THE SOCIAL GRADIENT OF FRAILTY IN INDIA: A MULTI-STATE ANALYSIS USING WHO-SAGE DATA

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***Abstract*—This study derives a composite frailty index for adults aged 50 and above in India, examines the distribution of frailty conditions across socioeconomic and demographic strata, and estimates the independent effects of background characteristics on frailty using multivariate analysis. Data and Methods: Data from the WHO Study on Global Ageing and Adult Health (SAGE) India Wave 1 (2007) were used, encompassing 6,560 respondents aged 50 and above across six Indian states. A modified frailty index incorporating seven deficit indicators - low grip strength, slowness, low body mass index, low physical activity, cognitive limitation, psychological limitation, and exhaustion - was constructed. Participants were classified as robust (0 deficits), pre-frail (1–2), intermediate (3–4), or frail (5–7). Multinomial logistic regression was employed to estimate the association between socioeconomic variables and frailty categories. Results: Frailty prevalence was 15.5% overall, rising sharply with age from 7.1% in the 50–59 group to 50.8% in those aged 80 and above. Female sex, no formal education, low wealth, rural residence, and scheduled caste/tribe status were consistently associated with higher frailty burden. Multinomial logistic regression confirmed that advanced age, low education, and low wealth quintile were the strongest predictors of frailty, with statistically significant odds ratios at $p < 0.01$.**

***Index Terms*—Frailty, older adults, India, WHO-SAGE, frailty index, ageing.**

I. Introduction

Population ageing is one of the consequential demographic transformations of the twenty-first century. Globally, the share of individuals aged 60 and above is projected to reach nearly 22% of the world's population by 2050, compared with approximately 12% in 2015 (WHO, 2015). India, while still a relatively young nation in demographic terms, is not immune to these trends. The number of older adults in India - defined here as those aged 50 and above - is expected to exceed 320 million within the next two to three decades, driven by sustained improvements in life expectancy and declining fertility rates. This unprecedented demographic shift will have profound implications for healthcare systems, social support structures, and public health policy.

Within this context, frailty has emerged as a central concern in geriatric medicine and public health. Frailty is broadly understood as a state of increased vulnerability in which an individual's physiological reserves are insufficient to withstand even minor external stressors, thereby elevating the risk of adverse outcomes such as functional decline, hospitalisation, disability, and death (Fried et al., 2001). Unlike many conventional disease categories, frailty is not attributable to any single pathological process; rather, it reflects the cumulative erosion of reserve capacity across multiple biological systems, including the musculoskeletal, cardiovascular, neuroendocrine, and immune systems (Sarkisian & Lachs, 1996).

The concept of frailty has gained considerable traction in gerontological research since its formal operationalisation by Fried and colleagues in 2001, who described it as a clinical phenotype characterised by unintentional weight loss, exhaustion, low physical activity, slowness of gait, and muscular weakness. Despite this progress, significant conceptual and measurement heterogeneity persists in the literature, with competing frameworks - including the phenotypic model and the deficit accumulation model developed by Rockwood and Magnitsky - offering distinct but complementary perspectives on frailty's aetiology and assessment. The challenge is compounded in low- and middle-income countries (LMICs) such as India, where the epidemiological profile of ageing differs substantially from high-income countries: higher burdens of undernutrition, infectious disease sequelae, poverty, and limited healthcare access create a distinct frailty landscape.

India presents a particularly important case for frailty research. It is home to approximately 140 million individuals aged 60 and above, a number that will continue to grow at accelerating rates. The Indian ageing population is characterised by high rates of poverty, low educational attainment, gender inequalities, and regional heterogeneity in health outcomes. These structural factors are likely to shape both the prevalence and the distribution of frailty in ways that are poorly understood. Despite the potential public health significance of frailty in India, empirical research on this topic has been remarkably sparse. No prior nationally representative study had specifically examined frailty conditions and their socioeconomic correlates among older Indians at the time of this study.

The present study addresses this gap by leveraging data from the WHO Study on Global Ageing and Adult Health (SAGE) India Wave 1, conducted in 2007. Using a modified frailty index adapted to the available data, this study (a) derives a composite measure of frailty suitable for the Indian context; (b) documents the distribution of frailty across age, sex, education, wealth, caste, religion, residence, and state; and (c) employs multinomial logistic regression to identify the independent socioeconomic predictors of frailty severity. By doing so, this study aims to provide an empirical foundation for frailty-aware health policy in India and to contribute to the broader literature on frailty in LMICs**.**

II. Conceptual Framework and Literature Review

2.1 Conceptualising Frailty

The term 'frail elderly' was first introduced in 1978 by the U.S. Federal Council on Aging to describe older individuals who were at heightened risk for adverse health outcomes (Morley et al., 2006). Conceptually, frailty has been understood through several competing frameworks. Campbell (1997) offered one of the earliest systematic definitions, describing frailty as a syndrome resulting from a multi-system reduction in reserve capacity such that multiple physiological systems are close to, or past, the threshold of symptomatic clinical failure. This formulation captures the notion that frail individuals are not merely ill but are in a state of generalised vulnerability - liable to deteriorate rapidly in response to stressors that a robust individual would tolerate without difficulty.

Fried and colleagues (2001) subsequently proposed the most widely cited operationalisation of frailty, defining it as a clinical syndrome in which three or more of the following criteria are present: unintentional weight loss of at least 10 lbs in the preceding year, self-reported exhaustion, muscular weakness as measured by grip strength, slow walking speed, and low physical activity. Individuals meeting one or two criteria are classified as pre-frail, while those meeting none are designated as robust. This phenotypic model emphasises the biological substrate of frailty and its independence from disability and comorbidity, although the three constructs are recognised as closely interrelated.

An alternative approach is the deficit accumulation model developed by Rockwood and Mitnitski, which conceptualises frailty as a quantitative index reflecting the proportion of health deficits present in a given individual. This model is inherently inclusive and can be adapted to any dataset that contains a sufficient

range of health-related variables, making it particularly suitable for secondary analysis of large surveys such as SAGE. The present study adopts a modified frailty index drawing on elements of both traditions, adapted to the specific variables available in the SAGE India dataset.

It is important to distinguish frailty from related but conceptually distinct constructs. Primary frailty is defined as the condition arising in the absence of a specific associated disease or substantial pre-existing disability; secondary frailty occurs in the context of established comorbidity such as dementia or cardiovascular disease (Boockvar & Mier, 2006). Frailty has historically been conflated with disability and comorbidity, but accumulating evidence supports its status as an independent clinical syndrome with a distinct biological basis (Fried et al., 2004). The clinical manifestations of frailty - decreased activity, anorexia, weight loss, fatigue, sarcopenia, osteopenia, balance impairment, and cognitive decline - reflect the downstream consequences of multisystem physiological dysregulation (Ferrucci et al., 2004).

2.2 Review of Empirical Evidence

The empirical literature on frailty has grown substantially over the past two decades, though the bulk of evidence remains concentrated in high-income country settings. Fried et al. (2001), in their seminal analysis of the Cardiovascular Health Study, found that frailty affected approximately 7% of community-dwelling adults aged 65 and above in the United States, with rates rising steeply with age. Frailty was found to be associated with lower educational attainment, reduced income, poorer self-rated health, and higher rates of chronic comorbidity. Crucially, frailty was an independent predictor of incident falls, hospitalisation, functional decline, and mortality over a three-year follow-up period.

Meredith et al. (2009), examining older Mexican Americans in the Hispanic Established Populations for Epidemiologic Studies of the Elderly (H-EPESE), found that pre-frail and frail status were significantly associated ($p < 0.001$) with lower scores across all dimensions of health-related quality of life, after adjustment for sociodemographic and health co-variables. This work underscored frailty's broad functional consequences and its clinical importance as a target for preventive intervention.

Yaw-Wen Chang et al. (2012) conducted a cross-sectional study of community-dwelling elderly persons aged 65 and above in Taiwan, using the Fried criteria to determine frailty status. They found that frailty prevalence was 9.6% and pre-frailty was 45.3%, and that both were associated with substantially lower scores on physical and mental health-related quality of life compared with robust individuals. The study highlighted the importance of early identification and intervention in the pre-frail stage, when functional decline may still be reversible.

Research on frailty in LMICs has been less extensive but is growing in volume. Studies from sub-Saharan Africa and Latin America have documented frailty prevalence rates ranging from 12% to 25% in community-dwelling older populations, with patterns generally consistent with those observed in high-income settings - higher frailty burden associated with female sex, advanced age, low socioeconomic status, and rural residence. The mechanisms linking poverty to frailty are likely to involve nutritional deficiency, limited access to healthcare, greater lifetime burden of infectious disease, and restricted opportunities for physical activity. In India specifically, the near-absence of empirical data on frailty makes the present study a timely and important contribution.

III. Data and Methodology

3.1 Data Source

This study uses data from the WHO Study on Global Ageing and Adult Health (SAGE) India Wave 1, conducted in 2007. SAGE is a longitudinal study implemented in six countries - China, India, Ghana, Mexico, Russia, and South Africa - with the primary objective of generating internationally comparable data

on the health and well-being of older adults and their social determinants. The Indian SAGE was conducted across six states: Assam, Karnataka, Maharashtra, Rajasthan, Uttar Pradesh, and West Bengal, representing diverse geographic, linguistic, and socioeconomic contexts.

The SAGE India Wave 1 covered 12,198 households. For the purposes of this study, only respondents aged 50 and above were retained, yielding an analytic sample of 6,560 individuals (Urban: 1,676; Rural: 4,884). The SAGE survey gathered comprehensive information on socioeconomic background, health state descriptions, burden of chronic disease, healthcare utilisation, physical and cognitive performance, and multiple indicators of health and functioning.

3.2 Construction of the Frailty Index

Frailty was operationalised through a modified version of the index developed by Fried and colleagues, adapted to the available variables in the SAGE India dataset. Seven deficit indicators were used to construct the index: (1) low grip strength (weakness), (2) slowness in gait, (3) low body mass index (undernutrition), (4) low physical activity, (5) cognitive limitation, (6) psychological limitation, and (7) exhaustion. Each indicator was dichotomised, with 1 indicating the presence of the deficit. Participants were classified into four frailty categories based on the total number of deficits present: Robust (0 deficits), Pre-frail (1–2 deficits), Intermediate frail (3–4 deficits), and Frail (5–7 deficits).

3.2.1 Definitions of Frailty Indicators

3.2.1.1 Weakness

Weakness was assessed by grip strength, measured separately for both hands using a dynamometer. Grip strength was stratified by BMI quartile and sex. An individual was classified as weak if their grip strength fell below the 20th percentile in their specific BMI-gender stratum. Table A1 presents the cutoff criteria.

3.2.1.2 Slowness

Gait slowness was determined from performance on a four-metre walk test. Participants were classified as slow if their time to complete the walk exceeded the 80th percentile within their height-gender stratum. Sex-specific height cutoffs and corresponding time thresholds are provided in Table A2.

3.2.1.3 Low Body Mass Index (Undernutrition)

In the original Fried phenotype, unintentional weight loss is a key criterion. Due to data constraints in the SAGE India survey, low BMI was used as a proxy indicator, consistent with the recommendation of the Canadian Initiative on Frailty and Aging. An individual was classified as undernourished if their BMI was 18.5 kg/m² or below.

3.2.1.4 Low Physical Activity

Energy expenditure was estimated using a modified International Physical Activity Questionnaire (IPAQ) Short Form (2005). Total weekly energy expenditure was derived by summing kilocalorie estimates for vigorous activity, moderate activity, walking, and cycling. Frailty thresholds were set at 504.8 kcal/week for men and 341.2 kcal/week for women.

3.2.1.5 Cognitive Limitation

Cognitive limitation was assessed using three self-reported variables: memory compared to the previous year, problems in remembering things, and problems in learning new things, each rated on a five-point scale. Responses were dichotomised, and participants reporting difficulty in at least two of these domains were classified as having cognitive limitation.

3.2.1.6 Physical Limitation

Two items assessed psychological limitation: perceived problems with sadness or depression and problems with worry or anxiety. Participants reporting problems in both domains were classified as having psychological limitation.

3.2.1.7 Exhaustion

Exhaustion was assessed by a single item: 'How much of a problem did you have with feeling tired/not having energy?' Responses were recoded such that none/mild (scores 1–2) were classified as non-exhausted and moderate/severe (scores 3–5) as exhausted.

3.3 Socioeconomic and Demographic Variables

Several socioeconomic and demographic co-variables were included: age group (50–59, 60–69, 70–79, 80+); sex (male, female); years of formal schooling (no schooling, 1–5 years, 6–9 years, 10+ years); wealth quintile (lowest to highest, derived from household asset indices); place of residence (urban, rural); state of residence (Assam, Karnataka, Maharashtra, Rajasthan, Uttar Pradesh, West Bengal); caste (SC/ST; Others); and religion (Hindu, Islam, Others).

3.4 Statistical Analysis

Descriptive analyses were conducted to characterise the distribution of frailty indicators and frailty conditions across socioeconomic and demographic subgroups. Column percentages are reported for frailty indicators by background characteristics. Multinomial logistic regression, implemented in Stata 13, was used to estimate the association between socioeconomic background variables and frailty conditions, with the robust category serving as the reference outcome. Odds ratios (OR) are reported alongside 95% confidence intervals (CI). Statistical significance was assessed at three levels: $p < 0.01$ (***), $0.01 \leq p < 0.05$ (**), and $0.05 \leq p < 0.10$ (*).

IV. Results

4.1 Sample Characteristics

Table 1 presents the socioeconomic and demographic profile of the analytic sample by urban-rural residence. The total sample of 6,560 respondents was distributed 26% urban and 74% rural, broadly consistent with India's demographic structure in 2007. The 50–59 age group constituted the largest share in both urban (45.4%) and rural (44.7%) settings, followed by the 60–69 group. Sex composition was broadly balanced, with a slightly higher proportion of males in rural areas (51.6%) compared with urban areas (47.2%).

Educational attainment varied markedly by residence. Among rural respondents, 58.4% had no formal schooling, compared with only 31.9% in urban areas. Conversely, 31.2% of urban respondents had 10 or more years of education, compared with just 10.5% in rural areas. Wealth distribution was also sharply differentiated: 43.1% of urban respondents fell in the highest wealth quintile, compared with 18.7% in rural

areas. SC/ST caste members constituted 25.9% of rural respondents and 13.0% of urban respondents. Hindu religion predominated across both residence categories (>83%). Among states, Rajasthan had the highest sample share (21.0% overall), and Assam the lowest (10.3%).

Table 1: Characteristics of sample of older adults aged 50 and above from WHO-SAGE India 2007

Characteristics	Urban (1,676)	Rural (4,884)	Total (6,560)
Age Group			
50–59	45.35	44.68	44.85
60–69	32.94	34.30	33.95
70–79	17.48	15.79	16.22
80+	4.24	5.24	4.98
Total	100	100	100
Sex			
Male	47.20	51.60	50.47
Female	52.80	48.40	49.53
Total	100	100	100
Years of Education			
No schooling	31.94	58.37	51.62
1–5 years	19.53	19.61	19.59
6–9 years	17.38	11.56	13.04
10+ years	31.16	10.47	15.75
Total	100	100	100
Wealth Index			
Lowest	4.77	20.26	16.28
Lower	8.47	22.22	18.69
Middle	16.29	19.25	18.49
Higher	27.33	19.60	21.59
Highest	43.14	18.65	24.95
Total	100	100	100
Caste			
SC/ST	13.01	25.94	22.64
Others	86.99	74.06	77.36
Total	100	100	100
Religion			
Hindu	83.41	84.64	84.33
Islam	10.92	12.45	12.06
Others	5.67	2.91	4.00
Total	100	100	100
State			
Assam	7.58	11.26	10.32
Karnataka	17.84	12.78	14.07
Maharashtra	27.86	12.92	16.74
Rajasthan	15.57	22.87	21.01
Uttar Pradesh	11.87	22.77	19.98
West Bengal	19.27	17.40	17.88
Total	100	100	100

4.2 Sample Characteristics

Table 2 presents the prevalence of individual frailty indicators across socioeconomic and demographic subgroups. Several consistent patterns emerge. First, the prevalence of every frailty indicator increases monotonically with age. Low grip strength rose from 12.8% in the 50–59 age group to 34.7% among those aged 80 and above; slowness increased from 14.3% to 57.0%; undernutrition from 34.2% to 57.7%; low activity from 11.3% to 52.5%; cognitive limitation from 23.2% to 60.0%; psychological limitation from 18.3% to 39.1%; and exhaustion from 27.4% to 56.7%. These gradients confirm the strong age-dependency of each component of frailty.

Second, sex differentials were notable for certain indicators. While low grip strength and undernutrition showed minimal sex differences (17.4% vs 17.7% and 40.3% vs 38.5% for males and females respectively), cognitive limitation (24.4% vs 38.5%), psychological limitation (20.1% vs 27.0%), and exhaustion (29.1% vs 40.7%) were substantially higher among women. These patterns likely reflect gender-specific social exposures, including lower educational attainment, fewer economic resources, and greater psychological burden of caregiving among older Indian women.

Third, a clear socioeconomic gradient was evident across the wealth index. Undernutrition was reported by 57.2% of respondents in the lowest wealth quintile, compared with only 22.4% in the highest. Similarly, cognitive limitation was reported by 41.7% in the lowest quintile versus 19.3% in the highest. These patterns were replicated across nearly all frailty indicators, suggesting that material deprivation is a powerful driver of frailty risk. Rural residents showed higher prevalence of most frailty indicators compared with urban residents, most notably for undernutrition (43.5% vs 28.9%) and cognitive limitation (34.1% vs 24.2%).

There was also meaningful interstate variation. Uttar Pradesh stood out for its exceptionally high rate of low grip strength (31.7%), while West Bengal showed the highest rates of cognitive limitation (46.2%) and exhaustion (46.7%). Karnataka exhibited a notably low prevalence of grip weakness (5.7%), suggesting possible measurement heterogeneity or genuine population differences in physical conditioning. SC/ST respondents consistently showed higher frailty indicator prevalence compared with other caste groups, particularly for undernutrition (50.1% vs 36.4%).

Table 2: Frailty indicators of older adults aged 50 and above by background characteristics from WHO-SAGE India 2007 (%)

Characteristics	Low Grip	Slowness	Under-nutrition	Low Activity	Cognitive Limit.	Psych. Limit.	Exhaustion
Age Group							
50–59	12.8	14.3	34.2	11.3	23.2	18.3	27.4
60–69	18.6	24.0	40.3	21.8	32.4	27.2	38.1
70–79	25.6	39.2	49.0	35.0	45.5	27.6	44.9
80+	34.7	57.0	57.7	52.5	60.0	39.1	56.7
Sex							
Male	17.4	24.6	40.3	20.0	24.4	20.1	29.1
Female	17.7	21.8	38.5	20.1	38.5	27.0	40.7
Residence							
Urban	27.3	26.57	28.88	23.66	24.23	18.86	30.27
Rural	13.6	21.83	43.54	18.58	34.12	25.35	36.63
Years of Education							
No schooling	18.8	23.6	46.8	20.8	40.4	28.3	40.7
1–5 years	16.8	25.6	37.7	22.5	26.3	23.8	36.2

5–9 years	11.2	20.1	36.0	18.9	24.0	19.2	29.8
10+ years	19.5	21.0	21.0	15.7	13.7	11.2	18.0
Wealth Index							
Lowest	20.6	21.5	57.2	18.9	41.7	31.8	45.6
Lower	18.9	25.4	47.2	17.6	37.0	25.4	36.9
Middle	20.1	21.0	42.5	20.0	35.0	28.0	35.4
Higher	14.4	23.8	33.3	22.2	26.7	20.1	31.5
Highest	14.9	24.0	22.4	21.0	19.3	14.6	26.8
State							
Assam	16.6	22.4	41.7	28.6	43.0	24.8	34.8
Karnataka	5.7	28.7	28.7	25.2	16.2	24.7	30.3
Maharashtra	10.9	22.9	31.8	21.3	26.3	23.7	38.4
Rajasthan	9.2	24.1	34.1	15.5	34.6	14.4	34.3
Uttar Pradesh	31.7	19.1	47.5	18.2	29.2	20.8	27.9
West Bengal	12.5	27.3	43.7	18.8	46.2	32.7	46.7
Caste							
SC/ST	19.2	19.4	50.1	18.5	35.9	27.1	39.0
Others	17.1	24.3	36.4	20.5	30.0	22.5	33.6
Religion							
Hindu	17.3	22.6	39.1	19.1	30.3	22.8	34.8
Islam	19.5	26.4	42.5	26.6	38.5	29.2	35.4
Others	16.6	27.8	35.4	17.8	28.8	19.7	33.2

4.3 Frailty Conditions by Background Characteristics

Table 3 shows the distribution of frailty categories - robust, pre-frail, intermediate frail, and frail - by background characteristics. Overall, the sample was distributed approximately as follows: 20.0% robust, 28.5% pre-frail, 35.3% intermediate frail, and 15.5% frail. The age gradient was striking: among those aged 50–59, 26.8% were robust and only 7.1% frail; by age 80 and above, only 4.1% remained robust while 50.8% were frail. This near-inversion of the frailty distribution across age groups underscores frailty as fundamentally an age-related phenomenon.

Female respondents showed a more adverse frailty profile than males: 18.3% of women were frail compared with 13.6% of men, and only 18.2% of women were robust compared with 22.1% of men. Rural respondents were somewhat more likely to be frail (17.1%) compared with urban respondents (13.0%). Educational attainment showed a strong inverse gradient: frailty prevalence fell from 21.0% among those with no schooling to 6.0% among those with 10 or more years of education. The corresponding increase in robustness was equally marked, rising from 13.9% to 34.8%.

Wealth showed a consistent inverse association with frailty: respondents in the lowest wealth quintile had a frailty prevalence of 24.6%, compared with 8.9% in the highest quintile. Robustness correspondingly increased from 12.4% (lowest) to 29.5% (highest). SC/ST respondents had higher frailty prevalence (19.1%) compared with others (15.0%). Among states, West Bengal (23.6%) and Assam (21.1%) had the highest frailty rates, while Karnataka (9.6%) and Rajasthan (11.6%) had the lowest.

Table 3: Frailty conditions of older adults aged 50 and above by background characteristics from WHO-SAGE India 2007 (%)

Characteristics	Robust (0 deficits)	Pre-frail (1–2)	Intermediate (3–4)	Frail (5–7)
Age Group				
50–59	26.8	34.3	31.8	7.1
60–69	17.8	26.8	37.2	18.2
70–79	9.4	20.1	42.2	28.3
80+	4.1	11.0	34.0	50.8
Residence				
Urban	21.04	30.60	35.40	12.96
Rural	19.85	27.87	35.20	17.07
Sex				
Male	22.1	31.6	32.7	13.6
Female	18.2	25.6	37.9	18.3
Years of Education				
No schooling	13.9	26.8	38.3	21.0
1–5 years	21.3	26.3	39.2	13.2
5–9 years	25.4	32.4	30.6	11.6
10+ years	34.8	34.7	24.5	6.0
Wealth Index				
Lowest	12.4	22.8	40.1	24.6
Lower	13.3	30.6	39.7	16.4
Middle	16.7	27.8	37.3	18.2
Higher	26.2	28.7	31.8	13.3
Highest	29.5	32.2	29.3	8.9
Caste				
SC/ST	16.3	27.0	37.6	19.1
Others	21.3	29.1	34.6	15.0
Religion				
Hindu	21.2	28.7	34.6	15.5
Islam	13.6	28.1	39.0	19.3
Others	19.4	31.1	37.1	12.4
State				
Assam	15.8	27.8	35.3	21.1
Karnataka	22.2	34.5	33.7	9.6
Maharashtra	24.9	30.7	28.7	15.7
Rajasthan	24.1	31.2	33.2	11.6
Uttar Pradesh	17.7	28.0	39.3	14.9
West Bengal	16.3	22.0	38.0	23.6

4.4 Multivariate Analysis: Determinants of Frailty

Table 4 presents the results of multinomial logistic regression estimating the independent effects of socioeconomic background characteristics on frailty conditions. Age group was the single strongest predictor of frailty. Relative to the 50–59 reference group, respondents aged 60–69, 70–79, and 80+ were 3.84, 12.74, and 48.78 times more likely to be classified as frail, respectively (all $p < 0.01$). The odds ratios for intermediate frailty followed a similar but less steep gradient: 1.73, 4.03, and 6.54 for the 60–69, 70–79, and 80+ age groups respectively. These findings confirm the overwhelming importance of chronological age as a predictor of frailty severity in the Indian context.

Educational attainment demonstrated a strong and statistically significant inverse association with frailty. Compared with respondents with no formal schooling, those with 1–5 years of education were 0.46 times as likely to be frail (95% CI: 0.31–0.69); those with 5–9 years were 0.43 times as likely (95% CI: 0.27–0.67); and those with 10 or more years were only 0.22 times as likely (95% CI: 0.11–0.46). A similar protective gradient was observed for the pre-frail and intermediate categories, although the magnitude was somewhat smaller.

Wealth was independently and inversely associated with frailty. Respondents in the higher wealth quintile were 0.46 times as likely to be frail as those in the lowest quintile (95% CI: 0.29–0.73), and those in the highest quintile were 0.29 times as likely (95% CI: 0.17–0.49). Both estimates were significant at $p < 0.01$. Rural residence was associated with lower odds of intermediate frailty compared with urban (OR = 0.66, $p < 0.05$), though the association with frailty itself did not reach statistical significance. Female sex was associated with marginally higher odds of being frail (OR = 1.09, $p < 0.10$).

Interstate variation was significant even after controlling for individual socioeconomic characteristics. Relative to Assam (reference), respondents in Karnataka (OR = 0.25), Maharashtra (OR = 0.36), Rajasthan (OR = 0.24), and Uttar Pradesh (OR = 0.46) were all substantially less likely to be frail (all $p < 0.01$). West Bengal did not differ significantly from Assam for frailty. Caste (SC/ST vs others) and religion did not show statistically significant independent associations with frailty once other factors were controlled.

Table 4: Multinomial logistic regression estimates of socioeconomic background characteristics on frailty conditions, adults aged 50+ from WHO-SAGE India 2007

Socioeconomic Variable	Pre-frail vs Robust	Intermediate vs Robust	Frail vs Robust
Age Group (ref: 50–59)			
60–69	1.16 (0.92–1.40)	1.73*** (1.37–2.19)	3.84*** (2.79–5.29)
70–79	1.70*** (1.40–2.40)	4.03*** (2.88–5.62)	12.74*** (8.21–19.77)
80+	2.00* (0.92–4.20)	6.54** (3.27–13.08)	48.78*** (24.19–98.39)
Sex (ref: Male)			
Female	0.76** (0.61–1.00)	1.07 (0.85–1.35)	1.09* (0.81–1.45)
Residence (ref: Urban)			
Rural	0.72** (0.44–0.94)	0.66** (0.50–0.86)	0.79 (0.53–1.18)
Years of Education (ref: No schooling)			
1–5 years	0.63*** (0.47–0.86)	0.79 (0.59–1.07)	0.46*** (0.31–0.69)
5–9 years	0.67*** (0.48–0.94)	0.58** (0.41–0.83)	0.43*** (0.27–0.67)
10+ years	0.53*** (0.38–0.76)	0.39*** (0.28–0.55)	0.22*** (0.11–0.46)
Wealth Index (ref: Lowest)			
Lower	1.31 (0.87–2.00)	0.99 (0.68–1.45)	0.71 (0.46–1.11)
Middle	1.01 (0.68–1.50)	0.84 (0.58–1.22)	0.82 (0.52–1.31)
Higher	0.70* (0.48–1.00)	0.52*** (0.36–0.76)	0.46*** (0.29–0.73)
Highest	0.78 (0.52–1.20)	0.46*** (0.31–0.67)	0.29*** (0.17–0.49)
State (ref: Assam)			

Karnataka	0.88 (0.60–1.30)	0.63** (0.43–0.91)	0.25*** (0.16–0.39)
Maharashtra	0.68* (0.46–1.00)	0.44*** (0.30–0.64)	0.36*** (0.22–0.58)
Rajasthan	0.65** (0.45–0.90)	0.51*** (0.36–0.72)	0.24*** (0.15–0.38)
Uttar Pradesh	0.80 (0.56–1.20)	0.85 (0.60–1.20)	0.46*** (0.30–0.71)
West Bengal	0.71 (0.47–1.10)	0.92 (0.62–1.34)	0.92 (0.59–1.42)
Caste (ref: SC/ST)			
Others	1.01 (0.76–1.30)	1.03 (0.79–1.34)	1.00 (0.69–1.45)
Religion (ref: Hindu)			
Islam	1.32 (0.93–1.90)	1.32 (0.91–1.90)	1.44 (0.97–2.13)
Others	1.19 (0.67–2.10)	1.26 (0.73–2.17)	0.88 (0.33–2.35)

Notes: *** = P < .01; ** = .01 ≤ P < .05; * = .05 ≤ P < .10. Figures in parentheses are 95% confidence intervals.

V. Discussion

This study offers the first large-scale empirical characterisation of frailty among older adults in India, using a nationally representative sample covering six geographically and socioeconomically diverse states. The findings reveal that frailty is not only prevalent - affecting approximately one in six adults aged 50 and above - but that it is profoundly and consistently shaped by socioeconomic disadvantage. These results have important implications for both the conceptualisation of frailty in the Indian context and for the design of targeted preventive and health promotion interventions.

The age gradient in frailty observed in this study is consistent with global evidence. The dramatic escalation in frailty prevalence from 7.1% in the 50–59 age group to 50.8% in those aged 80 and above confirms that frailty is fundamentally a syndrome of physiological ageing. The near-linear increase in odds ratios for frailty with each successive age group in the regression analysis - reaching almost 49 times for the 80+ group relative to those aged 50–59 - reflects the cumulative nature of deficit accumulation described in the theoretical literature (Rockwood & Mitnitski, 2007). Clinicians and public health practitioners should view individuals entering their seventh decade as a critical target population for frailty screening and preventive intervention.

The sex differentials in frailty observed here merit careful interpretation. Although women showed moderately higher frailty rates - reflecting higher burdens of psychological limitation, exhaustion, and cognitive difficulty - the difference did not emerge as a highly significant independent predictor in the multivariate model, with a borderline odds ratio of 1.09 ($p < 0.10$). This is consistent with the broader literature, where the relationship between female sex and frailty is attenuated when socioeconomic factors are controlled, suggesting that much of women's apparently higher frailty burden reflects structural disadvantage - lower education, lower wealth, greater exposure to poverty - rather than inherent biological sex differences.

The strong protective effects of education against frailty deserve emphasis. Education is widely recognised as a fundamental social determinant of health, operating through multiple pathways: greater health literacy, better access to healthcare, more health-promoting behaviours, higher lifetime earnings, and reduced psychosocial stress. In the Indian context, where a majority of older women in rural areas have no formal schooling, the highly significant education gradient in frailty represents both a profound health equity issue and an argument for sustained investment in educational attainment for younger cohorts, with downstream benefits for healthy ageing several decades hence.

Similarly, the wealth gradient in frailty is both statistically and substantively important.

Respondents in the lowest wealth quintile faced frailty odds nearly three and a half times higher than those in the highest quintile, even after adjusting for other factors. This finding is consistent with the growing body of evidence linking material poverty to frailty through pathways including nutritional insufficiency, physical inactivity, elevated allostatic load from chronic stress, and limited access to preventive healthcare. Programmes targeting food security, nutritional supplementation, and access to physical rehabilitation services among low-income older adults are therefore likely to yield significant frailty prevention benefits.

The interstate variation in frailty, which persisted even after controlling for individual-level socioeconomic characteristics, points to the importance of structural state-level factors - including health infrastructure, public health investment, climate, and agricultural practice - in shaping frailty risk. The relatively low frailty rates in Karnataka, Maharashtra, and Rajasthan compared with Assam and West Bengal require further investigation. Potential explanatory factors include differences in dietary patterns, physical activity norms, the quality and accessibility of primary healthcare, and state-level social protection programmes. Future research should attempt to decompose these state-level effects into their contributing pathways.

Several limitations of the present study should be acknowledged. First, the cross-sectional design of the SAGE India Wave 1 precludes causal inference; the observed associations between socioeconomic variables and frailty may reflect reverse causation (frailty leading to poverty) or residual confounding. Second, the frailty index constructed here departs somewhat from the original Fried phenotype, notably in substituting low BMI for unintentional weight loss and in including psychological and cognitive limitation as frailty components. While these adaptations were necessitated by data availability and are defensible on conceptual grounds, they limit direct comparability with studies using the standard Fried criteria. Third, the SAGE India data are now nearly two decades old; the frailty landscape may have changed with subsequent improvements in nutrition, healthcare access, and living standards in some parts of India. Updated estimates from more recent surveys are needed.

VI. Conclusion

This study provides robust empirical evidence that frailty is a prevalent and socially patterned condition among older adults in India. Using data from the WHO-SAGE India Wave 1 survey and a modified seven-component frailty index, frailty was found to affect 15.5% of adults aged 50 and above, rising to more than half of those aged 80 and above. Frailty was strongly and independently associated with advanced age, low educational attainment, low wealth, female sex, and specific state of residence. Individual frailty indicators showed consistent socioeconomic gradients, with undernutrition, cognitive limitation, and exhaustion all markedly more prevalent among disadvantaged subgroups.

These findings have clear policy implications. First, frailty screening should be integrated into India's existing primary healthcare infrastructure, particularly for adults aged 60 and above. Second, nutritional supplementation and food security programmes should explicitly target older adults in low-income rural households, where undernutrition rates exceed 43%. Third, educational investments in younger cohorts will yield long-term dividends for healthy ageing, given the strong protective effect of schooling on frailty risk. Fourth, state-level variation in frailty rates argues for tailored health promotion strategies that account for regional differences in frailty burden and its determinants.

Future research should build on these findings using longitudinal designs capable of establishing causal pathways between socioeconomic disadvantage and frailty onset. The development of culturally validated, standardised frailty assessment tools for the Indian context - drawing on both the Fried phenotype and the deficit accumulation model - will be essential for enabling cross-study comparability and guiding clinical practice. As India's older population continues to grow, frailty will inevitably become an increasing burden on families, communities, and healthcare systems. An evidence-based, proactive approach to frailty prevention is not only a moral imperative but also an economic necessity for sustaining the health and productivity of India's ageing population.

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