Polymorbidity and Health Outcomes Among Middle-Aged and Older Adults: Evidence from the Longitudinal Ageing Study in India

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Abstract

Polymorbidity is the leading cause of morbidity and mortality, particularly in the aging population. The present study analyses the prevalence and explores the determinants of polymorbidity among middle-aged and older adults. The study utilizes the 2017–2018 Longitudinal Ageing Study in India (LASI 2017–2018), a national representative dataset on health conditions of people aged 45 years and above, to study the relative risk estimates. The analysis uses the multinomial logit model (MNL) with their relative risk ratios (RRR). The findings of RRR suggest that the risk of polymorbidity significantly depends on parents' medical history, residing in a front-runner state, and consultation at healthcare centers in both middle-aged and older adults. The prevalence of severe polymorbidity is higher among well-educated individuals and rural residents. The richer household carries a lower risk of polymorbidity, and the older adults from the general caste category are at higher risk of severe polymorbidity. The findings aim to redress the problems attached to the old age population in India. The paper recommends promoting preventive and precautionary attitudes over curative attitudes through health policies by introducing a patient-oriented and disease-centered approach to healthcare provision in India.

Keywords

Aging; LASI; middle-aged; multinomial logit model; noncommunicable diseases; older adults; polymorbidity; relative risk ratio

Introduction

One out of six people in the world will attain an age of 60 or above by 2030, and this digit will double by 2050, with approximately 80% of these individuals residing in low- and middle-income countries (LMICs). These older adults are more susceptible to noncommunicable diseases (NCDs) and experience a higher risk of polymorbidity (Co-occurrence of multiple chronic diseases in one person). The issue becomes more severe with the fact that NCDs are responsible for 77% of total global deaths (World Health Organization [WHO], 2023).

In the last century, we witnessed rapid population aging globally, including in India. With the significant reduction in infant and adult mortality along with a declining replacement rate and rising life expectancy, India will soon experience a massive leap in its aging population in the next three decades. However, the prevalence of inadequate health care provisions, economic insecurity, and improper financial sustenance in modern Indian society shows its lack of preparedness to meet the health challenges of its aging population (Vathesatogkit et al., 2014). Regrettably, the Government of India's spending on NCDs is merely 0.5% of GDP, constituting around 25% of total health spending (Gupta & Ranjan, 2019). This has accelerated the burden of disability and fatalities in India, as the incidence of NCDs is already on the rise (Siegel et al., 2014; Wu et al., 2023).

India has implemented rules meant to improve older people's health and well-being. In 2010–2011, the Indian government began the National Program for Healthcare of the Elderly (NPHCE). NCD flexible pool services such as Geriatric Outpatient Departments (OPDs), Geriatric Wards at District Hospitals, and Geriatric Clinics every two weeks at Community Health Care Centres (CHC) and Primary Health Care Centres (PHC) comprise the NHM component. AIIMS, New Delhi, and Madras Medical College (MMC), Chennai, can open 19 Regional Geriatric Centres (RGCs) and two National Centres of Aging (NCAs). These will connect those who cannot access primary care with the appropriate people. In addition to the Rashtriya Swasthya Bima Yojana (RSBY), there is the Senior Citizen Health Insurance Scheme. Senior citizens in qualifying RSBY homes receive an extra 30,000 INR in health insurance. Rashtriya Vayoshri Yojana (RVY), Integrated Programme for Senior Citizens (IPSrC), and Pradhan Mantri Vaya Vandana Yojana (PMVVY) reduce the main dangers for Indian seniors while they are alive (Press Information Bureau [PIB], 2022). All these schemes demand a patient-oriented approach and a disease-centred approach in the context of the healthcare provision of a nation (Noor et al., 2020; van Bussel et al., 2007).

This study addresses the following research questions: (i) what factors determine the prevalence of polymorbidity in middle-aged and older adults? (ii) do factors determining the prevalence of polymorbidity vary according to severity? (iii) do factors determining the prevalence of polymorbidity vary according to cohort (middle-aged and older adults)?

In this context, it is constructive to determine the factors that influence the severity and prevalence of polymorbidity in middle-aged and older adults. The study utilizes data from the Longitudinal Ageing Study in India (LASI) 2017–2018 and analyses the primary risk variables that contribute to polymorbidity using data collected from households in India. The subsequent sections provide detailed information on the research gaps, data, and methods, followed by results, discussion, and conclusion of the study.

Literature review

An increasing count of individuals suffering from more than one chronic NCD gives rise to the problem of polymorbidity in the middle-aged and later stages of life. However, one chronic NCD is rare compared to polymorbidity among older adults (Tugwell & Knottnerus, 2019). It is observed that polymorbidity has a high association with increased disability, mortality, healthcare resources, and degraded quality of life (Gomes et al., 2018).

Demographic factors

The studies emphasizing demographic factors such as age, marital status, caste, gender, residence across diseases, and risk factors observed that these are crucial determinants of chronic diseases in the population of a low and middle-income country. In context to the place of residence, rural households experience more morbidities than urban households. Also, there is a negligible difference in the number of people with chronic illnesses living in the richer cities and the poorer rural areas (Biswas et al., 2016). Middle-aged and older Indians are health illiterate and lack awareness regarding the precautionary and preventive attitude toward health, making education an essential factor for assuring healthy and active aging in the country (Barve & Joshi, 2019; Levy & Janke, 2016). In addition, a recent study found that middle-aged and older adults with poor health have lower health literacy levels, worsening their health (Lovrić et al., 2022).

Marital status also plays a crucial role in the occurrence of chronic disease, as living with a partner improves the health-related behavior of an individual. It is found that people living with a spouse experience more appropriate health-seeking behavior than divorced, widowed, or separated individuals (Hinkaew & Nuntaboot, 2024). In the context of caste, it is ambiguous to state that the unprivileged or backward sections are more prone to illness than the privileged section as the latter follow a sedentary lifestyle, which makes them riskier to acquire lifestyle diseases in the later stage of life (Sangar et al., 2019). Besides, gender inequality is a pressing issue in India. The older male family member makes decisions regarding visits to healthcare centers and attaining health services. Hence, the health of female members is neglected in the patriarchal set-up of the family, making them more prone to chronic illness at an older age (Reininger et al., 2015).

Socioeconomic factors

The economic burden of NCDs, such as diabetes, chronic heart disease, chronic lung disease, and cancer, is notably high in terms of out-of-pocket expenditure and premature death (Menon et al., 2022; Yadav & Mohanty, 2021). The prevalence of socioeconomic inequalities imposes a negative impact on the mortality of its population (Vathesatogkit et al., 2014). Moreover, the prevalence of chronic NCDs raises the number of healthcare visits and, hence, the out-of-pocket expenditure on health (Brinda et al., 2015). Furthermore, it has been regularly observed that the probability of having several chronic conditions is directly linked to the income and wealth of the household (Begum & Hamid, 2021). The households with a higher income level maintain a better quality of life than those with lower ones. The direct and indirect costs to health, catastrophic health expenditure, and out-of-pocket spending are easily incurred without affecting the basic life necessities (Chung et al., 2015; Singer et al., 2019).

Health-related factors

Apart from demographic and socioeconomic factors, various other factors such as genetics, lifestyle, biological risk factors, social environment, the physical environment, and health care subject to severe consequences of healthcare utilization, complications of treatment, treatment strategy, and functional status affect the severity of disease (Sapkota et al., 2023). Additionally, body mass index is one of the leading factors determining the prevalence and incidence of NCDs among middle-aged and older adults (Shang et al., 2020). The decision to visit public or private healthcare centers significantly determines an individual's health-seeking behavior. However, there is a considerable disparity in the behavior of health service providers and facilities provided at public and private healthcare centers. This requires a study that analyses the pattern, prevalence, and risk factors associated with polymorbidity in aging India.

Research gaps

The focus on the middle-aged population is considered appropriate in the Indian context due to the increasing older population, which poses a substantial challenge for policy solutions. Since both the frequency and types of NCDs are on the rise hence, the financial burden on Indian households due to out-of-pocket expenditures (OOPE) on older adults is significant. While a limited number of case-based and country-specific studies have addressed polymorbidity on a global scale, there is a scarcity of recent studies in India that provide a comprehensive representation at the national level. Existing studies have not exclusively delved into the issues of polymorbidity among the middle-aged and older population. Additionally, there is a lack of studies that specifically investigate the prevalence of polymorbidity while connecting it to the Good Health and Well-being Index as an indicator of health policy effectiveness. The literature has also overlooked the role of parents' medical history and visits to healthcare centers in this context. Furthermore, there has not been an in-depth exploration of the relative risk ratio (RRR) for a specific cohort concerning polymorbidity. This study aims to address these gaps in the literature by examining middle-aged health outcomes as precursors to polymorbidity issues in old age.

Methodology

Sample selection

The study analyzes the Indian population aged 45 and above using data compiled and extracted from Wave 1 of 2017–2018 Longitudinal Ageing Study (LASI 2017–2018). This cross-sectional population-based survey covers all of India (except Sikkim) and provides data on many relevant topics related to the aged population.

The data is classified into two categories, namely middle-aged and older adults. The categorization of middle-aged individuals as 45–64 years and older individuals above 64 years is based on the grouping of Lee et al. (2018), dividing the data into similar age groups. The procedure of sample selection is elaborated in Figure 1.

Figure 1: Sample Selection Procedure
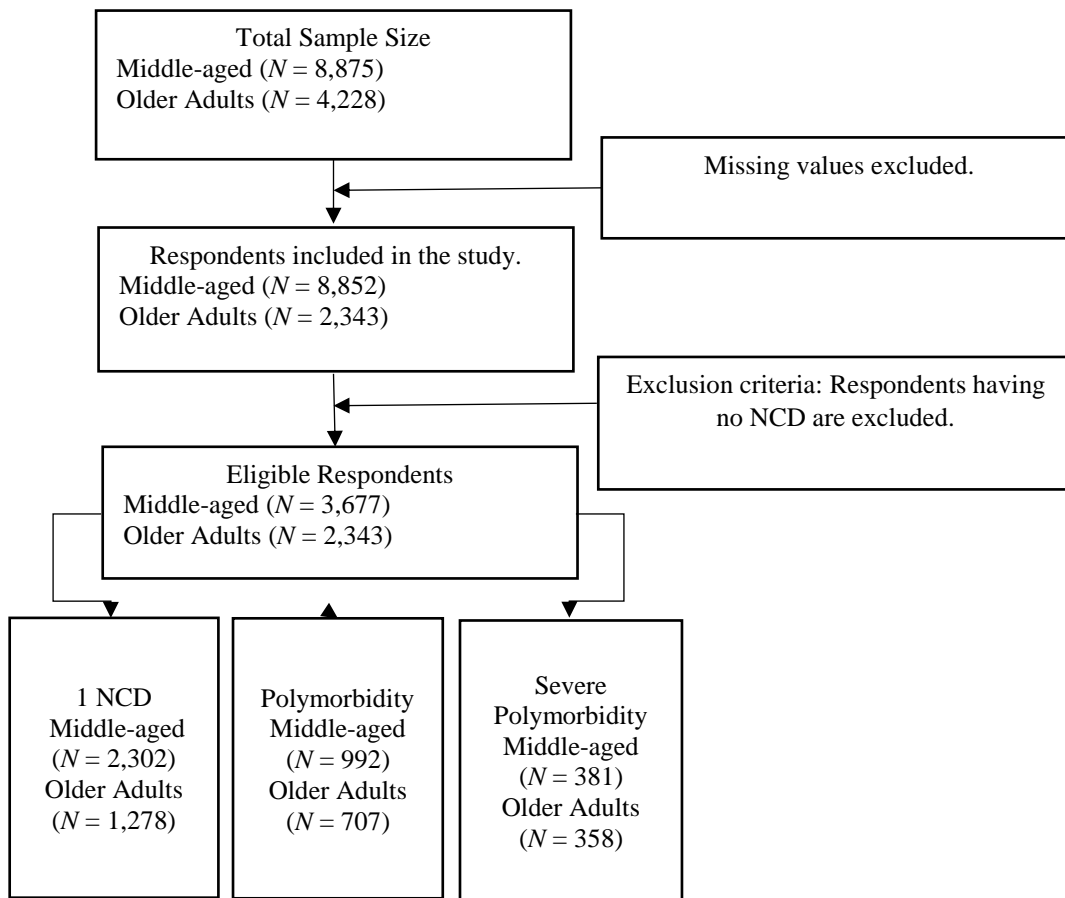
Model specification

The explanatory variables are subdivided into (i) Demographic factors, (ii) Socioeconomic factors, and (iii) Health-related factors. The operationalization of these variables is provided in Table 1. The prevalence of polymorbidity is divided into three categories: no-polymorbidity (having only 1 NCD), polymorbidity (having 2 NCDs), and severe polymorbidity (having three or more NCDs). The algorithm for the same is provided in Table 2.

Table 1: Variable Description

Variable	Description
Polymorbidity	No polymorbidity (base outcome) = 1, Polymorbidity = 2, Severe Polymorbidity = 3
Demographic Variable	
Age square	Square of age at last birthday
Gender	Female = 0, Male = 1
Marital status	Currently not living with a spouse = 0, Currently living with spouse = 1
Residence	Rural = 0, Urban = 1
SDGs states category	Category of the states according to Goal 3 Good Health and Well-being of Sustainable Development Goals; Aspirant = 1, Performer = 2, Front runner = 3

Variable	Description
Education	Till primary school = 1, Middle school completed = 2, Secondary completed = 3, Higher Secondary or more = 4
Caste	Scheduled Castes (SCs) = 1, Scheduled Tribes (STs) = 2, Other Backward Classes (OBCs) = 3 Others = 4
Socioeconomic Variable	
ln_Household income	Log of household income: Household income is the total of a) Agricultural Income from Farm/Fishery/Forestry, b) Non-agricultural Business Income, c) Individual Earnings such as Wages and salaries from Agricultural Laborers, Self-Employed and Employees, d) Individual Pension Income, e) Private transfers, f) Government transfers, g) Other sources such as rent, dowry, etc.
ln_OOPE	Log of out-of-pocket expenditure on health care.
Health-related Variable	
Parents medical history	No = 1, Father = 2, Mother = 3, Both (mother and father) = 4
Health care visit	Nowhere = 1, Only private = 2, Only public = 3, Both (public and private) = 4
Body Mass Index	Underweight ($\leq 18 kg/m^2$) = 1, Healthy ($18–25 kg/m^2$) = 2, Overweight ($25–30 kg/m^2$) = 3, Obesity ($\geq 30 kg/m^2$) = 4

Note: Author's estimation using LASI 2017–2018

Table 2: Disease and Algorithms used to derive Prevalence of Polymorbdity using Individual Questionnaire of LASI Wave 1

Disease Name	Question	Response
Hypertension	Have you ever been diagnosed with hypertension or high blood pressure?	Yes = 1 No = 0
Diabetes	Have you ever been diagnosed with diabetes or high blood sugar?	Yes = 1 No = 0
Cancer	Have you ever been diagnosed with cancer or a malignant tumor?	Yes = 1 No = 0
Chronic Lung Disease	Have you ever been diagnosed with chronic lung disease such as asthma, chronic obstructive pulmonary disease/Chronic bronchitis, or other chronic lung problems?	Yes = 1 No = 0
Chronic Heart Disease	Have you ever been diagnosed with chronic heart diseases such as coronary heart disease (heart attack or myocardial infarction), congestive heart failure, or other chronic heart problems?	Yes = 1 No = 0
Arthritis	Have you ever been diagnosed with arthritis, rheumatism, Osteoporosis, or other bone/joint diseases?	Yes = 1 No = 0
Psychological issues	Have you ever been diagnosed with any neurological or psychiatric problems such as depression, Alzheimer's/dementia, unipolar/bipolar disorders, convulsions, Parkinson's, etc.?	Yes = 1 No = 0
High Cholesterol	Have you ever been diagnosed with high cholesterol?	Yes = 1 No = 0
Algorithms of Polimorbidity	A summative index is generated if the response for any one of the above questions is 'Yes,' then the respondent is said to have 'no-polymorbidity,' and if the response for any of the two questions is 'Yes,' then they said to have 'polymorbidity' and 'severe polymorbidity' for three or more positive responses.	1 = No poly morbidity 2 = Polymorbidity 3 = Severe poly morbidity ($1\lneq 2\lneq 3$)

Note: Authors' creation

Existing studies used the ordered logit model to analyze the outcome based on natural ordering (low to high severity level). However, a few limitations are found in these studies (Foucade et al., 2020; Holmes & Deb, 2003). The increased probability of the most severe class is associated with the lowest severe class's decreased probability in an ordered model. Hence, the MNL has been recommended for evaluating severe outcomes (Damsere-Derry et al., 2021). The nominal category of the dependent variable is transformed into a numerical scale (Hashimoto et al., 2020).

Let Y be a random variable given that Category 1 is the reference category and follows a multinomial distribution where $Y \sim MN(p,1)$ and probability mass function in Equation (1):

$$f(Y) = \frac{1}{\sum_{i=1}^{I} Y!} \sum_{i=1}^{I} p_Y^i \ (1)$$

Where $p = (p_1, \ldots, p_I)$ is a vector of probabilities of occurrence of poly morbidity for a set of explanatory variables given as $x = (x_1, \ldots, x_n)$ in Equation (2):

$$P_i(x) = P(Y = i|x), i = 1,2,\ldots I \ (2)$$

This is a multinomial probability, given that $\sum_{i=1}^{I} p_i(x) = 1$,

The MNL model is given in Equation (3).

$$p_{ni} = \frac{e^{\beta_i X_{ni}}}{\sum_{i=1}^{I} e^{\beta_i X_{ni}}}, i = 1,2,\ldots I \ (3)$$

where p_{ni} is the probability of the individual n experiencing the polymorbidity of I βi is a coefficient of the polymorbidity i, and X_{ni} is an explanatory variable.

In this context, four different models are derived, viz. Model 1 is for middle-aged people with polymorbidity, Model 2 is for middle-aged people with severe polymorbidity, Model 3 is for older adults with polymorbidity, and Model 4 is for older adults with severe polymorbidity. No-poly morbidity was used as the reference category in estimating all four models. The MNL model takes the form as

$$Polymorbidity_{ir} = \alpha + \beta_1 age_i + \beta_2 \ln\_household\_income_i + \beta_3 lnOOPE_i + \beta_4 gender_i + \beta_5 marital\_status_i + \beta_6 residence_i + \beta_7 education_i + \beta_8 caste_i + \beta_9 SDG\_state\_category_i + \beta_{10} health\_care_i + \beta_{11} parents\_medical\_care_i + \beta_{12} BMI_i + \varepsilon_i \ (4)$$

where *r =1 for middle-aged with polymorbidity, r = 2 for middle-aged with severe polymorbidity, r = 3 for older adults with polymorbidity, and r = 4 for older adults with severe polymorbidity.*

The assumption of nonlinearity of the MNL states that the estimated coefficients are not acceptable for determining the direct effect on the severity outcomes. Hence, the relative risk ratio (RRR) is used to evaluate the risk factors estimated relative to the reference category (Greene, 2012).

$$RRR = \frac{\Pr(i=2)}{\Pr(i=I)} = e^{\beta i}$$

The RRR denotes the risk factor for the prevalence of polymorbidity. When an RRR is greater than 1, it indicates an increase in risk; an RRR equal to 1 shows no association. In contrast, an RRR of lower than 1 indicates a decrease in the risk of prevalence of polymorbidity in terms

of the level of severity compared with the base category (Chakrabarti & Shankar, 2015). This study estimates the MNL and the associated RRR at the 95% confidence level using statistical software "Stata" (Version 17.0).

Results

Prevalence statistics of the middle-aged and older adults with polymorbidity

The prevalence of polymorbidity among middle-aged and older adults is very high in India. Table 3 depicts the percentage of middle-aged and older adults living with polymorbidity across various demographic and socioeconomic groups. Among the total middle-aged rural residents, 29% and 13% are living with polymorbidity and severe polymorbidity, respectively. On the other hand, 34% and 18% of the older adults rural residents are living with polymorbidity and severe polymorbidity, respectively.

Middle-aged females report more severe polymorbid cases than their male counterparts, but the issue gets reversed in the older population. A high of 37% of older adults who have completed their higher secondary or higher level of education are suffering from polymorbidity, and the same pattern is followed in middle-aged. The prevalence of polymorbidity does not vary significantly between SCs and STs caste groups. However, the "None of Them" category, which is an indicator of the general caste group in India, has a more significant proportion of older people suffering from polymorbidity.

The prevalence of severe polymorbidity is higher for the aging population who holds a parents' medical history of both father and mother. A high of 21% of older adults living in front-runner states are severely polymorbid, while 12% of middle-aged from the same states are severely polymorbid. The prevalence of both polymorbidity and severe polymorbidity is very high for overweight and obese individuals belonging to both cohorts. Moreover, 32% of older adults visiting either private or public healthcare services are living with polymorbidity, and 30% of middle-aged visiting both private and public healthcare services are polymorbid. This corroborates that health literacy is crucial in tackling early age prevalence and incidence of polymorbidity in India (Barve & Joshi, 2019).

Table 3: Descriptive Statistics for Middle-Aged and Older Adults Living with Polymorbidity

Variable	Middle-Aged (%)			Older adults (%)		
	No Polymorbidity	Polymorbidity	Severe Polymorbidity	No Polymorbidity	Polymorbidity	Severe Polymorbidity
Residence						
Rural	57.08	29.35	13.57	46.88	34.29	18.83
Urban	66.68	25.28	8.04	60.34	27.06	12.59
Gender						
Female	62.12	26.66	11.21	55.18	30.42	14.40
Male	63.40	27.48	9.12	53.84	29.40	16.26
Marital Status						
Not living with a spouse	60.39	29.5	10.11	54.09	31.68	14.23
Living with spouse	63.19	26.38	10.43	54.90	29.01	16.10
Education						
Primary or less	61.87	28.00	10.13	52.35	32.80	16.84
Middle school	61.39	24.89	13.71	50.33	32.68	16.99
Secondary	54.74	28.44	16.82	42.50	33.00	24.50
Higher Secondary or more	60.32	29.93	9.75	43.69	37.84	18.47
Caste						
SCs	67.79	24.04	8.17	58.03	27.04	14.93
STs	65.02	24.66	10.31	62.60	29.77	7.63
OBCs	63.17	26.53	10.30	56.22	27.29	16.48
None of them	58.33	30.51	11.17	48.18	35.43	16.39
SDGs State Category						
Aspirant	70.53	22.43	7.04	64.47	27.80	7.73
Performer	65.82	25.67	8.52	56.00	32.00	12.00
Front runner	58.20	29.52	12.28	49.43	28.83	21.74
Parents Medical History						

Variable	Middle-Aged (%)			Older adults (%)		
	No Polymorbidity	Polymorbidity	Severe Polymorbidity	No Polymorbidity	Polymorbidity	Severe Polymorbidity
No medical history	65.53	25.49	8.98	57.30	28.60	14.10
Only father	63.24	27.03	9.73	47.24	34.67	18.09
Only mother	60.04	29.25	10.71	42.64	37.56	19.80
Both (father and mother)	49.89	32.44	17.67	45.86	33.76	20.38
Health Care						
Nowhere	73.92	20.84	5.24	64.38	24.46	11.15
Only private	59.55	29.28	11.16	52.52	32.27	15.21
Only public	61.58	27.34	11.08	53.15	32.22	14.63
Both (private and public)	52.59	30.36	16.75	45.87	28.93	25.21
Body Mass Index (BMI)						
Underweight	75.61	21.14	3.25	67.53	26.30	6.17
Healthy	67.00	24.75	8.25	58.18	28.91	12.91
Overweight	58.72	28.88	12.39	43.27	36.23	20.50
Obesity	50.94	32.39	16.67	40.74	31.48	27.78

Note: Authors' estimation based on LASI Wave 1 (2017-2018) data; SCs: scheduled castes; STs: scheduled tribes; OBCs: other backward classes

Determinants of polymorbidity

The conceptual framework for action on the social determinants of health developed by the Commission on Social Determinants of Health (CSDH) lists age, sex, marital status, caste, region, level of education, and household income as significant health determinants (Solar & Irwin, 2010). Regression models and the literature indicate that these structural variables are directly or indirectly related to polymorbidity, as explained in Table 4.

The RRR of 1 significantly indicates that age does not determine one's susceptibility to polymorbidity. It is observed that when household income improves, persons become less prone to being trapped by polymorbidity in middle-aged and severe polymorbidity in older adults scenarios. Older individuals from the general caste category display a significantly higher risk of severe polymorbidity, provided they belong to high economic status groups with a rich asset profile.

Table 4: Multinomial Logit Regression (Relative Risk Ratio)

Variable	Model 1 Middle-aged	Model 2 Middle-aged	Model 3 Older adults	Model 4 Older adults
Reference Category (No-Polymorbidity)	Polymorbidity	Severe Polymorbidity	Polymorbidity	Severe Polymorbidity
Age	1.00*** (0.00)	1.00*** (0.00)	1.00 (0.00)	1.00 (0.00)
Household Income (log)	0.97** (0.01)	0.98 (0.03)	1.00(0.01)	0.96* (0.01)
Out-of-pocket expenditure (log)	1.02 (0.04)	1.09*** (0.06)	1.00 (0.01)	1.08*** (0.02)
Gender (female®)	1.07 (0.29)	0.72** (4.23)	1.01 (0.13)	1.22 (0.22)
Marital status	0.96 (0.11)	1.33 (0.25)	0.83 (0.09)	0.99 (0.18)
Residence (rural®)	0.89 (0.23)	0.78 (0.24)	0.76** (0.09)	0.81 (0.13)
Education (Primary or less®)				
Middle School completed	0.97 (0.14)	1.53** (0.32)	0.96 (0.22)	0.77 (0.22)
Secondary completed	0.99 (0.15)	2.05*** (0.42)	1.58** (0.32)	1.75** (0.44)
Higher secondary or more completed	0.99 (0.16)	1.20 (0.30)	1.11 (0.22)	1.02 (0.23)
Caste (SCs®)				
STs	1.18 (0.31)	0.99 (0.73)	0.89 (0.22)	0.36** (0.16)
OBCs	1.02 (0.26)	1.02 (0.33)	0.97 (0.16)	1.09 (0.24)
None of them	1.23 (0.28)	0.94 (0.28)	1.10(0.24)	1.15* (0.28)
SDGs State Category (Aspirant®)				
Performer	1.19(0.19)	1.23 (0.30)	1.07 (0.16)	1.68** (0.39)

	Model 1	Model 2	Model 3	Model 4
Variable	Middle-aged	Middle-aged	Older adults	Older adults
Reference Category (No-Polymorbidity)	Polymorbidity	Severe Polymorbidity	Polymorbidity	Severe Polymorbidity
Front runner	1.47*** (0.21)	1.94*** (0.40)	1.19(0.16)	2.76*** (0.58)
Health Care (Nowhere®)				
Only private	1.74*** (0.21)	2.20*** (0.47)	1.64*** (0.26)	0.99 (0.21)
Only Public	1.44** (0.21)	2.24*** (0.55)	1.83*** (0.34)	1.06 (0.27)
Both private and public	2.10*** (0.36)	3.74*** (0.90)	1.71** (0.41)	1.83** (0.51)
Parents' Medical History (No medical history®)				
Father	1.14 (0.18)	0.84 (0.22)	1.32 (0.27)	1.24 (0.34)
Mother	1.08 (0.14)	1.06 (0.22)	1.50* (0.32)	1.90** (0.49)
Both	1.68*** (0.24)	2.02*** (0.41)	1.30 (0.30)	1.96** (0.53)
Body Mass Index (Underweight®)				
Healthy	1.35 (0.28)	2.53** (1.03)	1.23 (0.23)	2.14*** (0.61)
Overweight	1.61** (0.38)	4.30*** (1.64)	1.92*** (0.38)	4.33*** (1.35)
Obesity	2.51*** (0.50)	6.31*** (2.33)	1.88** (0.63)	5.20*** (1.96)
Constant	0.07*** (0.03)	0.00*** (0.00)	0.21*** (0.09)	0.02*** (0.01)
No. of observations	2,693	2,693	1,686	1,686
Pseudo-R²	0.05	0.05	0.06	0.06

Note: Authors' calculation using LASI data; ® Reference category. Figures in parentheses are standard errors; NCDs: noncommunicable diseases; LASI: longitudinal ageing study in India; SDGs: Sustainable Development Goals; SCs: scheduled castes; STs: scheduled tribes; OBCs: other backward classes; *p < .01, **p < .05, ***p < .10

As expected, middle-aged males have a lower chance than females of falling into the category of severe polymorbidity. This is substantiated by the existing literature stating that the prevalence of gender inequality in India is higher regarding seeking health literacy (Marengoni et al., 2011). It is discovered that those with a high school diploma are twice as riskier as those with only a primary school diploma or less education. The research conducted by Pati et al. (2020) contradicts this finding. The attainment of higher education does not guarantee the attainment of health literacy. Moreover, it confirms an inactive lifestyle in job prospects.

Compared to rural citizens, metropolitan communities exhibit reduced risk bearers, resulting in significant outcomes (Ingram et al., 2021). Furthermore, states have been divided into three categories based on their performance and aspirations in the Health and Well-being SDG Index of India 2018, which NITI Aayog released. It is found that residents of performer and front-runner states have an increased chance of being polymorbid than residents of aspirant states. These findings present the role of state health facilities in explaining polymorbidity along the lines of existing studies (Biswas et al., 2016; Marengoni et al., 2011), which is attributed to the state's healthcare systems' accessibility, affordability, and availability (Chung et al., 2015; Mohanty et al., 2014; Sum et al., 2018).

The natural logarithmic transformation of OOPE in healthcare is positively associated with the risk of severe polymorbidity among both cohorts, which may be due to the unavailability of public healthcare services and better insurance coverage (Brinda et al., 2015; Chatterjee et al., 2023). However, this finding contrasts with research by Wang et al. (2015) covering Sub-Saharan Africa. In terms of healthcare, it is observed that the risk of polymorbidity is twice as high for individuals who visit both public and private healthcare services or centers as for those who do not consult anywhere. This might result from dissatisfaction when seeking treatment from public and private health service providers and ultimately incurring enormous out-of-pocket costs to diagnose their illness (Brinda et al., 2015).

It is interesting to note that individuals with at least one NCD in both parents are twice as likely to acquire polymorbidity than persons without any NCDs in either parent, especially if they have more than one NCD. It makes it clear that the prevalence of polymorbidity among older adults and middle-aged is significantly influenced by hereditary disorders. Body Mass Index (BMI) is computed using self-reported weight and height measurements (Nishida et al., 2004). Regardless of their age group—middle-aged or older adults—obese people are six times more likely to experience polymorbidity than underweight ones. Our results are consistent with the body of research showing a link between obesity and the prevalence of NCDs in people (Alaba & Chola, 2013; Shang et al., 2020).

Discussion

In this study, analysis of the RRR revealed that individuals accessing private and public health service centers, having parents with a medical history of NCDs, or respondents residing in leading states are most susceptible to polymorbidity (Singer et al., 2019). This shows how important it is for older people in India to attain awareness of their holistic health (Nutbeam & Lloyd, 2021). The regression analysis showed that having more schooling made people more likely to suffer from more than one chronic NCD condition simultaneously, also known as polymorbidity. This is authenticated by the fact that the curriculum of the Indian Education System direly needs to implement strategies that directly impact health information-seeking behavior at an early age (Zimmerman & Shaw, 2020). People with curative attitudes lack preventive and precautionary attitudes for their health, hence end up with high OOPE, affecting their socioeconomic status (Levy & Janke, 2016). Overweight and obese people are more likely to have multiple long-term illnesses (polymorbidity) than underweight or healthy people at any age. The findings emphasize the importance of practicing appropriate health-seeking and appropriate preventive health behavior from the beginning of the middle-aged stage of life (Shang et al., 2020).

The analyses of the data of the responses of the individuals confirm that adults following a sedentary lifestyle, irrespective of their level of education, are prone to getting trapped in the vicious circle of polymorbidity. The study also validates the results of visits to private and public health care services and out-of-pocket expenditures incurred on health by the people already suffering from NCDs. This warrants that practical public policy implication and utilization, along with behavioral insights, is required at the local level to improve the holistic well-being of older adults and middle-aged in India (Gupta & Ranjan, 2019; Mohanty et al., 2021; Yousefi et al., 2014). The study also identifies socioeconomic issues that raise the probability of developing polymorbidity in middle-aged and older Indians. These aspects assist in reframing existing public health policies by incorporating behavioral insights to promote health-seeking behavior. This will ensure consistency in following preventive health

behavior at the micro level and redesigning effective policies at the macro level (Banu et al., 2022; Carminati, 2020).

Conclusion and implications

In conclusion, this paper offers a comprehensive framework encompassing a patient-centric and disease-oriented approach, validating the rehabilitative and curative perspectives for older adults. However, to instill a preventive mindset among older adults, there is a pressing need for age-friendly healthcare initiatives (Rasul et al., 2019). The initiatives should focus on training and equipping the healthcare workforce, including psychologists, physiotherapists, personal care workers, audiologists, and speech therapists. Promoting inter-professional degree programs in geriatric services is also essential for enhancing the quality of life and life expectancy of older adults in India (EH News Bureau, 2022). In essence, healthcare workers and service providers must be skilled and well-informed about the challenges arising from inadequate health literacy in the country. This will help people to be aware of the probability of encountering adverse outcomes regarding their health. Further, it will imbibe a feeling that "prevention is better than a cure" at an early age.

This paper addresses the health-related problems associated with the older population in India and identifies the crucial determinants for improved policymaking for older adults. The strategic focus should be directed towards correcting early-age incidences, including issues with the middle-aged, to effectively tackle the challenges faced by older individuals in India for future generations.

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