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ORIGINAL ARTICLE

Age and socioeconomic gradients in frailty among older adults in India

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Abstract

Background Although individuals with frailty and lower socioeconomic status (SES) are vulnerable to morbidity and early mortality, few studies have investigated this association. We intend to fill this gap with a study using older adults aged ≥ 50 years from the SAGE WAVE I 2007 in India.

Objective The two objectives of the study are to examine the association of frailty with SES and how this association varies across different age groups.

Methods A modified Fried phenotype approach with five frailty indicators was used to categorize 6560 older adults as frail, pre-frail or robust who had more than two, one or zero indicators, respectively: grip strength, exhaustion, weight loss, walking speed and physical activity. Multinomial logistic regression estimated the likelihood of being pre-frail and frail for various levels of SES, controlling and not controlling for confounders. This study also shows the overall socioeconomic gradients and age patterns of socioeconomic gradients of frailty indicators using predicted probabilities.

Results Approximately 26%, 55% and 20% participants were robust, pre-frail and frail, respectively. The number of frailty indicators was positively associated with lower income and education levels in the case of controlling and not controlling for confounders. Also, among the higher age groups, individuals with low SES had higher chances of being frail.

Conclusion Overall, the results in this article indicated a negative low SES and frailty association as found in previous studies worldwide. This highlights the need for comprehensive and centered public health interventions for older adults with low SES.

Keywords Frailty · Socioeconomic status · SAGE · Older adults

Background

Poor health is shown to be one of the outcomes of low socioeconomic status in the literature (Hogan 2003; Newman et al. 2001; Garre-Olmo et al. 2013). Researchers in developed countries have intensively studied an inverse association between socioeconomic status and health (Mirowsky and Ross 2008). Interestingly, the SES well-being gradient appears to be less reliable across well-being indicators for lower- and middle-income countries (LMICs). There is evidence of better reporting of self-rated health and lower mortality rates with higher SES and years of schooling among older adults in Asia and Latin America (Hurt et al. 2004; Smith and Goldman 2007; Liang et al. 2000). These relationships are consistent regardless of measurement of SES by wealth, education, income or occupation (Ostrove et al. 1999; Kitagawa and Hauser 1973; McDonough et al. 1997 Marmot et al. 1984). However, SES is not consistently related to well-being indicators in low- and middle-income countries (LMICs); the association of SES and functional limitations is significantly less steady and generally weaker (Zimmer et al. 2002, 2004; Zimmer and Amornsirisomboon 2001; Zimmer and Kwong 2004; Rosero-Bixby and Dow 2009). Studies are scarce on how health varies among different socioeconomic statuses within a country as well as on the socioeconomic gradient of frailty.

The number of older individuals with lower education levels is expanding faster than that of those with more education (Morenoff et al. 2004). This makes understanding how education and other sociological variables are especially important to comprehending disparities in well-being among older individuals imperative (Taylor et al. 1997; Pollitt et al. 2007; Steptoe et al. 2002). A study on a Swiss population characterized by universal health insurance coverage analyzed

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determinants of frailty with an emphasis on socioeconomic gradient (Guessous et al. 2014) and showed that, regardless of all-inclusive medical coverage scope, family income is independently related with frailty. A longitudinal study in Hong Kong showed that individuals with lower SES are more likely to be frail (Woo et al. 2005). A study assessing the association of race and frailty showed that SES was not related to probability of frailty (Hirsch et al. 2006). Another study explored whether low income and education predict self-reported frailty (Fugate et al. 2005).

Frailty is a geriatric disorder that results from combined decays of different physiologic frameworks and makes individuals vulnerable to stressors because of hindrance of the physiologic reserve and unfavorable health outcomes (Hogan 2003). Despite decades of endeavors to construct a standard and quantifiable conceptualization of the frailty disorder, there is no standard definition of frailty (Rodríguez-Mañas et al. 2013). Distinguishing frail older adults in the elderly population is essential as they have special health care needs. This might enable clinicians to determine which individuals are at greater risk of unfavorable health outcomes including demise, hospitalization and death (van Kan et al. 2010). Research has shown that frailty is variable and ranges from 4.0 to 59.1% of the considered population. Frailty can be partly or fully reversed in its starting phase and is recognized as a modifiable predictor of disability (Sternberg et al. 2011). Furthermore, recognizing frail older adults and following up with viable interventions could conceivably forestall disability and other unfavorable health results. The relationship of frailty and SES among older adults has not been widely investigated. We address these issues in this study by showing the prevalence of frailty indicators and evaluating the relationship between frailty indicators and lower SES in a population-based investigation of older adults using SAGE data.

Data

The data for the present study are taken from WAVE I of the WHO multi-country study on Global Aging and Adult Health (SAGE) concentrated on three upper-middle-income countries (South Africa, Mexico and the Russian Federation), two lower-middle countries (China and India) and one low-income country (Ghana) according to the 2007 World Bank Income categories. SAGE WAVE I was implemented in India in 2007 to collect information on a range of characteristics such as socioeconomic and demographic characteristics, access to health insurance, responsiveness of the health system, utilization of health care services, chronic health conditions, caregiving among older adults, subjective well-being and quality of life. Subtle details of the sampling techniques and information collection strategies utilized as part of India's SAGE have been explained elsewhere (Kowal et al. 2012).

The SAGE study in India consists of a sample of 11,230 respondents, 6873 women and 4357 men, aged 18 years and older in six states: Assam, Karnataka, Maharashtra, Rajasthan, Uttar Pradesh and West Bengal. The SAGE states vary greatly in the levels of economic advancement, geographic areas and stages of demographics and well-being level and are representative of the whole nation. Our study only incorporates individuals aged 50 and above and includes 3311 males and 3249 females.

Hypotheses

Addressing the research gaps in the SES Health debate in India, this article tests two hypotheses: (1) higher SES is negatively associated with frailty; (2) the SES differences in frailty tend to increase with age.

Socioeconomic status Self-reported years of schooling and income were used to characterize SES. Education levels were categorized into five groups: high (≥ 10 years), middle (6–9 years), moderate (1–5 years) and low (0 years). The second SES indicator, the household wealth index, was computed based on a detailed list of household asset items using a hierarchical ordered probit (DIHOPIT) model (Ferguson et al. 2003). Quintile 1 is the lowest with the poorest households and quintile 5 the highest with the richest households.

Frailty Frailty indicators were evaluated by utilizing a modified version of the index developed by Fried and colleagues (2001). These indicators had to be modified because our population has different characteristics from the original Hispanic population for which Fried and colleagues defined the cutoff points. Also, many previous studies defined valid frail indicators according to the study population (Blaum et al. 2005). Each of the frail indicators yielded a dichotomous score of 0 or 1 based on the following criteria:

Shrinking Due to unviability of data on weight loss during the past 1 year, we took the BMIs for both the sexes in the lowest quintile to measure shrinking and assigned a value of 1 and 0 otherwise.

Exhaustion The study participants were asked, "Do you have enough energy for your daily activities?" Those who responded "not at all" or "a little" were classified as exhausted and assigned a score of 1 and 0 otherwise.

Low activity The self-reported timings spent on vigorous and moderate activities listed in the Global Physical Activity Questionnaire (Bull et al. 2009) were added up. The respondents who spent more > 300 min a week were classified as physically active and assigned a value of 1 and 0 otherwise.

Weakness This was measured by grip strength and was defined as the gender-specific and BMI-adjusted lowest quintile measure and assigned a value of 1 and 0 otherwise. The grip strength test was performed on both hands with a hand dynamometer using the mean of three measurements.

Slow walking speed This was defined as being in the lowest quintile for a 4-m timed walk at a usual pace (height and sex standardized).

These dichotomous scores were added from the above five indicators. Individuals were considered robust if they did not have any of the frailty indicators, pre-frail if they fell in the range of 1–2 frailty indicators and frail if they had more than three frailty indicators.

Socioeconomic, demographic and spatial variables

We also included the control variables that could be related to frailty and SES in the study. The socioeconomic and demographic variables were: gender (male or female), age (grouped as 50–54, 55–59, 60–64, 65–69, 70–74, 75–79 and 80 plus), educational level (no education, less than primary, primary, secondary and higher), marital status (never married, currently married, separated/divorced and widowed), state of residence, locality (urban or rural), religion (broadly categorized as Hindu, Muslim and other), caste (categorized as Scheduled Castes/Scheduled Tribes and other) and marital status (currently married or cohabiting and other). The household wealth index was computed based on a detailed list of household asset items using a hierarchical ordered probit (DIHOPIT) model (Ferguson et al. 2003). Quintile 1 was the lowest with the poorest households and quintile 5 the highest with the richest households.

Health Behavior Variables

Questions about alcohol use and smoking status were assessed by the health interview survey and included as covariates in our analyses. The health risk variables were: tobacco use [current users (daily or non-daily) or non-user]; alcohol consumption [current user (consumed alcohol in the last 30 days) or non-user].

Health status variables

Individuals who had suffered injury in the last 12 months because of falls were categorized under falls. Limitations in the activities of daily living (ADL) were used to assess the functional limitation. SAGE Survey data collected on ADLs were based on self-reports about particular activities in the last 30 days and rated on a five-point scale ranging from none to extreme difficulty. In this study, severe and extreme difficulties were combined to represent limitations in a particular activity. The ADLs included sitting, walking, standing up, standing, climbing, crouching, picking up, eating, dressing, using the toilet, moving around in the home, transferring and concentrating for about 10 min. Biomarkers were assessed using the BMI, waist-to-hip ratio, systolic and diastolic blood pressure and grip strength.

Analytical approach

We performed the analysis in three stages. In the first step, bivariate analysis was used to understand the differentials in frailty status by socioeconomic and demographic variables, health risk factors and biomarkers. Also, distribution of background characteristics by education categories and household wealth quintiles was presented. Multivariate analysis (multinomial logistic regression) was used to assess the adjusted impact of SES on frailty. We used multinomial logistic regression to model the association between frailty status and SES at the individual level with demographic and socioeconomic predictors along with risk factors and biomarkers. The logit-link function was formulated as:

$$\text{Logit}\left(p_{ij}\right) = \log\left[\left(\frac{p_i}{1-p_i}\right)\right] = \beta_0 + \beta_1 X_i + \beta_2 SES + \varepsilon_i$$

Here, the response variables (y is zero if the individuals are robust, 1 if they are pre-frail and 2 if they are frail) for each individual were related to a set of categorical predictors, Xi (age, sex, education level, wealth quintile, place of residence, state, 1+ ADL, chronic diseases, falls, alcohol consumption and smoking tobacco, and biomarkers), and ε was assumed to be a zero mean error term. Finally, we estimated the predicted probabilities to compare change in frailty with SES over different age groups. In all the regression models, the control variables were used to generate adjusted estimates.

Results

Table 1 shows the baseline characteristics of the 6560 older adults. The study covered a nationally representative sample of 6560 individuals aged 50 years and above. Approximately 26% of the older adults were robust, 55% were pre-frail, and 20% were frail. With increasing age, the prevalence of frailty increased and percentage of robust individuals decreased; for example, in the 50–59-year age group, 34.4% were robust, but this decreased to 22.6% in the 60–69-year age group and further reduced to 10.5 and 1.9% in the age groups of 70–79 and 80+ years, respectively. The percentage of frail people

Table 1 Percentage distribution of number of frailty status among older adults in India by selected background characteristics

Variables	Exhaustion	Weakness	Slowness	Low weight	Low physical activity		Frailty Indicators	
	(*n* = 1797, 27.4)	(*n* = 1426, 21.7)	(*n* = 1521, 23.2)	(*n* = 2250, 35.3)	(*n* = 2016 30.7)	Robust (*N* = 1672, 25.5)	Pre-frail (*N* = 3610, 55.04)	Frail (*N* = 1277, 19.5)
Sex								
Male	19.8	25.0	24.3	39.9	30.0	27.1	54.8	18.1
Female	34.5	23.9	21.4	37.7	33.0	23.8	55.3	20.9
Age groups (years)								
50–59	16.5	17.2	14.0	33.6	21.0	34.4	57.9	7.8
60–69	30.4	27.3	24.0	39.2	31.9	22.6	56.2	21.2
70–79	43.4	33.9	38.5	49.5	53.7	10.5	48.5	40.9
80+	58.8	49.5	55.5	56.3	63.2	1.9	38.7	59.4
Years of schooling								
No schooling	36.2	26.7	23.2	46.3	32.8	38.9	53.3	63.5
1–5 Years	25.1	24.5	25.3	37.4	33.1	20.4	17.8	21.0
6–9 Years	16.3	16.4	19.8	34.2	27.3	16.3	13.3	8.1
10+ Years	8.6	23.9	21.0	21.0	28.6	24.4	15.5	7.4
Wealth quintile								
Poorest	40.0	28.3	21.9	55.8	29.6	15.7	58.9	25.4
Poorer	31.7	25.7	25.0	45.1	31.0	20.5	57.0	22.5
Middle	24.3	25.5	21.0	40.5	30.8	26.9	53.5	19.6
Richer	21.9	21.0	23.0	28.8	34.9	33.3	51.2	17.5
Richest	14.3	20.8	23.5	20.5	31.6	35.3	53.7	11.0
State								
Assam	20.4	11.9	26.5	28.6	36.7	23.1	52.6	24.4
Karnataka	30.2	18.6	22.8	31.6	36.4	30.6	54.1	15.3
Maharashtra	22.6	17.2	24.0	33.7	26.0	26.4	56.7	16.9
Rajasthan	22.9	37.2	19.0	47.0	31.1	33.7	51.5	14.7
Uttar Pradesh	36.1	25.1	22.4	41.3	36.0	20.9	56.7	22.3
West Bengal	35.6	20.8	27.3	41.8	24.7	24.8	53.5	21.8
Residence								
Rural	29.6	21.9	21.5	42.8	28.2	26.1	54.5	19.4
Urban	20.7	30.7	26.3	28.7	39.5	24.0	56.3	19.7
Caste								
Others	33.5	26.5	19.1	49.5	26.5	26.6	54.8	18.7
SC/ST	25.2	23.9	24.0	35.8	32.9	21.7	56.1	22.3
Religion								
Hindu	25.9	24.1	22.2	38.7	30.6	26.4	55.2	18.4
Muslim	35.6	26.9	26.3	41.2	38.1	19.2	53.7	27.1
Others	24.1	23.8	27.8	32.1	28.5	26.3	55.8	17.9
Marital status								
Currently married	21.8	23.3	21.5	36.9	27.7	14.9	51.9	33.2
Otherwise	44.5	28.4	27.6	45.4	44.0	28.7	55.9	15.3
Chronic disease								
None	34.4	38.8	31.8	47.3	35.4	28.9	57.0	14.2
One-two	29.1	30.0	31.5	27.6	28.3	26.8	53.9	19.3
Above	36.6	31.2	36.6	25.2	36.3	18.6	53.2	28.2
Consume alcohol								
Yes	23.7	25.1	21.9	29.2	85.4	25.0	55.3	19.7

Table 1 (continued)

Variables	Exhaustion ($n = 1797$, 27.4)	Weakness ($n = 1426$, 21.7)	Slowness ($n = 1521$, 23.2)	Low weight ($n = 2250$, 35.3)	Low physical activity ($n = 2016$ 30.7)	Frailty Indicators		
						Robust ($N = 1672$, 25.5)	Pre-frail ($N = 3610$, 55.04)	Frail ($N = 1277$, 19.5)
No	27.6	21.2	23.1	31.9	14.6	28.0	53.8	18.2
Tobacco								
No	50.9	47.0	53.9	58.6	56.0	27.6	52.6	19.8
Yes	49.2	53.0	46.1	41.4	44.0	23.3	57.5	19.2
Falls over the last year								
No	24.3	26.36	22.49	38.71	31.5	25.6	55.3	19.0
Yes	27.0	36.22	28.59	40.25	31.3	23.4	51.0	25.6
1 + ADL limitations								
Zero	21.4	13.1	15.7	36.5	25.5	32.8	56.4	10.9
One	28.1	43.7	31.5	41.6	38.7	16.7	53.5	29.8
Biomarker								
Systolic blood pressure	123.61 (27.62)	121.11 (25.67)	115.89 (42.92)	119.00 (21.37)	120.86 (33.87)	124.52 (20.09)	118.00 (31.07)	122.40 (27.94)
Diastolic blood pressure	80.48 (17.95)	74.78 (28.51)	78.85 (17.16)	78.41 (14.13)	78.69 (22.57)	82.34 (14.06)	77.68 (20.90)	79.71 (18.12)
Waste/hip ratio	0.92 (0.08)	0.92 (0.08)	0.91 (0.10)	0.93 (0.08)	0.93 (0.09)	0.93 (0.08)	0.92 (0.09)	0.92 (0.09)
Grip strength	18.03 (10.38)	12.28 (4.72)	19.39 (14.98)	19.49 (9.76)	18.45 (11.91)	26.07 (8.39)	21.14 (10.80)	14.78 (11.00)
BMI	19.84 (7.05)	19.61 (5.36)	20.62 (7.25)	16.44 (1.66)	20.29 (6.62)	22.81 (4.21)	20.17 (5.18)	18.13 (6.53)

Weighted percentages were obtained using sampling weights provided in the data set and excluding the missing case

was 7.8% in the 50–59-year age group and reached 59.4% in those aged 80+. Nearly 27% of the Muslims were frail compared with 18% of the Hindus. A considerably higher proportion of females reported the presence of frailty. Each gradient after zero years of schooling was associated with a lower presence of frailty. The percentage of frail individuals decreased with higher wealth quintiles. Hence, respondents in higher wealth quintiles reported low frailty. We found leveling off of the presence of frailty among rural and urban residents. Among the states, Uttar Pradesh had the highest presence of both pre-frailty and frailty (56.7 and 22.3% respectively), while Rajasthan had the lowest percentage of pre-frailty and frailty, respectively. Frailty is linked to chronic diseases; the more chronic diseases that were reported, the higher the frailty rate. Only 14.2% of older adults without any chronic diseases were frail compared with 28.2% among those who had two+ chronic diseases. The percentage of frailty was higher among those who smoked and consumed alcohol compared with their counterparts, but there was not a considerable difference. The presence of frailty was higher among those who had experienced falls in the last 12 months and among those with 1+ ADL limitations (25.6 and 29.8%, respectively).

Figure 1 shows the distribution of frailty status by age group. The percentage of frail individuals over age groups increased moving up from 50 to 59 to the 80+ age group, whereas the percentage of robust individuals decreased.

From the Table 2 it is clear that Among the frail indicators, the most reported problems were low weight and low physical activities (35.3% and 30.7, respectively) followed by

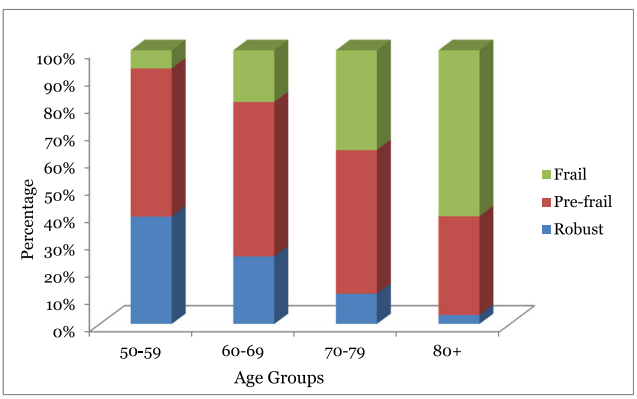

Fig. 1 Prevalence of robust, pre-frail and frail participants by age group, SAGE Study, India, 2007, = 6560. Comparison

Table 2 Percentage distribution of background characteristics by socioeconomic status among older adults in India by selected background characteristics

Variables	Years of schooling				Poorest	Wealth quintile			Richest
	Zero	1–2	3–5	10+		Poorer	Middle	Richer	
Sex									
Male	30.9	60.1	75.8	85.4	49.1	50.2	51.1	53.6	52.5
Female	69.1	39.9	24.2	14.6	50.9	49.8	48.9	46.4	47.5
Age groups (years)									
50–59	43.7	46.6	55.0	61.9	44.5	47.0	51.0	52.0	49.6
60–69	32.6	32.8	29.7	23.8	33.5	30.8	30.0	30.0	29.8
70–79	17.8	15.7	13.0	12.8	16.4	18.1	15.1	15.0	15.0
80+	5.9	4.9	2.3	1.6	5.6	4.2	4.0	3.0	5.6
State									
Assam	3.9	6.2	6.5	5.6	4.4	4.8	6.9	4.3	4.5
Karnataka	12.3	12.5	10.7	13.0	6.7	8.8	14.1	19.7	13.4
Maharashtra	18.4	26.5	25.9	21.5	22.2	17.0	25.0	22.6	21.0
Rajasthan	14.1	9.1	7.3	7.4	7.3	10.6	9.7	11.9	16.9
Uttar Pradesh	36.3	25.8	24.9	36.5	33.3	37.3	30.9	31.5	30.6
West Bengal	15.1	19.9	24.7	16.1	26.1	21.6	13.5	10.0	13.7
Residence									
Urban	19.7	33.0	35.5	48.0	15.4	20.1	30.7	33.8	47.9
Rural	80.3	67.0	64.5	52.0	84.6	79.9	69.3	66.2	52.1
Caste									
SC/ST	71.9	79.9	80.8	93.4	59.0	74.0	81.2	86.1	93.8
Others	28.1	20.1	19.2	6.6	41.0	26.0	18.8	13.9	6.2
Religion									
Hindu	82.0	82.8	86.8	92.0	81.6	80.6	83.3	88.8	88.3
Muslim	15.0	13.0	8.6	5.8	14.2	16.3	12.9	9.3	8.1
Others	2.9	4.2	4.6	2.6	4.2	3.1	3.8	1.9	3.7
Marital status									
Currently married	32.7	17.3	12.2	8.0	31.5	22.8	24.2	18.2	17.2
Otherwise	67.3	82.8	87.8	92.0	68.5	77.3	75.8	81.8	82.8
Chronic disease									
None	46.0	39.0	44.9	40.4	49.6	46.8	45.4	38.2	36.1
One–two	27.5	34.6	29.4	29.6	26.8	26.8	30.2	33.2	31.2
Above	26.6	26.4	25.7	30.0	23.6	26.4	24.4	28.5	32.7
Alcohol									
Yes	86.7	79.6	81.7	83.6	80.1	83.3	84.5	87.5	86.8
No	13.3	20.4	18.3	16.4	19.9	16.8	15.5	12.5	13.2
Tobacco									
No	51.4	46.1	43.2	55.2	39.7	44.6	47.7	56.6	63.8
Yes	48.6	53.9	56.8	44.8	60.3	55.4	52.3	43.4	36.2
Falls									
No	92.5	93.6	93.9	95.7	92.7	93.3	93.5	93.8	94.0
Yes	7.5	6.4	6.1	4.3	7.3	6.7	6.5	6.3	6.0
1 + ADL									
Zero	47.0	54.7	64.7	70.9	48.6	53.4	51.9	58.3	62.1
One	53.0	45.3	35.4	29.1	51.4	46.6	48.1	41.7	37.9
Biomarker									
Systolic BP	120.67	120.87	120.69	121.39	119.36	118.75	121.07	121.20	123.99

Table 2 (continued)

Variables	Years of schooling				Poorest	Wealth quintile			Richest
	Zero	1–2	3–5	10+		Poorer	Middle	Richer	
Diastolic BP	79.14	79.64	80.12	78.77	78.41	78.10	80.25	79.31	80.50
Waist/hip ratio	0.92	0.93	0.93	0.95	0.92	0.92	0.92	0.93	0.93
Grip strength	18.57	22.11	24.84	25.67	20.10	20.15	20.66	22.19	23.30
BMI	19.83	20.62	20.55	22.23	18.85	19.91	20.18	21.01	22.75

Weighted percentages are obtained using sampling weights provided in the data set and excluding the missing case

exhaustion (27.4%), weakness (21.7%) and slowness (23.2%). The presence of each frailty indicator increased with age. The percentage of exhaustion and low physical activity was higher among women, whereas reporting of weakness, slowness and low weight was higher among men. The prevalence of exhaustion and low weight decreased with each gradient of years of schooling. The highest reporting of exhaustion, weakness, low weight, slowness and low physical activity was among the states Uttar Pradesh, Rajasthan, West Bengal and Assam, respectively. Urban older adults had a higher prevalence of weakness, slowness and low physical activity, and rural people had more individuals with exhaustion and low weight. Individuals with falls had the highest reporting of exhaustion and slowness followed by low weight, weakness and low physical activity. Among the tobacco users, the most (53%) reported exhaustion and the least (41%) low weight. Reporting of low weight was lower among individuals with one to two and more chronic diseases. About one fourth of the older adults with 1 + ADL reported exhaustion. The prevalence of exhaustion, slowness and low physical activities was higher, and the prevalence of low weight was lower in the older adults with 1+ ADLs.

Figure 2 presents the predicted probability of individuals having specific frailty indicators by age group. Among the various frailty indicators, the predicted probability was higher for low weight in the 50–59 and 60–69 age groups and for low physical activity for the 70–79 and 80+ age groups. The predicted probability increased faster for all types of frailty indicators after 50 years of age, indicating the vulnerability of older people and their health.

In the Table 3 the multinomial logistic regression analysis demonstrates that the measures of socioeconomic status were significantly associated with frailty. In the unadjusted model, if individuals moved up from the lowest wealth quintile, the likelihood of being prefrail compared with robust was expected to decrease given years of schooling in the model were held constant (poorer RRR = 0.731, $p < 0.05$, 95% CI = 0.578, 0.925; middle RRR = 0.488, $p < 0.001$, 95% CI = 0.385, 0.619; higher RRR = 0.401, $p < 0.001$, 95% CI = 0.313, 0.514; highest RRR = 0.381, $p < 0.001$, 95% CI = 0.294, 0.493). The likelihood of being pre-frail compared with robust was expected to decrease if an individual moved from no schooling to higher years of schooling while holding the wealth quintile constant in the unadjusted model (1–5 years RRR = 0.766, $p < 0.001$, 95% CI =

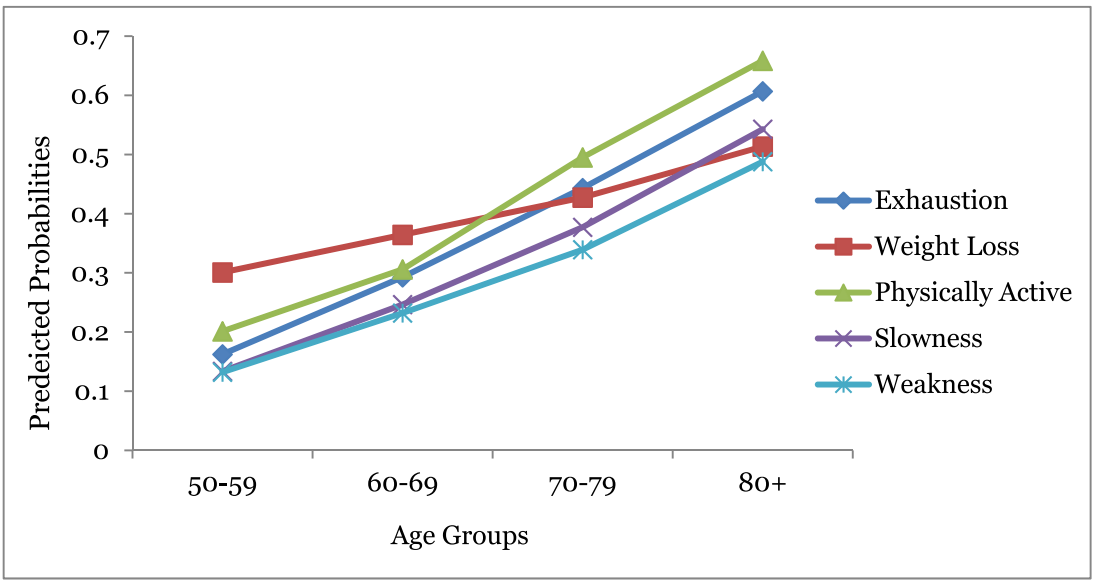

Fig. 2 Predicted probability of having any of the frail markers by age group, 2010

Table 3 Multivariate associations (relative risk ratio, 95% CI) of characteristics with groups of numbers of frailty indicators

	Unadjusted		Unadjusted	
	Frail vs. robust		Pre-frail vs. robust	
Years of schooling	OR	95% CI	OR	95% CI
No schooling	1			
1–5 Years	0.8***	(0.638; 0.952)	0.766***	(0.631; 0.929)
6–9 Years	0.753***	(0.633; 0.895)	0.409***	(0.317; 0.529)
10+ years	0.619***	(0.524; 0.732)	0.294***	(0.226; 0.385)
Wealth quintile				
Poorest	1			
Poorer	0.779**	(0.638; 0.952)	0.731**	(0.578; 0.925)
Middle	0.585***	(0.482; 0.711)	0.488***	(0.385; 0.619)
Richer	0.555***	(0.456; 0.675)	0.401***	(0.313; 0.514)
Richest	0.519***	(0.425; 0.635)	0.381***	(0.294; 0.493)
	Adjusted		Adjusted	
	Frail vs. robust		Pre-frail vs. robust	
Years of schooling	OR	95% CI	OR	95% CI
No schooling	1			
1–5 Years	0.782*	(0.607;1.007)	0.756***	(0.632; 0.904)
6–9 Years	0.459***	(0.329; 0.641)	0.713***	(0.579; 0.877)
10+ years	0.366***	(0.254; 0.528)	0.612***	(0.493; 0.760)
Wealth quintile				
Poorest	1			
Poorer	0.819	(0.617; 1.088)	0.862	(0.694; 1.07)
Middle	0.567***	(0.422; 0.761)	0.671***	(0.542; 0.831)
Richer	0.668**	(0.489; 0.912)	0.726***	(0.583; 0.904)
Richest	0.704**	(0.499;0.994)	0.797*	(0.630; 1.008)

India, 2007–2010, = 6560

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

0.631, 0.929, 6–9 years RRR = 0.294, $p < 0.001$, 95% CI = 0.226; 0.385). Individuals were less likely to be frail compared with robust if they moved from no schooling to higher years of schooling while holding the wealth quintile constant in the unadjusted model (poorer RRR = 0.779, $p < 0.05$, 95% CI = 0.638, 0.952; middle RRR = 0.585, $p < 0.001$, CI = 0.482, 0.711; higher RRR = 0.555, $p < 0.001$, 95% CI = 0.456, 0.675; RRR = 0.519, $p < 0.001$, 95% CI = 0.425, 0.635). Furthermore, if individuals moved from no schooling to higher years of schooling, the chances of being frail compared with robust were expected to decrease (1–5 years RRR = 0.8, $p < 0.001$, 95% CI = 0.638; 0.952; 6–9 years RRR = 0.753, $p < 0.001$, 95% CI = 0.633, 0.895; 10+ years RRR = 0.619, $p < 0.001$, 95% CI = 0.524, 0.732).

To further determine the relationship between socioeconomic status and frailty, we adjusted for potential confounders associated with both socioeconomic status and frailty: socioeconomic, demographic and spatial variables, biomarkers, smoking and alcohol status, chronic diseases and 1+ ADL. The association between SES indicators and frailty remained significant when adjusting for these potential confounders. As individuals have more years of schooling, they are less likely to be pre-frail compared with robust (1–5 years RRR = 0.756, $p < 0.001$, 95% CI = 0.632, 0.904; 6–9 years RRR = 0.713, $p < 0.001$, 95% CI = 0.579, 0.877; 10+ years RRR = 0.612, $p < 0.001$, 95% CI = 0.493, 0.760). The likelihood of being frail was greater than that of being robust among individuals with no schooling (1–5 years RRR = 0.782, $p < 0.001$, 95% CI = 0.607, 1.007; 6–9 years RRR = 0.459, $p < 0.001$, 95% CI = 0.329 0.641; 10+ years RRR = 0.366, $p < 0.001$, 95% CI = 0.254, 0.528). This was also true for the wealth quintile; the likelihood of being frail was greater than that of being robust among individuals in the poorest wealth quintile (middle RRR = 0.567, $p < 0.001$, CI = 0.422, 0.761; higher RRR = 0.668, $p < 0.001$, 95% CI = 0.489, 0.912; RRR = 0.704, $p < 0.001$, 95% CI = 0.499, 0.994). Also, the probability of being pre-frail was greater than that of being robust among individuals in the lowest wealth quintile (middle RRR = 0.671, $p < 0.001$, CI = 0.694; 1.07; higher RRR = 0.726, $p < 0.001$, 95% CI = 0.583; 0.904; RRR = 0.797, $p < 0.001$, 95% CI = 0.630; 1.008).

Figures 3 and 4 display the predicted probabilities of being frail by years of schooling and by wealth quintiles across

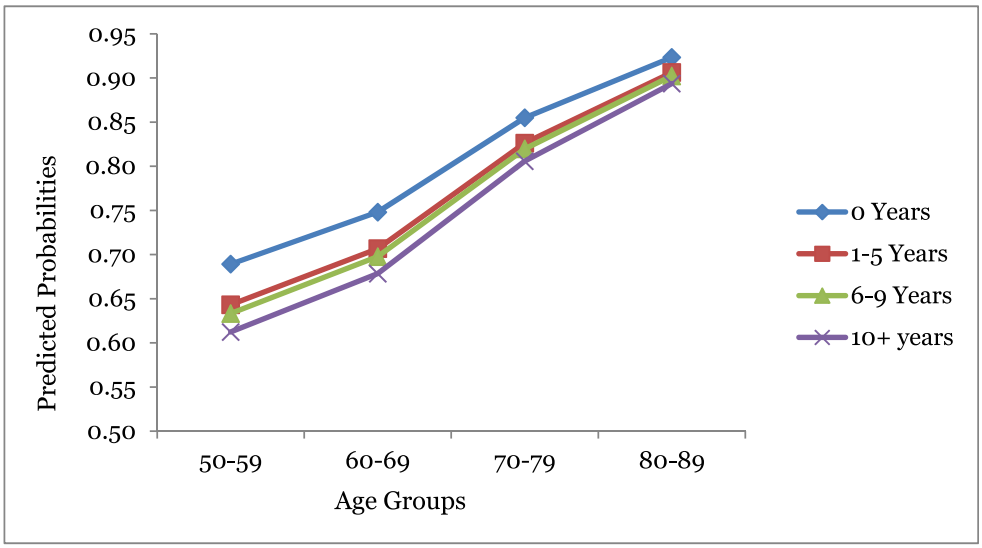

Fig. 3 Predicted probability of being frail by age group and years of schooling, 2010

different age groups. We can see that the probability of being frail decreased with each gradient of years of schooling and increased with older age groups.

Discussion

We used large-scale nationally representative survey data from mainland India, which is experiencing rapid aging and will continue to do so in the coming decades, to investigate the impact of socioeconomic status on frailty after controlling for correlates. In this study, SAGE India Wave 1 data (2007) were used for older adults aged 50 years or more to estimate the frailty gradients of two SES measures, namely years of schooling (education) and household wealth. The study also examined the SES gradients of being frail across four broad age groups of 50–59, 60–69 and 70–79 and 80+ years. This is the first study, to the best of our knowledge, to report the prevalence of socioeconomic gradient frail indicators among older adults in India. Our study affirmed the positive relationship of frailty and lower SES among older adults in India. Additionally, the prevalence of frailty indicators increased with age, in line with previous observations.

In different regards, this study broadens the results of other studies as our findings are in accordance with the other studies. For example, a study with 40,657 women aged 65–79 from 40 US clinical centers showed the significant relationship between income and education and the prevalence of frailty (Fugate et al. 2005). A study using the same SAGE study and 6560 older adults investigated the prevalence of

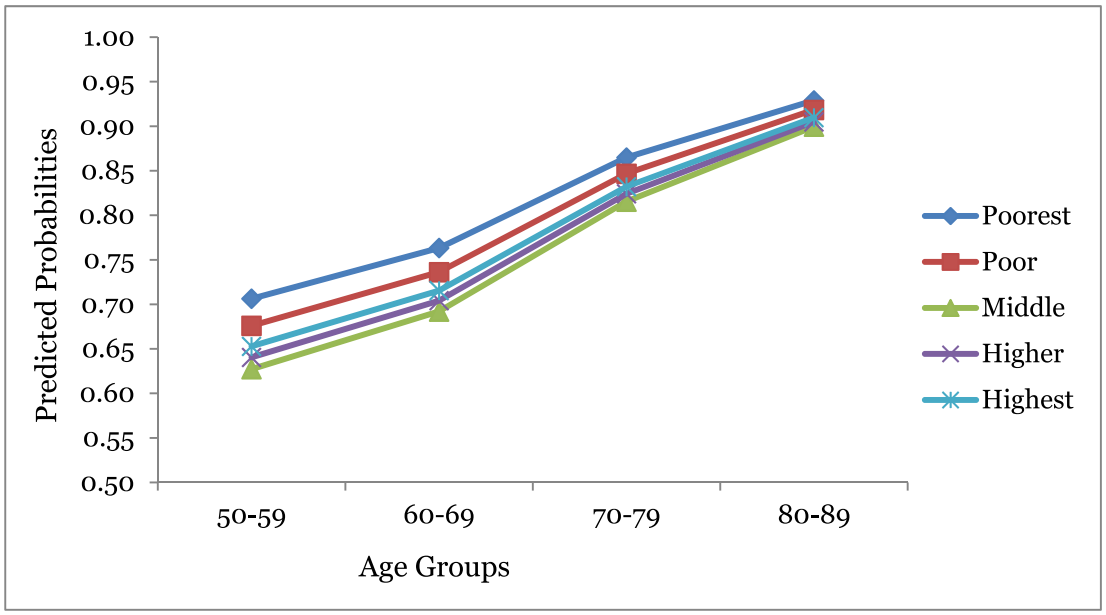

Fig. 4 Predicted probability of being frail by age group and socio-economic status, 2010

frailty and reported 56% of individuals were frail in India. The study used method deficit accumulation to create a frailty index and individuals with a frailty index score > 0.2 were characterized as frail. Studies in the USA have demonstrated a disproportionately high percentage of frail individuals with lower education and income categories without controlling for confounders (Fried et al. 2001; Ensrud et al. 2008). As opposed to our results, a study using data on 786 African American and 4491 white participants in the Cardiovascular Health Study showed that neither education nor income was associated with frailty (Hirsch et al. 2006).

The material, behavioral and psychologic pathways are conceivable explanations for the positive association of SES and frailty among older adults (Chen and Miller 2013; Adler and Newman 2002). In addition, individuals with higher SES have better living surroundings and workplaces, which benefit well-being in both the short and long term (Pampel et al. 2010; Singh-Manoux et al. 2011). Furthermore, high SES is a protective factor against health shortfalls as it promotes healthier lifestyles and better health practices (Lantz et al. 1998; Balia et al. 2008), which may promote well-being or lessen deficiencies. Moreover, individuals with higher SES have less psychologic distress and higher self-efficacy and adapting capacities (Gallo and Matthews 2003; Lorant et al. 2003). In addition, high SES is an essential factor in preserving reserve capacities and slows down the movement of functional limitations and health declines after some time. Considering all these advantages of high SES, a frail person in the high SES group is less likely to have a very poor condition. In summary, the moderating role of SES stems from the fact that SES provides additional resources and advantages, which weakens the effect of frailty on mortality at older ages (House et al. 2005).

The key strength of this study is that we utilized extensive data that are generalizable to older adults in India. Our study endeavored to fill the gap in the literature by providing an investigation of the SES-frailty relationship of individuals aged 50 years and more with a cluster of correlates and socioeconomic indicators in India. The study used large-scale generalizable data in six states and pooled data to give national-level estimates. It contributes to the estimation of the current prevalence rates of frailty, using the modified Fried phenotype approach, by socioeconomic status categories in India based on recent cross-sectional data, which might be helpful in improving the existing policies and programs and rolling out new ones, such as social security schemes that can improve the socioeconomic status of the elderly (Wandera et al. 2015). Our study has some limitations also. We could not show the cohort impact of aging on the relationship of frailty and SES among older adults, with which we could explain more about why the relationship of frailty and SES varies over different age groups. In addition, due to the restraints of cross-sectional data, we could not show any causal inferences of frailty and SES, which could be addressed using longitudinal data. Also, due to the smaller sample size in the higher age group, the relationship of SES-frailty gradients should be interpreted with caution. Future studies should prove more robust examination of the relationship of SES with frailty over age while controlling for background characteristics as the study will provide longitudinal data on an array of adult health indicators.

Conclusion

India is not an exception to the worldwide growing elderly population, mainly due to increased life expectancy. The increase in the elderly population is becoming a burden for the countries that do not provide universal social security coverage, which might further subject the elderly to a lower socioeconomic status and result in poor health outcomes. Frailty is one of the health outcomes witnessed by the elderly with growing age and further deteriorates because of low socioeconomic status. Utilizing an expansive one-of-a-kind across-the-nation prospective data set in India, this investigation discovered critical linkages between frailty and socioeconomic status and age groups. Frailty is one of the vital results in monitoring the well-being of older adults for the government when population aging is a challenge. With changing family norms, the role of government is becoming more critical than ever for securing the autonomy and independence of older adults by providing them basic social protection.

Compliance with Ethical Standards

Conflict of interest The authors have no conflict of interest.

Informed consent The study used the data set that is available online in the public domain; hence, there was no need to seek ethical consent to publish this study.

Ethical treatment of experimental subjects (animal and human) This article does not contain any studies with human or animal subjects performed by the author.

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