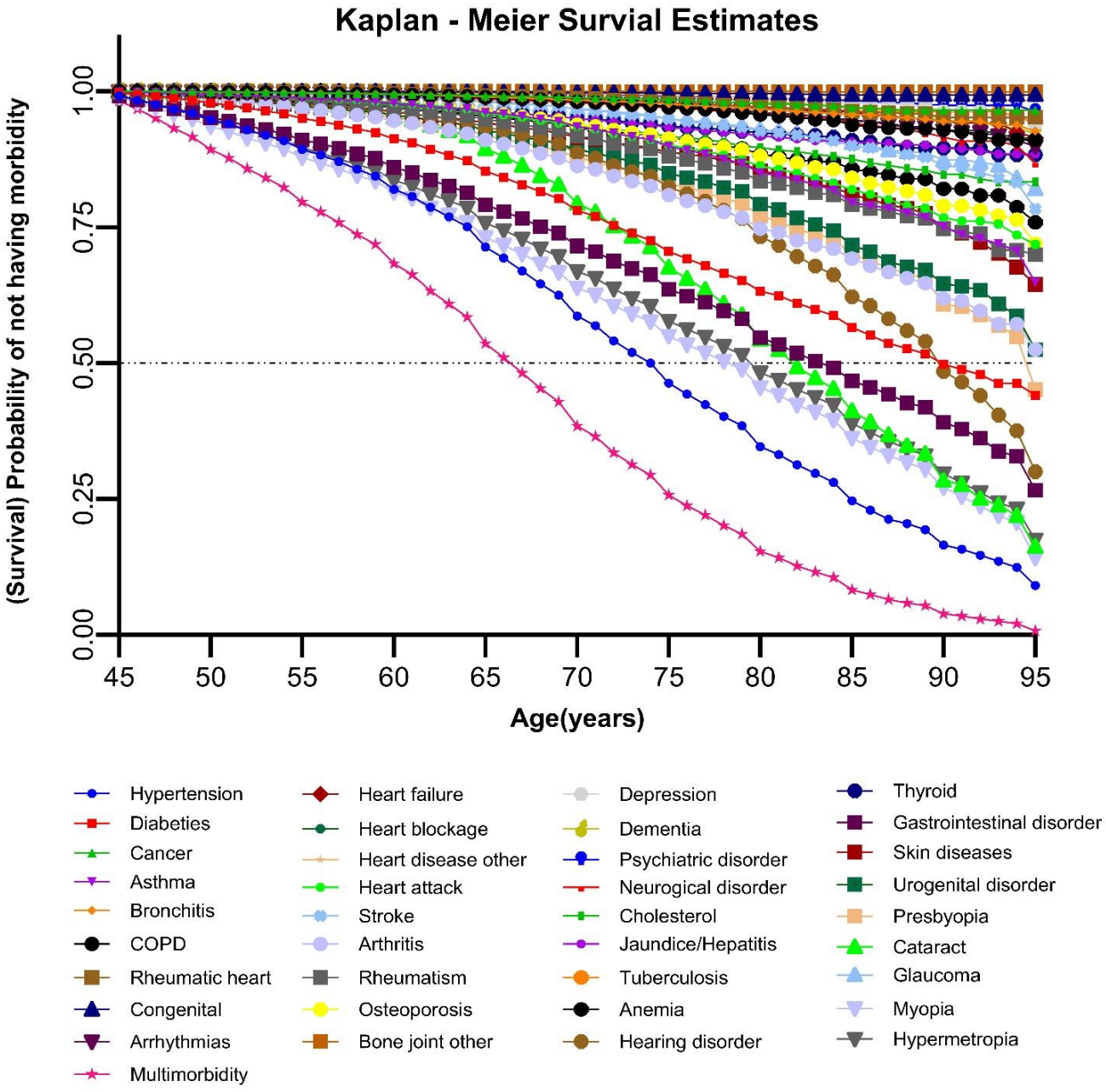


Fig. 1: Kaplan-Meier Survival estimates of 36 morbidities, LASI-Wave 1 (2017-18), India

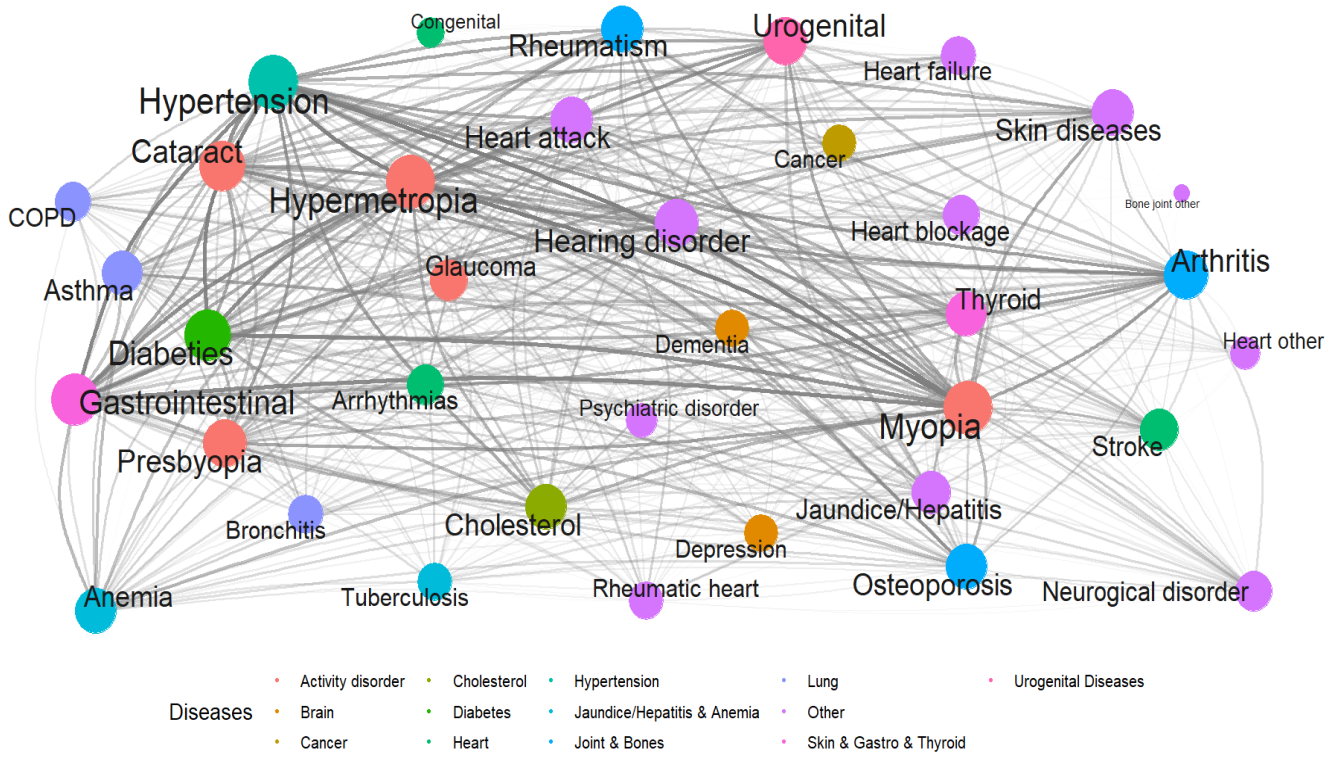


Fig. 2: Network analysis of 36 morbidities, LASI-Wave 1 (2017-18), India

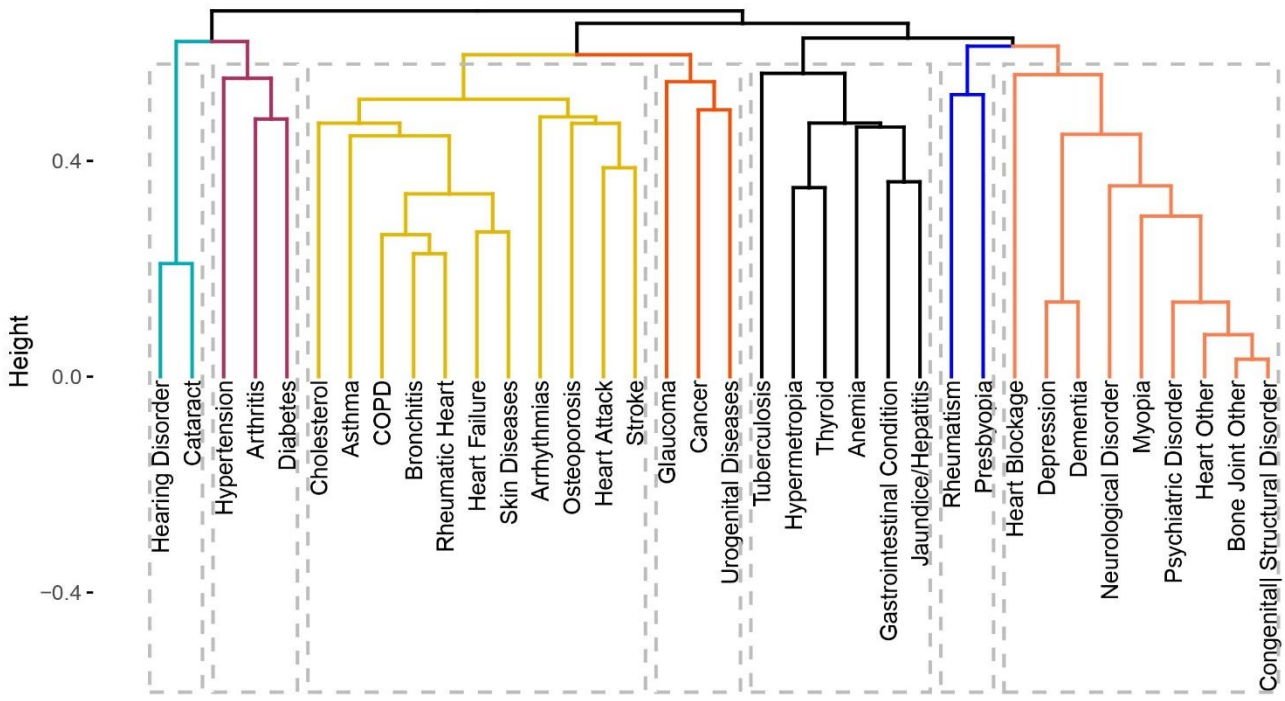


Fig. 3: Hierarchical Clustering of 36 morbidities, LASI-Wave 1 (2017-18), India

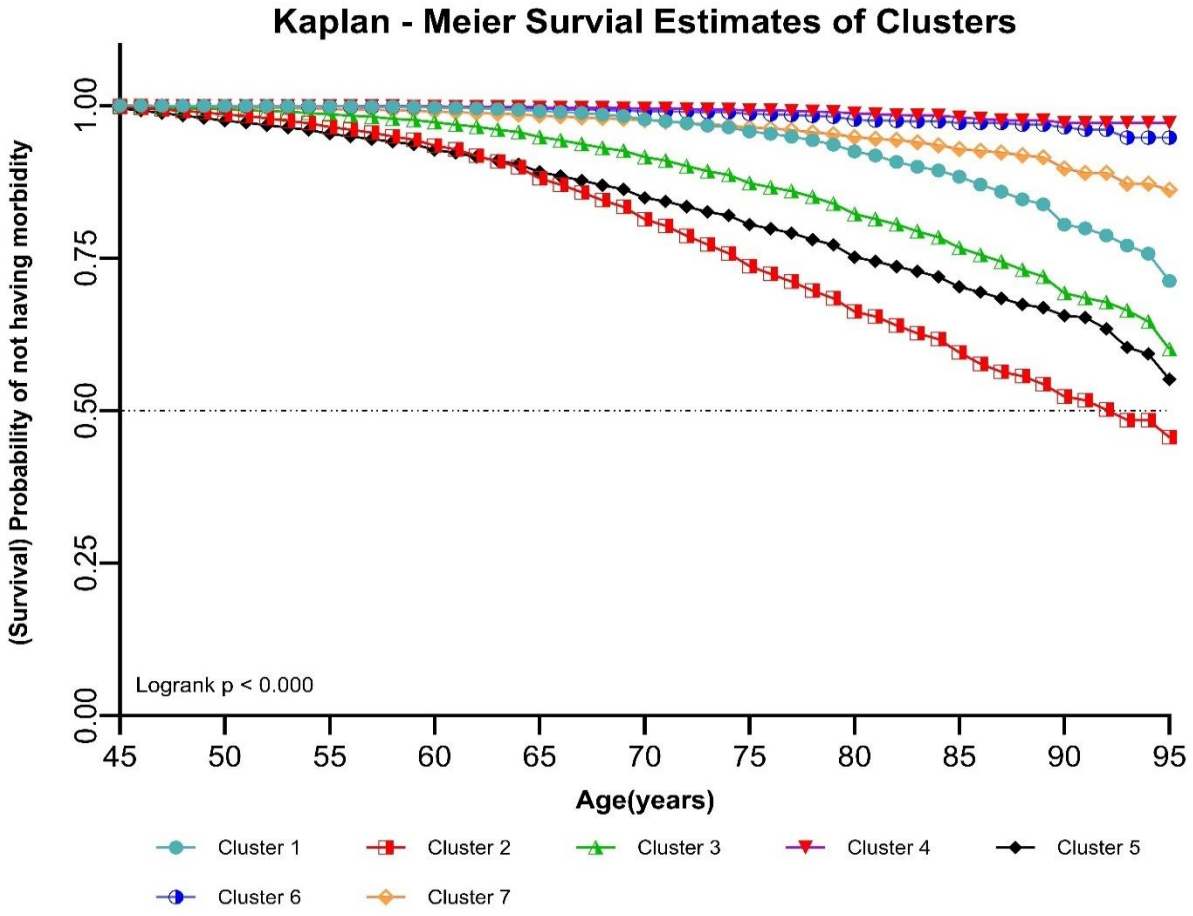
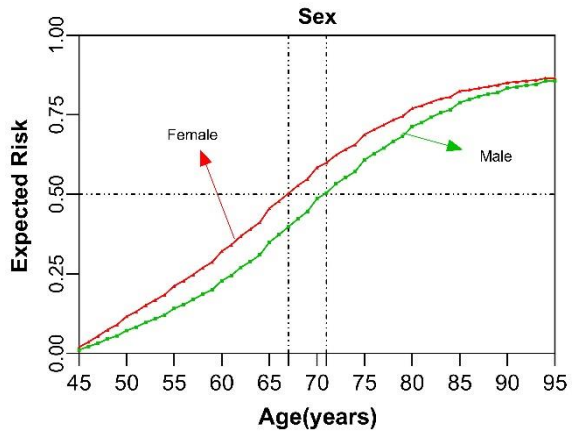
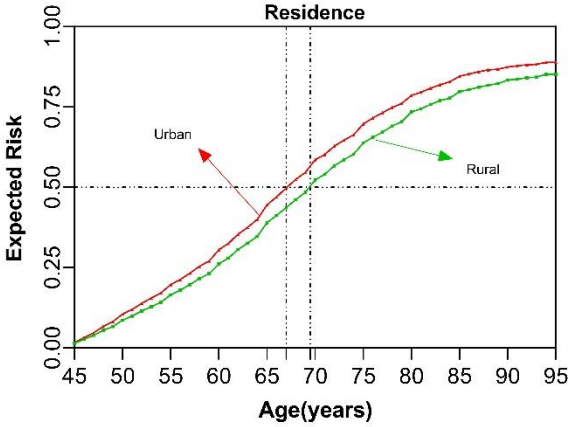
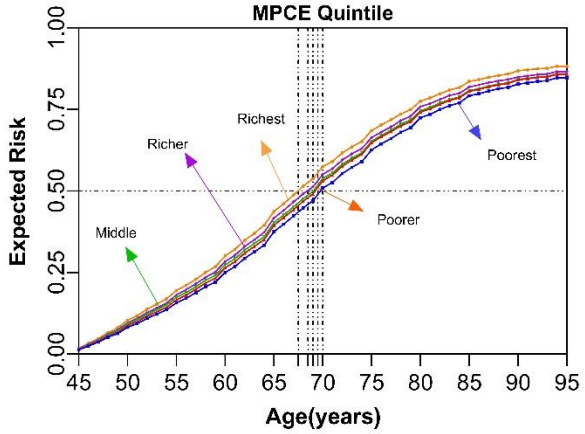
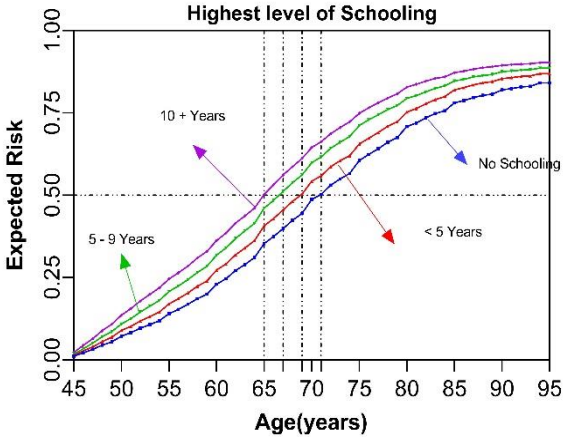


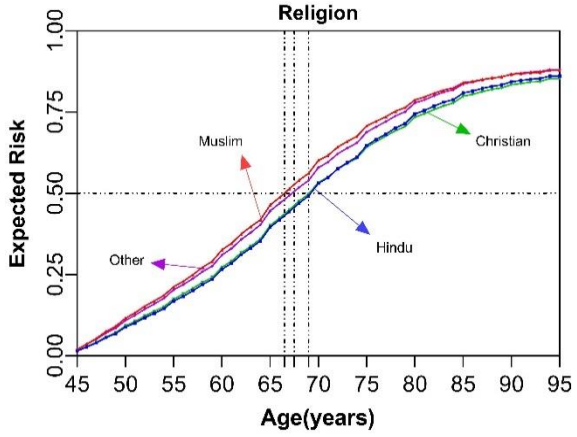
Fig. 4: Kaplan-Meier Survival estimates of 7 clusters of multimorbidity obtained from Hierarchical clustering, LASI-Wave 1 (2017-18), India

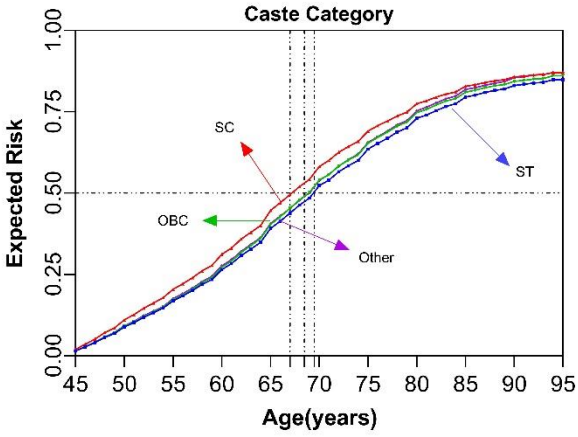

Sex
Expected Risk
0.00
0.25
0.50
0.75
1.00
Female
Male
45 50 55 60 65 70 75 80 85 90 95
Age(years)

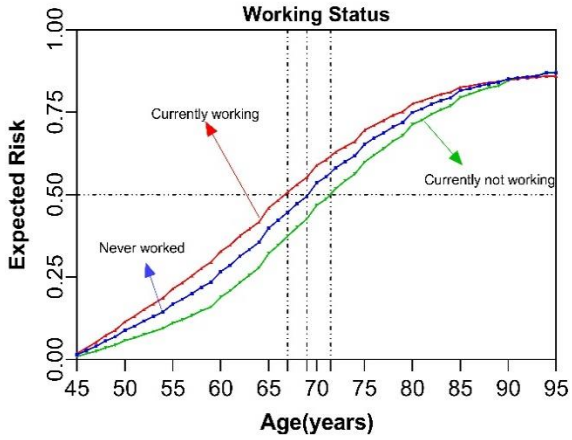

Residence
Expected Risk
0.00
0.25
0.50
0.75
1.00
Urban
Rural
45 50 55 60 65 70 75 80 85 90 95
Age(years)

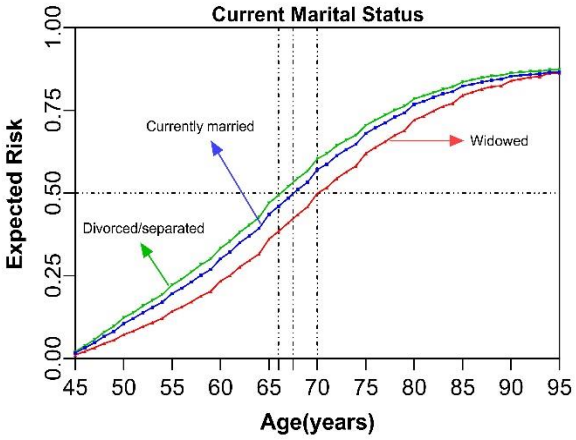

MPCE Quintile
Expected Risk
0.00
0.25
0.50
0.75
1.00
Richer
Richest
Poorest
Poorer
Middle
45 50 55 60 65 70 75 80 85 90 95
Age(years)

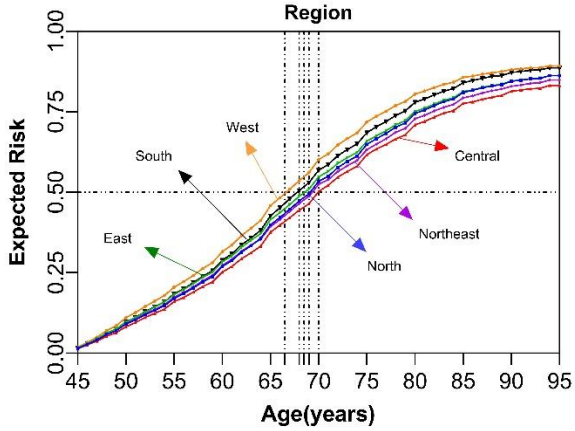

Highest level of Schooling
Expected Risk
0.00
0.25
0.50
0.75
1.00
10 + Years
No Schooling
5 - 9 Years
< 5 Years
45 50 55 60 65 70 75 80 85 90 95
Age(years)

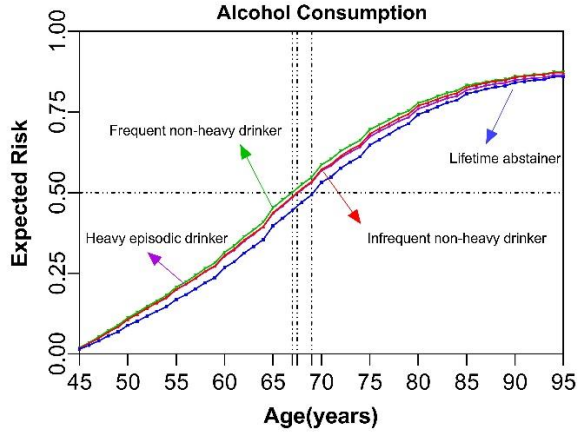

Religion
Expected Risk
0.00
0.25
0.50
0.75
1.00
Muslim
Christian
Other
Hindu
45 50 55 60 65 70 75 80 85 90 95
Age(years)

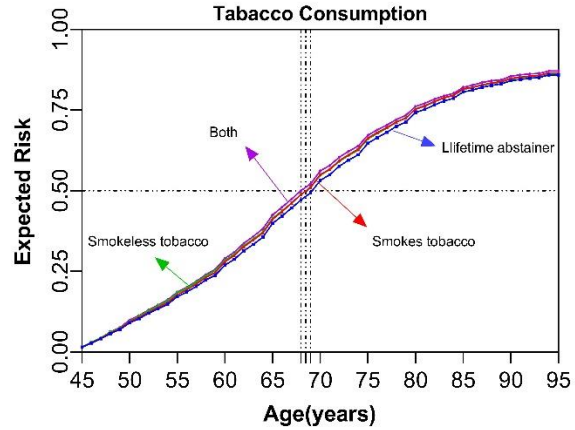

Caste Category
Expected Risk
0.00
0.25
0.50
0.75
1.00
SC
ST
OBC
Other
45 50 55 60 65 70 75 80 85 90 95
Age(years)

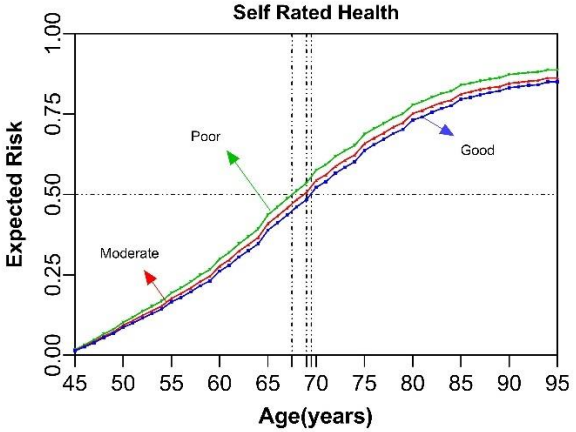

Working Status
Expected Risk
0.00
0.25
0.50
0.75
1.00
Currently working
Currently not working
Never worked
45 50 55 60 65 70 75 80 85 90 95
Age(years)


Current Marital Status
Expected Risk
0.00
0.25
0.50
0.75
1.00
Currently married
Widowed
Divorced/separated
45 50 55 60 65 70 75 80 85 90 95
Age(years)


Region
Expected Risk
0.00
0.25
0.50
0.75
1.00
West
South
Central
East
Northeast
North
45 50 55 60 65 70 75 80 85 90 95
Age(years)


Alcohol Consumption
Expected Risk
0.00
0.25
0.50
0.75
1.00
Frequent non-heavy drinker
Lifetime abstainer
Heavy episodic drinker
Infrequent non-heavy drinker
45 50 55 60 65 70 75 80 85 90 95
Age(years)


Tabacco Consumption
Expected Risk
0.00
0.25
0.50
0.75
1.00
Both
Llifetime abstainer
Smokeless tobacco
Smokes tobacco
45 50 55 60 65 70 75 80 85 90 95
Age(years)


Self Rated Health
Expected Risk
0.00
0.25
0.50
0.75
1.00
Poor
Good
Moderate
45 50 55 60 65 70 75 80 85 90 95
Age(years)

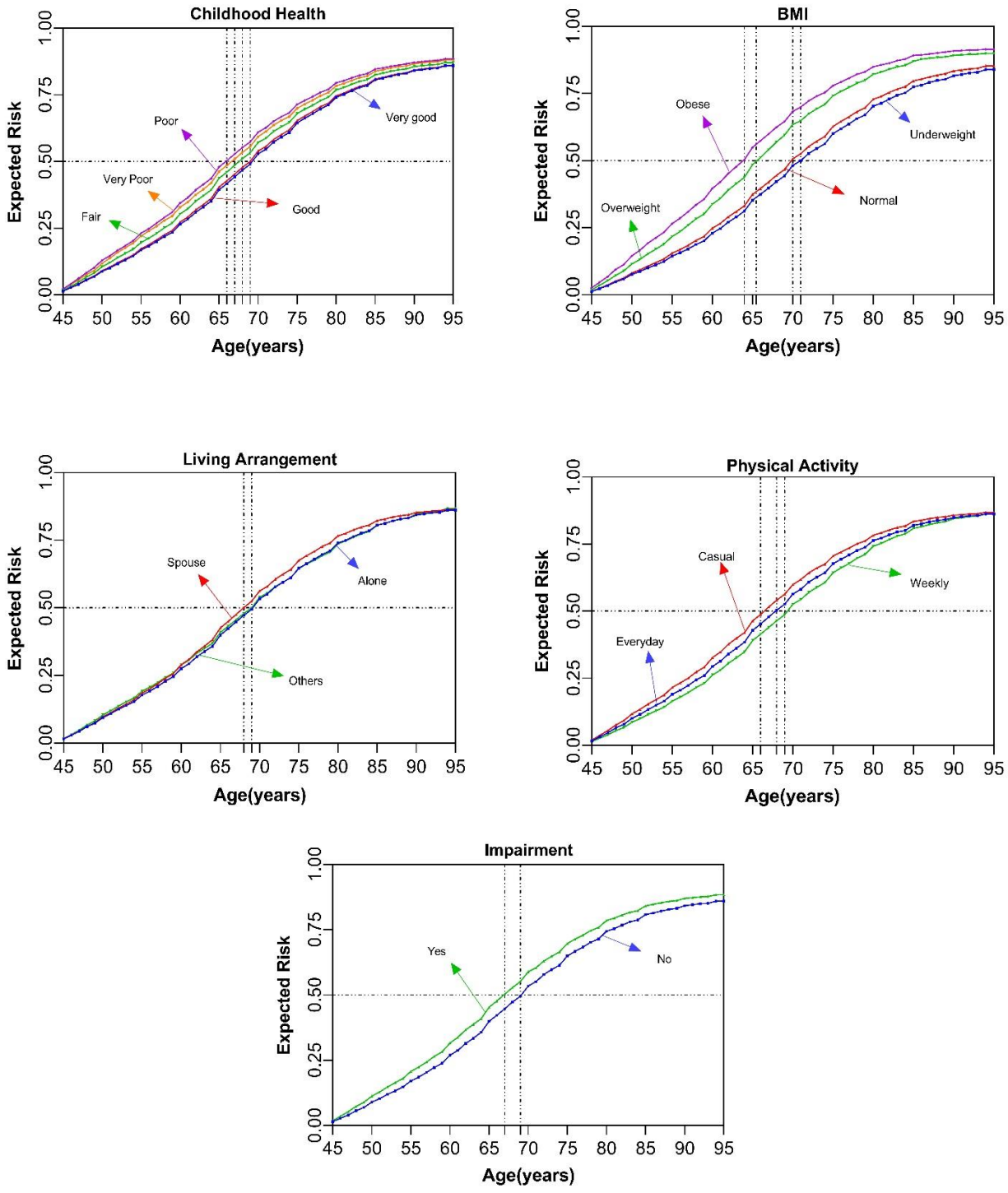


Fig 5: Expected risk of multimorbidity in the population 45 years and above by different background characteristics, LASI Wave-1, 2017-18, India

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

Multimorbidity	Frequency	Weighted Percentage
Zero Morbidity	16842	25.29
Single Morbidity	15837	23.78
Multimorbidity	33927	50.94
Single Morbidities		
Arthritis	5978	8.97
Rheumatism	4100	6.16
Osteoporosis	2213	3.32
Bone Joint Other [a]	5	0.01
Hypertension	17796	26.72
Diabetes	8130	12.21
Cancer	425	0.64
Asthma	3096	4.65
Bronchitis	798	1.2
COPD	902	1.35
Heart Attack	2505	3.76
Heart Blockage	671	1.01
Heart Failure	512	0.77
Arrhythmias Heart	746	1.12
Rheumatic Heart	558	0.84
Congenital| Structural Disorder	65	0.1
Heart Other [b]	116	0.17
Stroke	1262	1.89
Depression	402	0.6
Dementia	388	0.58
Neurological	915	1.37
Psychiatric	251	0.38
Cholesterol	1484	2.23
Hearing Disorder	4593	6.9
Cataract	9448	14.18
Glaucoma	1264	1.90
Hypermetropia	13823	20.75
Myopia	16090	24.16
Presbyopia	4595	6.9
Thyroid	1871	2.81
Gastrointestinal Condition	11978	17.98
Skin Diseases	3475	5.22
Urogenital Diseases	4303	6.46
Tuberculosis	681	1.02
Anaemia	3061	4.6
Jaundice/Hepatitis	1858	2.79

Footnote:		
a - Bone fracture, bone swelling, gout and haemophilia etc		
b - Heart functioning, coronary thrombosis, myasthenia graves- post thymectomy and pericardial effusion etc		

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

Covariates	Zero Morbidity	Single Morbidity	Multimorbidity (two or more)	Freq.	Percentage	p - Value
Age Group						
45- 49	35.48	25.33	39.18	12565	18.86	0.000
50 - 54	30.21	24.8	44.99	13679	20.54	
55 - 59	25.43	23.1	51.47	6907	10.37	
60 - 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 - 85	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	0.000
Female	24.73	23.41	51.86	36006	54.06	
Residence						
Rural	28.57	26	45.4	45648	68.53	0.000
Urban	18.13	18.88	62.99	20958	31.47	
MPCE quintile [a]						
Poorest	32.88	27.25	39.87	13896	20.86	0.000
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	0.000
< 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	0.000
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	0.000
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	0.000
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	0.000
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	0.000
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	0.000
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	0.000
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	0.000
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	0.000
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	0.000
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	0.000
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	0.000
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	0.000
Yes	15.68	19.83	64.49	5516	8.28	
Source: Own calculations, N=66,606. The model controls for other variables as well.						
Footnote:						
a - Wealth index.						
b - Self Rated 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 3: Mean expected risk of multimorbidity by covariates among older adults, Longitudinal Ageing Study in India (LASI), wave-1, 2017–2018

Covariates	Age Group									
	45- 49	50 - 54	55 - 59	60-64	65 - 69	70 - 74	75 - 79	80 - 85	85 +	p Value
Sex										
Male	0.033	0.097	0.170	0.269	0.398	0.530	0.646	0.749	0.827	0.000
Female	0.055	0.150	0.249	0.367	0.503	0.621	0.718	0.795	0.847	
Residence										
Rural	0.040	0.115	0.198	0.304	0.437	0.564	0.672	0.764	0.829	0.000
Urban	0.049	0.138	0.234	0.352	0.497	0.625	0.731	0.814	0.872	
MPCE quintile [a]										
Poorest	0.038	0.109	0.189	0.292	0.423	0.550	0.661	0.755	0.823	0.000
Poorer	0.040	0.115	0.199	0.308	0.443	0.573	0.682	0.771	0.835	
Middle	0.043	0.121	0.207	0.317	0.451	0.579	0.686	0.775	0.837	
Richer	0.045	0.126	0.216	0.328	0.465	0.592	0.697	0.787	0.846	
Richest	0.049	0.136	0.231	0.347	0.488	0.614	0.718	0.803	0.863	
Highest level of Schooling										
No Schooling	0.033	0.096	0.170	0.270	0.399	0.527	0.641	0.741	0.815	0.000
< 5 Years	0.041	0.118	0.205	0.317	0.455	0.583	0.690	0.784	0.849	

5 - 9 Years	0.052	0.145	0.245	0.367	0.511	0.639	0.743	0.819	0.870	
10 + Years	0.066	0.178	0.287	0.412	0.559	0.685	0.780	0.850	0.891	
Religion										
Hindu	0.041	0.116	0.201	0.309	0.444	0.572	0.682	0.774	0.839	0.000
Muslim	0.055	0.151	0.251	0.373	0.513	0.639	0.736	0.812	0.862	
Christian	0.043	0.122	0.208	0.315	0.450	0.572	0.675	0.764	0.830	
Other	0.053	0.143	0.239	0.356	0.493	0.618	0.721	0.805	0.862	
Caste Category										
ST	0.041	0.117	0.201	0.307	0.438	0.562	0.669	0.760	0.826	0.000
SC	0.052	0.144	0.241	0.356	0.495	0.622	0.721	0.799	0.853	
OBC	0.043	0.120	0.206	0.316	0.453	0.580	0.687	0.776	0.839	
Other	0.043	0.122	0.209	0.319	0.453	0.580	0.690	0.783	0.849	
Working Status										
Never worked	0.042	0.117	0.201	0.311	0.447	0.578	0.687	0.780	0.846	0.000
Currently working	0.054	0.151	0.255	0.373	0.507	0.626	0.725	0.800	0.846	
Currently not working	0.027	0.076	0.135	0.233	0.374	0.516	0.640	0.751	0.839	
Current Marital Status										
Currently married	0.049	0.138	0.232	0.348	0.485	0.610	0.713	0.795	0.849	0.000
Widowed	0.033	0.097	0.172	0.275	0.410	0.541	0.656	0.755	0.834	
Divorced/separated/other	0.059	0.158	0.262	0.380	0.519	0.640	0.735	0.809	0.859	
Region										
North	0.042	0.119	0.203	0.312	0.447	0.574	0.683	0.775	0.840	0.000
Central	0.039	0.110	0.190	0.292	0.421	0.543	0.649	0.740	0.808	
East	0.046	0.128	0.217	0.327	0.462	0.587	0.692	0.780	0.841	
Northeast	0.044	0.121	0.207	0.314	0.440	0.562	0.667	0.758	0.825	
West	0.051	0.144	0.243	0.364	0.510	0.644	0.752	0.830	0.878	
South	0.045	0.128	0.220	0.335	0.479	0.610	0.720	0.808	0.868	
Alcohol Consumption										
Lifetime abstainer	0.041	0.117	0.202	0.311	0.445	0.573	0.682	0.773	0.837	0.010
Infrequent non-heavy drinker	0.050	0.141	0.236	0.350	0.487	0.611	0.714	0.796	0.854	
Frequent non-heavy drinker	0.053	0.147	0.244	0.362	0.501	0.626	0.726	0.804	0.856	
Heavy episodic drinker	0.051	0.141	0.235	0.348	0.485	0.606	0.705	0.787	0.845	
Tabacco Consumption										
Lifetime abstainer	0.042	0.119	0.205	0.312	0.446	0.573	0.681	0.772	0.837	0.177
Smokes tobacco	0.044	0.124	0.212	0.325	0.462	0.590	0.696	0.783	0.844	
Smokeless tobacco	0.045	0.127	0.217	0.328	0.462	0.588	0.694	0.782	0.842	
Both	0.046	0.130	0.221	0.336	0.474	0.601	0.704	0.789	0.850	

SRH [b]										
Good	0.040	0.115	0.198	0.304	0.436	0.563	0.671	0.761	0.827	0.000
Moderate	0.044	0.123	0.211	0.322	0.458	0.585	0.692	0.780	0.841	
Poor	0.049	0.135	0.229	0.345	0.486	0.615	0.720	0.808	0.868	
Childhood Health										
Very good	0.041	0.117	0.201	0.308	0.442	0.570	0.679	0.771	0.836	0.000
Good	0.043	0.120	0.207	0.317	0.453	0.580	0.687	0.775	0.838	
Fair	0.049	0.139	0.232	0.349	0.486	0.610	0.711	0.795	0.852	
Poor	0.062	0.166	0.270	0.391	0.528	0.648	0.743	0.819	0.869	
Very Poor	0.057	0.157	0.259	0.374	0.510	0.633	0.730	0.809	0.863	
BMI [c]										
Underweight	0.035	0.100	0.172	0.270	0.398	0.523	0.636	0.736	0.811	0.000
Normal	0.038	0.107	0.186	0.289	0.420	0.549	0.663	0.760	0.829	
Overweight	0.053	0.152	0.259	0.388	0.540	0.672	0.772	0.844	0.889	
Obese	0.069	0.190	0.310	0.450	0.598	0.720	0.806	0.869	0.906	
Living Arrangement										
Alone	0.045	0.124	0.211	0.317	0.448	0.574	0.680	0.770	0.838	0.190
Spouse	0.046	0.129	0.220	0.335	0.475	0.603	0.709	0.793	0.848	
Others	0.049	0.136	0.225	0.330	0.455	0.576	0.677	0.768	0.841	
Physical Activity										
Everyday	0.047	0.132	0.224	0.339	0.477	0.605	0.709	0.789	0.845	0.000
Weekly	0.040	0.114	0.197	0.304	0.439	0.567	0.678	0.773	0.840	
Casual	0.056	0.152	0.252	0.374	0.514	0.639	0.735	0.807	0.855	
Impairment [d]										
No	0.042	0.118	0.204	0.313	0.448	0.575	0.683	0.774	0.837	0.000
Yes	0.054	0.147	0.244	0.363	0.503	0.627	0.729	0.811	0.866	
Footnote:										
a - Wealth index										
b - Self Rated 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										

References:

Alvarez-Galvez, J., & Vegas-Lozano, E. (2022, Nov 21). Discovery and classification of complex multimorbidity patterns: unravelling chronicity networks and their social profiles. *Sci Rep, 12*(1), 20004. https://doi.org/10.1038/s41598-022-23617-8

Andersen, R., & Newman, J. F. (1973). Societal and Individual Determinants of Medical Care Utilization in the United States. *The Milbank Memorial Fund Quarterly, Health and Society, 51*(1), 95-124.

Andersen, R. M. (1995). Revisiting the Behavioral Model and Access to Medical Care: Does it Matter? *Journal of Health and Social Behavior, 36*(1). https://doi.org/10.2307/2137284

Arokiasamy, P. (2018). India's escalating burden of non-communicable diseases. *The Lancet Global Health, 6*(12), e1262-e1263. https://doi.org/https://doi.org/10.1016/S2214-109X(18)30448-0

Babitsch, B., Gohl, D., & Lengerke, T. v. (2012). Re-revisiting Andersen's Behavioral Model of Health Services Use: a systematic review of studies from 1998–2011. *Psychosoc Med, 9*(11). https://doi.org/https://doi.org/10.3205%2Fpsm000089

Kumar, B. G. (1993, March 1993). Low Mortality and High Morbidity in Kerala Reconsidered. *Population and Development Review, 19*(1), 103–121.

Li, Y. N., Nong, D. X., Wei, B., Feng, Q. M., & Luo, H. Y. (2016, Oct 19). The impact of predisposing, enabling, and need factors in utilization of health services among rural residents in Guangxi, China. *Bmc Health Services Research, 16*. https://doi.org/10.1186/s12913-016-1825-4

MoHFW. (2017). *National Multisectoral Action Plan for Prevention and Control of Common Noncommunicable Diseases (2017-2022)*. MoHFW, GOI. https://main.mohfw.gov.in/sites/default/files/National%20Multisectoral%20Action%20Plan%20%28NMAP%29%20for%20Prevention%20and%20Control%20of%20Common%20NCDs%20%282017-22%29_1.pdf

Yadav, S., Perianayagam, A., Patel, S. A., & Cunningham, S. A. (2022, Nov 24). The role of age inequalities in cause of death in the slow pace of epidemiological transition in India. *Sci Rep, 12*(1), 20291. https://doi.org/10.1038/s41598-022-23599-7