Categorical Frailty Phenotype and Continuous Frailty Index: A Conceptual Overview of Frailty and Its Components among Older Persons in India

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DOI: ***10.2427/13212***
Accepted on October 29, 2019

ABSTRACT

Background: Frailty indicator can be an important indicator of understanding ageing and health in India. It will be interesting to examine and compared different model of frailty using the same dataset. The present paper aimed to compare two frailty models and examine the association between socioeconomic status with frailty and frailty components among older persons in India.
Methods: The WHO Study on Global AGEing and Adult Health (SAGE) Wave 1, collected between 2007 and 2010 in India was used for this study. Two frailty model was constructed. Education and wealth quintile was used as socio economic indicators. Sensitivity and specificity were calculated for comparing both frailty models. Linear regression and logistic regression were used. The regression analysis was separately done for each age group and gender category. The coefficients were reported separately for education and wealth quintile categories.
Results: Low sensitivity was observed between the two frailty models. The results suggest that frailty index was more useful in depicting wealth and education inequality among different gender and age groups in India. Wealth and education differences in, number of morbidities, morbidity symptoms and Self rated health (SRH) were most consistently significant across age groups and gender categories. BMI and functional limitation were even found significant at p-value <0.01 for education and wealth quintile.
Conclusion: The results of the analysis suggest that frailty index covers more dimension than categorical phenotype categories, and can be used as an indicator to depict the healthy aging.

Key words: Frailty Models, Older Persons, Healthy Aging, India

INTRODUCTION

Frailty among older persons is a state of increased vulnerability to external stressor and poor health outcomes or even death [1,2]. The adverse outcomes of frailty are well established and documented in various settings [3,4]. It becomes quite important to identify persons and groups at increased risk of developing

frailty. Various classifications and definitions of frailty have been developed and applied in different clinical and research settings [5]. There is a lack of consensus on conceptual and assessment tools to measure frailty among older persons [2]. There are two important models exist in the literature. First is the phenotype of physical frailty, which consists of counting certain criterion-based detritions [6,7]. Second is the more complex multi-domain frailty index comprises of morbidities, function and cognitive impairments which goes beyond the physical aspect [8,9]. Physical phenotype definition was developed by Fried et al. [7]. It operationalized the frailty by establishing five variable which include exhaustion, weight loss, week grip strength, slow walking speed and low energy expenditure. After that, further models were develop to include various aspect of frailty among older persons. The models known as expanded models of physical frailty look beyond physical aspect of frailty [9]. In the recent decade, researchers utilized both the physical and cognitive aspects in the phenotype index to measure fatality among older populations [10]. More availability of longitudinal data in ageing research helped in development of models and infusion of other aspects in measuring frailty among older persons. The inclusion of many other domains led to development of multi-domain frailty index.

India, similar to other developing nation in the world is experiencing rapid ageing of its population. Globally, India will have highest number of older adult population in near future [11]. According to 2011 census, the elderly population in India (aged 60 years or above) accounted for 8.6 percent (89 Million) of total population [12]. Ageing Report, published in 2017, highlights that India's population aged 60 years or over is expected to increase from 8 percent in 2015 to 19 percent in 2050. By the end of the twenty-first century, India will have nearly 34 percent elderly population in the country [13]. The ever-increasing proportion of older person population called upon categorizing health needs of this section of the population. Assessment of frailty and its component among older persons in India is important. Frailty indicator can be an important indicator of understanding ageing and health in India. It is also important for any health indicator to capture Social and economic dynamics in India

There are -few studies, which examined and compared different model of frailty using the same dataset. In addition, there is a lack of studies exploring which component of frailty has strongest association with socioeconomic factors (important in low-middle income countries). The present paper aimed to compare frailty models and examine the association between socioeconomic status with frailty and frailty components among older persons in India.

METHODS

Data Source

The WHO Study on Global AGEing and Adult Health (SAGE) Wave 1, collected between 2007 and 2010 in India was used for this study. SAGE is a nationally representative multi-country (China, Ghana, India, Mexico, Russian Federation and South Africa) study to assess the health and well-being of older persons. In India, respondents were selected from six states—Assam, Karnataka, Maharashtra, Rajasthan, Uttar Pradesh and West Bengal. A multistage, stratified, random sampling design was used. The detail information pertaining to the sampling process and SAGE India survey can be obtained from the official report [14]. The Sample size were individual aged 50 years and above resulting in 7171 individuals

Construction of frailty Models

The frailty phenotype, based on the criteria proposed by Fried et al. 2001 [7], including slow gait speed, weight loss, low grip strength, exhaustion, and low physical expenditure. The following criteria were used to construct these variables [8].

- Slow gait speed: The Gait speed was measured by recording the time taken in seconds to walk 4 meters at a normal pace. Slow gait speed was defined by the lowest quintile, stratified by sex and height.
- Weight loss: Body mass index was prepared using the measured height and weight of the individuals. The presence of the weight loss criterion was considered for the lowest quintile of body mass index (BMI).
- Low grip strength: Grip strength was assessed with a handheld dynamometer, we used the average of grip strength of both hands. The lowest quintile stratified by sex and BMI was applied as cut-off to indicate low grip strength.
- Exhaustion: The individual were asked whether they had enough energy for daily activities. It was a 5scale responses. If the answer was "Not at all" or "A little", it was considered as exhaustion.
- Low physical activity: The physical activity was assessed using the WHO Global Physical Activity Questionnaire (GPAQ). This information was analyzed as suggested in GPAQ. Individual who come had physical activity < 600 MET-minutes a week were categorized for low physical activity [15].

Participants were classified as pre-frail if one or two criteria were present and as frail if three or more criteria were present.

Frailty index was prepared using the deficits count approach. Variables can be included in a frailty index if they satisfy the following 5 criteria [9, 16].

1. The variables must be deficits associated with health status.
2. A deficit's prevalence must generally increase with age, although some clearly age-related adverse conditions can decrease in prevalence at very advanced ages due to survivor effects.
3. Similarly, the chosen deficits must not saturate too early.
4. When considering the candidate deficits as a group, the deficits that make up a frailty index must cover a range of systems
5. The items that make up the frailty index need to be the same from one iteration to the next.

As per these criteria and available literature, around 40 variables were used to create frailty index. The 40 variable can be divided into seven components [4].

1. Self-rated health: Measure in scale of 5 (Very good, Good, Moderate, Bad, Very bad)
2. Morbidity: Self-reported morbidity are used for 9 medically diagnosed conditions (Angina, Arthritis, Asthma, Cataract, Chronic Obstructive Pulmonary Disease, Diabetes, Depression, Hypertension and Stroke)
3. Medical symptom: Three variables related to self-reported symptom in last 30 days were used.
4. Functional Limitation in performing ADL and IADL: Total 23 variables exhibiting limitation in performing ADL and IADL were used.
5. BMI: Underweight (BMI<=18.5) and obesity (BMI>=30.0) was considered as frailty.
6. Week grip strength: Grip strength stratified by sex and BMI was used
7. Timed walk: Slow gait speed defined by less than 0.4 m/sec

The included variables accommodate different type of variables; such as dichotomous (simple yes/no), ordinal and continuous variables. The ordinal and continues variable was converted as the certain proportion of the deficit. For example, self rated health (Very good= 0 Good=0.25, moderate=0.5, bad=0.75, very bad=1.00). For each individual/respondents, these deficits were summed up. The index is consist of the sum of these deficits was divided by total possible deficit to create frailty index. The construction of frailty index for SAGE data is also explained elsewhere [4]. Age, gender and marital status were used as background variables. Education and wealth quintile were used as socioeconomic status (SES) indicators. Hospitalization rates and non fatal fall related injuries were used as outcomes of frailty index.

Analytical strategy

The frailty index was used to construct another four variables. By taking 1%, 5%, 10% and 20% of highest frail score were categorized as frail and created into four variables. Sensitivity and specificity were calculated for each category comparing it with frailty phenotype. Linear regression and logistic regression were used. The regression analysis was separately done for each age group and gender category. The coefficients were reported separately for education and wealth quintile categories.

RESULTS

As depicted in Figure 1 the mean frailty index by phenotype categories, the mean frailty index pre frail person by phenotype categories was significantly high compared to non and pre-frail older persons. However the histogram have not shown clear association between these two frailty indicators as frailty index was found to be spread out for frail phenotype category (Figure 2).

The table 1 shows the congruence between these two indicators of frailty. The frailty index was constructed by taking 1%, 5%, 10% and 20% of highest frailty score as frail to be compared with the categorical frailty phenotype. Low sensitivity was observed between these two indicators (Maximum 40% sensitivity was with Frailty index 1%). High specificity was observed between the two indicators (more than 90% for all frailty index variables). It suggest that the lack of congruence between two indicator for defining older persons as frail. However, while defining non frail the two indicators are similar.

The association of wealth quintile with the two indicator is depicted in table 2. The results suggest that frailty index was more useful in depicting wealth inequality among different gender and age groups. The frailty index can be more useful in estimating wealth inequalities in health. Similar results were also found with educational difference (Table 3). The frailty index was significantly related with education in different age groups and gender categories. Education and wealth quintile levels were most consistently associated with higher overall frailty index, more morbidities, symptoms and self rated health (P<.05 in both groups, see table 4 & 5). BMI and functional limitation were even found significant at p<0.01 for education and wealth quintile by gender and age categories. Grip strength and gait speed were not found significant for education and wealth quintile categories among females. Physical activity was also not found significant for education categories (table 5).

The result suggests that frailty index, BMI, functional health and morbidity components are more useful in

FIGURE 1. Mean frailty index by categorical phenotype categories

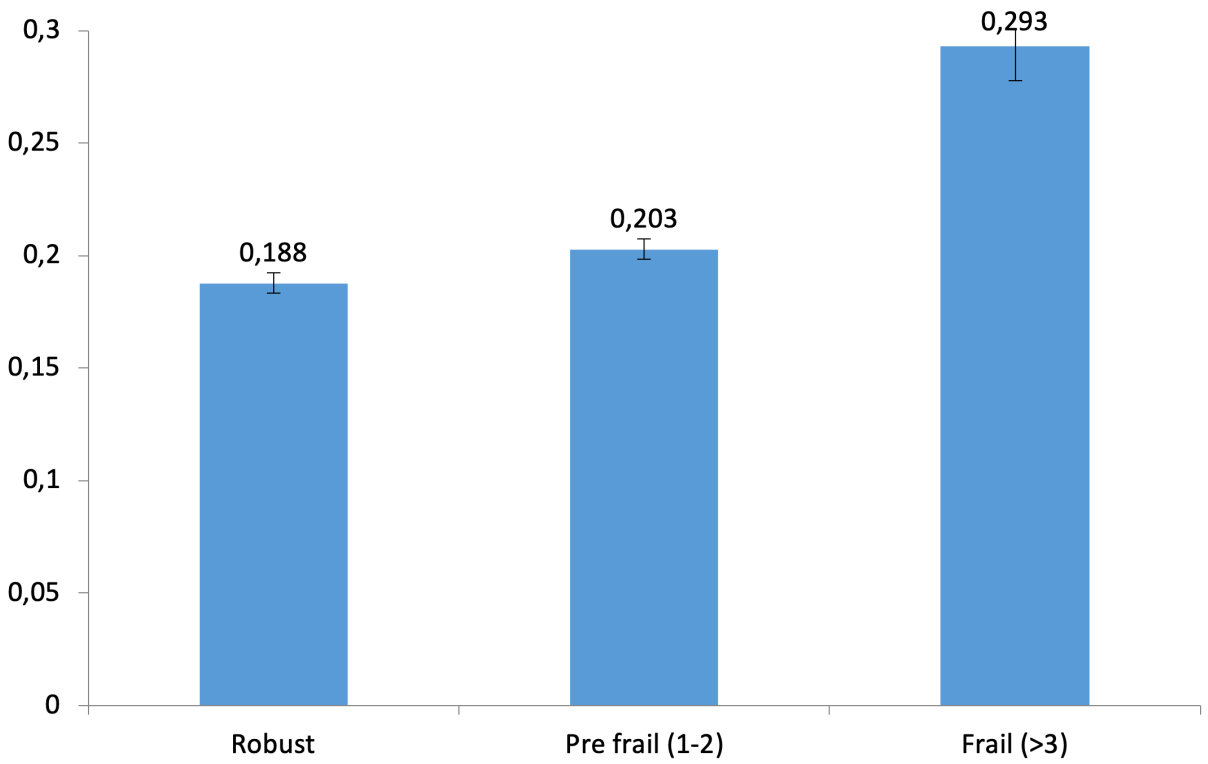

FIGURE 2. Histogram of frailty index by categorical phenotype category

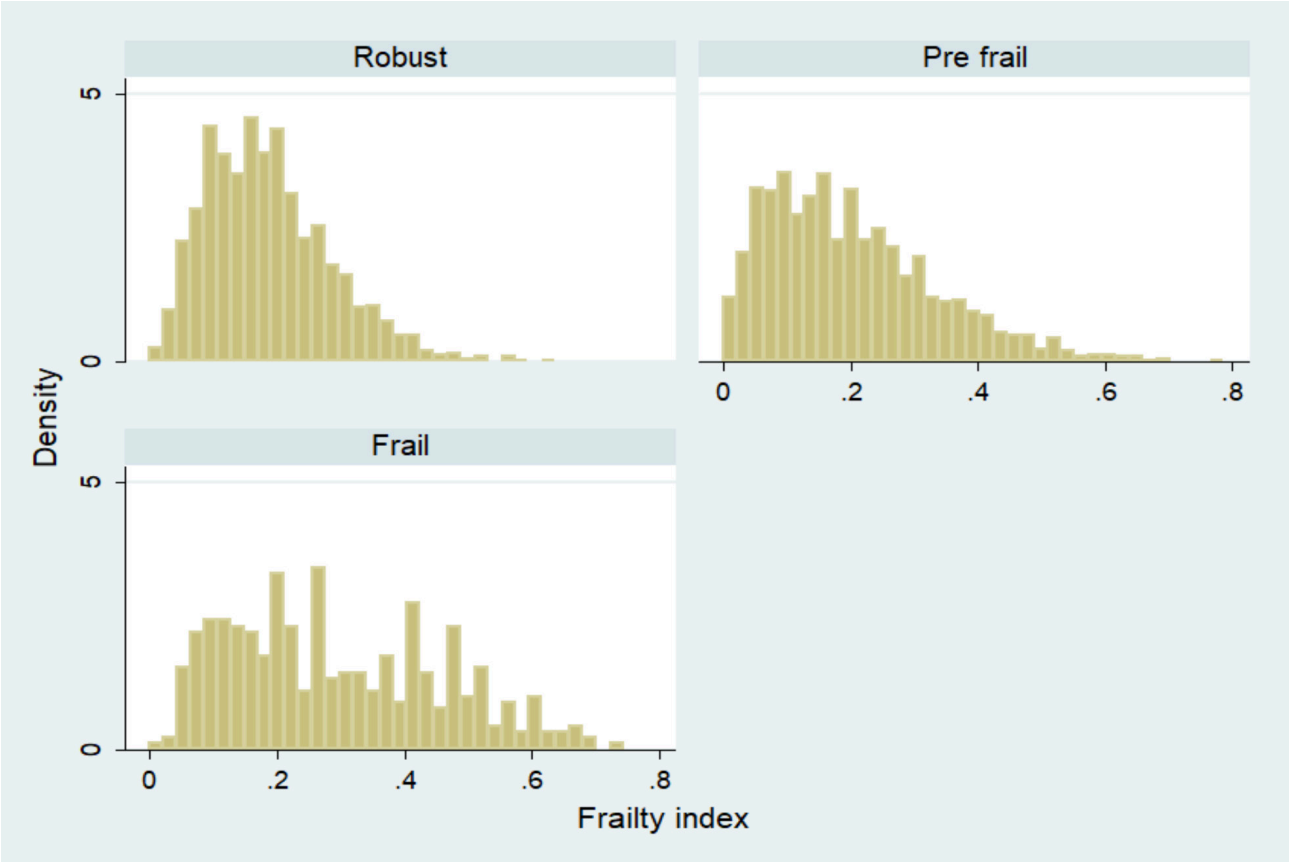

TABLE 1. The Congruence (Sensitivity and specificity) between two frailty models

	Sensitivity	Specificity	Positive Predicting power	Negative predicting power
Index1%	40.00%	92.40%	5.10%	99.30%
Index5%	30.10%	93.40%	20.60%	95.90%
Index10%	24.10%	94.00%	32.20%	91.30%
Index20%	16.30%	94.30%	43.50%	80.80%

TABLE 2. Association of two frailty models with wealth quintile

	FRAILTY INDEX		FRAILTY PHENOTYPE	
	Beta coefficient	p-value	Odds ratio	p-value
Age 50-59				
Lowest				
Lower	-0.01(-0.02-0.01)	0.535	1.01(0.56-2.01)	0.851
Middle	-0.02(-0.03–0.01)	0.008	0.99(0.37-1.48)	0.401
Higher	-0.03(-0.05–0.02)	0.000	1.99(0.29-1.16)	0.126
Highest	-0.04(-0.05–0.03)	0.000	2.99(0.62-2.03)	0.700
Age 60 and above				
Lowest				
Lower	-0.01(-0.03-0.00)	0.030	1.01(0.73-1.40)	0.934
Middle	-0.02(-0.04-0.00)	0.023	0.99(0.57-1.12)	0.197
Higher	-0.03(-0.05–0.01)	0.000	1.99(0.64-1.23)	0.472
Highest	-0.05(-0.07–0.04)	0.000	2.99(0.60-1.13)	0.232
Male				
Lowest				
Lower	-0.01(-0.03-0.00)	0.057	0.99(0.72-1.53)	0.812
Middle	-0.02(-0.03–0.01)	0.008	0.99(0.48-1.10)	0.127
Higher	-0.03(-0.05–0.02)	0.000	1.99(0.53-1.15)	0.206
Highest	-0.06(-0.08–0.05)	0.000	2.99(0.45-0.98)	0.041
Female				
Lowest				
Lower	-0.01(-0.02-0.01)	0.268	1.00(0.62-1.56)	0.944
Middle	-0.02(-0.03-0.00)	0.038	0.99(0.55-1.41)	0.598
Higher	-0.03(-0.04–0.01)	0.000	1.99(0.53-1.35)	0.487
Highest	-0.04 (-0.05–0.02)	0.000	2.99(0.78-1.81)	0.409

capturing socioeconomic health inequalities among older persons. Frailty index have also predicted rates of hospitalization and fall related injuries significantly for older adults (Table 6). Frailty phenotype also significant hospitalization compared to no frail persons. The Injury and hospitalization data was collected only for persons who survived this event, which might reflect survivor effect. However, The results of the analysis suggest that frailty index covers more dimension than categorical phenotype categories, and can be used as indicator to depict the healthy ageing in the context of population ageing.

DISCUSSION

Studies into socioeconomic health inequalities in LMICs are relatively scarce [17, 18]. The present study is the first attempt in Indian setting, which solely focused on comparing two frailty model and socioeconomic inequalities in frailty for India. Frailty index as depicted as shown by the analysis is more useful for assessing socio-economic inequality in health. However, as mentioned in many literatures the categorical or counting based frailty model is far easier to calculate and understandable compared to complex multivariable frailty index [19,20].

TABLE 3. Association of two frailty model with Education

	FRAILTY INDEX		FRAILTY PHENOTYPE	
	Beta coefficient	p-value	Odds ratio	p-value
Age Group 50-59 years				
No education/less than primary				
Primary Education	-0.01(-0.02-0.00)	0.142	1.16(0.66-2.04)	0.611
Secondary	-0.03(-0.04–0.02)	0.000	1.00(0.53-1.90)	0.996
Higher secondary and above	-0.04(-0.05–0.03)	0.000	1.17(0.67-2.07)	0.578
Age group 60 and above				
No education/less than primary				
Primary Education	-0.02(-0.03–0.01)	0.007	1.06(0.79-1.42)	0.683
Secondary	-0.03(-0.05–0.02)	0.000	0.82(0.54-1.23)	0.326
Higher secondary and above	-0.07(-0.09–0.06)	0.000	0.75(0.52-1.07)	0.111
Male				
No education/less than primary				
Primary Education	-0.02(-0.04–0.01)	0.000	1.17(0.85-1.61)	0.349
Secondary	-0.03(-0.04–0.02)	0.000	0.95(0.64-1.41)	0.812
Higher secondary and above	-0.06(-0.07–0.05)	0.000	0.83(0.59-1.17)	0.291
Female				
No education/less than primary				
Primary Education	0.00(-0.01-0.02)	0.873	0.99(0.62-1.59)	0.980
Secondary	-0.04(-0.06–0.02)	0.000	0.77(0.35-1.69)	0.516
Higher secondary and above	-0.05(-0.07–0.03)	0.000	1.16(0.61-2.20)	0.657

As similar to other studies, we found the strongest association between education level and wealth quintile with Self-rated health, IADL limitations, BMI and chronic morbidities. Many studies have explored the association of education with functional health in low and middle income countries [4,8,18]. As certain morbidities are more prevalent among persons with a lower SES, this could at a younger age result in worse psychosocial health or self-rated health, but may as one ages increasingly impact on functional health [8,21]. Socioeconomic inequalities in frailty and all frailty components were larger among persons aged 60 years and above. This finding is often explained by a 'healthy survivor effect', where unhealthier persons with a low SES have died at a younger age and is found in cross-sectional research for various health outcomes [21,22]. However, longitudinal research has found confirming and contradicting results, depending on the indicator by which SES and health is measured [23]. Further research is needed to understand the mechanisms behind these findings. Inequalities in frailty, number of morbidities and self-rated health are most consistent across age groups [24]. The number of morbidities a person has play a role in explaining socioeconomic inequalities in frailty and should be considered in the management of frailty.

The study has several limitations, such as self-reporting of disease diagnosis is a standard method to capture this information in health studies, it comes with known concerns about reliability. It is still possible that there was selective non-response. Previous research has shown that in particular, frail older people are less likely to participate in epidemiological surveys [25]. The survivor effect may also produce some bias in injury and hospitalization data.

CONCLUSION

This study compared and quantify many components of frailty models at age 50 years to later-life. Wealth and education differences in frailty, number of morbidities, BMI, functional limitations and SRH are most consistent across age groups and gender categories. Indicators such as functional limitations, morbidities and Body mass index, shall be consider in the management of frailty and hold importance for healthy ageing in India and similar countries.

Ethical Approval

This study is based on the secondary data analysis of WHO-SAGE Wave 1 for India, which is available in the public domain (http://www.who.int/healthinfo/sage/en/). Thus, The ethical approval for this study is not required.

TABLE 4. Association of frailty component with wealth index

		AGE 50-59		AGE 60 AND ABOVE		MALE		FEMALE	
		Beta coefficient/ odds ratio	p-value	Beta coefficient/ odds ratio	p-value	Beta coefficient/ odds ratio	p-value	Beta coefficient/ odds ratio	p-value
Self-rated health	Lowest								
	Lower	-0.05(-0.14-0.04)	0.596	-0.10(-0.18–0.02)	0.018	-0.05(-0.14-0.04)	0.250	-0.08(-0.17-0.00)	0.058
	Middle	-0.12(-0.20–0.03)	0.004	-0.10(-0.18–0.02)	0.018	-0.12(-0.20–0.03)	0.009	-0.11(-0.20–0.03)	0.010
	Higher	-0.20(-0.28-0.11)	0.000	-0.17(-0.25–0.09)	0.000	-0.20(-0.28-0.11)	0.000	-0.18(-0.27–0.10)	0.000
	Highest	-0.37(-0.45–0.29)	0.000	-0.34(-0.42–0.27)	0.000	-0.37(-0.45–0.29)	0.000	-0.27(-0.35–0.19)	0.000
Medical Symptom	Lowest								
	Lower	-0.49(-0.83–0.15)	0.033	-0.49(-0.83–0.14)	0.006	-0.49(-0.83–0.15)	0.004	-0.39(-0.75–0.03)	0.032
	Middle	-0.40(-0.74–0.06)	0.005	-0.45(-0.80–0.10)	0.012	-0.40(-0.74–0.06)	0.021	-0.54(-0.90–0.18)	0.003
	Higher	-0.73(-1.06–0.41)	0.000	-0.79(-1.14–0.45)	0.000	-0.73(-1.06–0.41)	0.000	-0.80(-1.15–0.45)	0.000
	Highest	-1.42(-1.74–1.10)	0.000	-1.52(-1.85–1.19)	0.000	-1.42(-1.74–1.1)	0.000	-1.18(-1.52–0.85)	0.000
Morbidity	Lowest								
	Lower	0.01(-0.11-0.14)	0.729	0.12(-0.01-0.24)	0.060	0.01(-0.11-0.14)	0.822	0.14(0.02-0.26)	0.020
	Middle	0.01(-0.13-0.12)	0.381	0.25(0.12-0.37)	0.000	0.00(-0.13-0.13)	0.976	0.34(0.22-0.46)	0.000
	Higher	0.21(0.09-0.34)	0.008	0.39(0.26-0.51)	0.000	0.21(0.09-0.34)	0.001	0.36(0.24-0.47)	0.000
	Highest	0.14(0.03-0.26)	0.000	0.39(0.27-0.50)	0.000	0.14(0.03-0.26)	0.017	0.49(0.37-0.6)	0.000
Functional health	Lowest								
	Lower	-1.51(-3.38-0.35)	0.840	-2.49(-4.54–0.43)	0.018	-1.51(-3.38-0.35)	0.112	-1.38(-3.41-0.66)	0.184
	Middle	-1.97(-3.84–0.11)	0.037	-2.44(-4.52–0.37)	0.021	-1.97(-3.84–0.11)	0.038	-2.38(-4.42–0.33)	0.023
	Higher	-4.31(-6.09–2.54)	0.000	-4.41(-6.43–2.39)	0.000	-4.31(-6.09–2.54)	0.000	-4.16(-6.14–2.17)	0.000
	Highest	-7.91(-9.65–6.18)	0.000	-8.42(-10.35–6.48)	0.000	-7.91(-9.65–6.18)	0.000	-5.99(-7.91–4.08)	0.000
BMI (Body Mass Index)	Lowest								
	Lower	0.60(0.01-1.20)	0.001	0.19(-0.43-0.81)	0.544	0.60(0.01-1.20)	0.048	0.60(-0.07-1.27)	0.079
	Middle	1.06(0.46-1.66)	0.000	1.16(0.54-1.78)	0.000	1.06(0.46-1.66)	0.001	1.80(1.13-2.47)	0.000
	Higher	2.10(1.52-2.67)	0.000	1.48(0.87-2.09)	0.000	2.10(1.52-2.67)	0.000	2.13(1.48-2.78)	0.000
	Highest	3.37(2.81-3.93)	0.000	3.2(2.61-3.79)	0.000	3.37(2.81-3.93)	0.000	4.15(3.52-4.79)	0.000
Grip strength	Lowest								
	Lower	0.80(0.63-1.02)	0.755	0.86(0.69-1.07)	0.165	0.80(0.63-1.02)	0.071	0.99(0.79-1.25)	0.948
	Middle	0.84(0.66-1.07)	0.224	0.85(0.68-1.06)	0.147	0.84(0.66-1.07)	0.155	0.86(0.68-1.08)	0.199
	Higher	0.61(0.48-0.76)	0.002	0.73(0.59-0.91)	0.004	0.61(0.48-0.76)	0.000	0.83(0.66-1.04)	0.100
	Highest	0.59(0.48-0.74)	0.000	0.84(0.68-1.03)	0.094	0.59(0.48-0.74)	0.000	0.93(0.75-1.16)	0.524
Poor gait speed	Lowest								
	Lower	1.17(0.83-1.64)	0.367	1.04(0.78-1.39)	0.785	1.17(0.83-1.64)	0.377	1.03(0.73-1.44)	0.887
	Middle	1.12(0.79-1.57)	0.178	1.00(0.75-1.35)	0.974	1.12(0.79-1.57)	0.535	1.10(0.79-1.54)	0.569
	Higher	1.10(0.79-1.54)	0.819	1.17(0.88-1.55)	0.277	1.10(0.79-1.54)	0.568	1.06(0.77-1.48)	0.713
	Highest	1.35(0.99-1.86)	0.022	1.15(0.88-1.51)	0.306	1.35(0.99-1.86)	0.059	1.19(0.87-1.63)	0.277
Having enough energy	Lowest								
	Lower	1.47(1.11-1.95)	0.025	1.15(0.84-1.56)	0.386	1.47(1.11-1.95)	0.007	1.04(0.75-1.45)	0.795
	Middle	1.60(1.21-2.12)	0.002	1.32(0.97-1.78)	0.077	1.6(1.21-2.12)	0.001	1.26(0.92-1.74)	0.155
	Higher	1.75(1.34-2.28)	0.000	1.42(1.06-1.91)	0.019	1.75(1.34-2.28)	0.000	1.38(1.01-1.88)	0.042
	Highest	3.24(2.51-4.19)	0.000	2.41(1.84-3.17)	0.000	3.24(2.51-4.19)	0.000	2.00(1.49-2.67)	0.000
Low physical activity	Lowest								
	Lower	0.97(0.72-1.31)	0.921	1.06(0.83-1.36)	0.646	0.97(0.72-1.31)	0.846	1.13(0.83-1.54)	0.441
	Middle	0.96(0.71-1.30)	0.375	1.30(1.02-1.66)	0.037	0.96(0.71-1.30)	0.809	1.42(1.05-1.92)	0.022
	Higher	1.18(0.89-1.56)	0.364	1.31(1.03-1.67)	0.028	1.18(0.89-1.56)	0.259	1.39(1.03-1.88)	0.029
	Highest	0.94(0.71-1.24)	0.014	1.11(0.88-1.40)	0.394	0.94(0.71-1.24)	0.644	1.65(1.24-2.19)	0.001

TABLE 5. Association of frailty component with education

		Age group 50-59		Age group 60 and above		Male		Female	
		Beta coefficient/ odds ratio	p-value	Beta coefficient/ odds ratio	p-value	Beta coefficient/ odds ratio	p-value	Beta coefficient/ odds ratio	p-value
Self-rated health	No education/ less than primary								
	Primary Education	-0.01(-0.09-0.07)	0.761	-0.11(-0.19-0.04)	0.003	-0.09(-0.16-0.02)	0.014	-0.03(-0.11-0.05)	0.472
	Secondary	-0.12(-0.21-0.04)	0.004	-0.25(-0.34-0.15)	0.000	-0.18(-0.26-0.11)	0.000	-0.19(-0.31-0.07)	0.002
	Higher secondary and above	-0.30(-0.38-0.22)	0.000	-0.44(-0.53-0.36)	0.000	-0.38(-0.45-0.31)	0.000	-0.34(-0.45-0.23)	0.000
Medical Symptom	No education/ less than primary								
	Primary Education	0.01(-0.29-0.31)	0.949	-0.61(-0.92-0.3)	0.000	-0.45(-0.73-0.17)	0.001	-0.13(-0.47-0.22)	0.464
	Secondary	-0.41(-0.73-0.09)	0.012	-1.10(-1.51-0.70)	0.000	-0.78(-1.07-0.48)	0.000	-0.66(-1.16-0.17)	0.009
	Higher secondary and above	-0.86(-1.17-0.56)	0.000	-2.02(-2.37-1.66)	0.000	-1.39(-1.66-1.13)	0.000	-1.58(-2.06-1.11)	0.000
Morbidity	No education/ less than primary								
	Primary Education	0.07(-0.04-0.17)	0.198	0.21(0.10-0.32)	0.000	0.03(-0.07-0.14)	0.549	0.32(0.21-0.44)	0.000
	Secondary	0.12(0.00-0.23)	0.042	0.32(0.18-0.47)	0.000	0.20(0.09-0.31)	0.000	0.23(0.06-0.39)	0.007
	Higher secondary and above	0.15(0.05-0.26)	0.004	0.28(0.16-0.41)	0.000	0.19(0.09-0.29)	0.000	0.27(0.11-0.42)	0.001
Functional health	No education/ less than primary								
	Primary Education	-1.57(-3.1-0.03)	0.045	-3.44(-5.27-1.62)	0.000	-3.17(-4.68-1.65)	0.000	-1.23(-3.14-0.68)	0.206
	Secondary	-4.05(-5.69-2.41)	0.000	-5.07(-7.35-2.79)	0.000	-3.86(-5.46-2.26)	0.000	-6.46(-9.09-3.84)	0.000
	Higher secondary and above	-5.46(-6.98-3.93)	0.000	-10.24(-12.23-8.24)	0.000	-7.51(-8.93-6.1)	0.000	-7.66(-10.23-5.1)	0.000
BMI (Body Mass Index)	No education/ less than primary								
	Primary Education	1.02(0.46-1.59)	0.000	0.98(0.42-1.55)	0.001	0.57(0.08-1.06)	0.023	1.45(0.8-2.11)	0
	Secondary	1.82(1.21-2.43)	0.000	1.64(0.91-2.38)	0.000	1.33(0.8-1.86)	0.000	2.33(1.39-3.27)	0.000
	Higher secondary and above	2.99(2.42-3.56)	0.000	2.88(2.25-3.52)	0.000	2.41(1.94-2.88)	0.000	4.13(3.23-5.03)	0.000
Week grip strength	No education/ less than primary								
	Primary Education	0.9(0.72-1.12)	0.362	1.06(0.86-1.32)	0.566	0.96(0.79-1.19)	0.732	0.98(0.78-1.24)	0.889
	Secondary	0.76(0.6-0.96)	0.022	0.66(0.5-0.86)	0.002	0.66(0.53-0.82)	0.000	0.89(0.64-1.24)	0.501
	Higher secondary and above	0.7(0.56-0.88)	0.002	0.93(0.73-1.18)	0.538	0.71(0.59-0.86)	0.000	1.15(0.84-1.57)	0.382
Slow gait speed	No education/ less than primary								
	Primary Education	0.59(0.27-1.26)	0.17	1.07(0.75-1.53)	0.711	0.79(0.51-1.24)	0.311	1.23(0.77-1.95)	0.389
	Secondary	0.77(0.37-1.62)	0.490	1.03(0.64-1.67)	0.893	1.08(0.68-1.72)	0.744	0.63(0.25-1.58)	0.324
	Higher secondary and above	0.75(0.37-1.51)	0.421	0.68(0.42-1.10)	0.115	0.69(0.43-1.10)	0.121	0.85(0.39-1.87)	0.688
Having enough energy	No education/ less than primary								
	Primary Education	1.37(1.09-1.73)	0.008	1.73(1.36-2.20)	0.000	1.65(1.33-2.05)	0.000	1.34(1.01-1.76)	0.039
	Secondary	2.30(1.81-2.92)	0.000	2.25(1.68-3.01)	0.000	2.20(1.76-2.74)	0.000	2.66(1.88-3.74)	0.000
	Higher secondary and above	2.91(2.32-3.64)	0.000	3.73(2.93-4.75)	0.000	3.42(2.81-4.17)	0.000	2.79(2.01-3.86)	0.000
Low physical activity	No education/ less than primary								
	Primary Education	1.10(0.79-1.53)	0.587	0.97(0.78-1.20)	0.754	1.12(0.88-1.42)	0.366	0.90(0.67-1.21)	0.475
	Secondary	1.42(1.01-1.99)	0.044	0.95(0.71-1.26)	0.720	1.27(0.98-1.65)	0.070	0.87(0.56-1.37)	0.554
	Higher secondary and above	1.30(0.94-1.80)	0.118	0.67(0.51-0.87)	0.003	0.90(0.71-1.15)	0.398	0.90(0.59-1.38)	0.641

Conflicts of interest statement

The authors have no conflicts of interest to declare.

Funding

This research received no specific grant from any funding agency, commercial entity or not-for-profit organization.

TABLE 6. Relationship of frailty with hospitalization and fall related injuries

	HOSPITALIZATION				FALL RELATED INJURIES			
	Rate	CI-Lower	CI-Upper	p-value	Rate	CI-Lower	CI-Upper	p-value
Frail phenotype	18.3	13.2	13.5	0.009	8.40	4.4	12.4	0.059
Index 1%	30.0	14.0	45.7	0.000	27.9	12.3	43.5	0.000
Index 5%	25.9	18.3	33.6	0.000	15.4	9.5	21.3	0.000
Index 10%	23.0	18.0	28.0	0.000	13.7	9.0	18.4	0.000
Index 20%	21.4	17.2	25.5	0.000	9.7	7.1	12.2	0.000
Overall	14.6	12.6	16.6	0.000	6.0	5.1	6.8	0.000

References

1. Kojima G, Liljas AE, Iliffe S. Frailty syndrome: implications and challenges for health care policy. Risk management and healthcare policy. 2019;12:23.
2. Clegg A, Young J, Iliffe S, Rikkert MO, Rockwood K. Frailty in elderly people. The lancet. 2013;381(9868):752-62.
3. Stow D, Matthews FE, Barclay S, Iliffe S, Clegg A, De Biase S, Robinson L, Hanratty B. Evaluating frailty scores to predict mortality in older adults using data from population based electronic health records: case control study. Age and ageing. 2018;47(4):564-9.
4. Harttgen K, Kowal P, Strulik H, Chatterji S, Vollmer S. Patterns of frailty in older adults: comparing results from higher and lower income countries using the Survey of Health, Ageing and Retirement in Europe (SHARE) and the Study on Global AGEing and Adult Health (SAGE). PloS one. 2013;8(10):e75847.
5. Morley JE, Vellas B, Van Kan GA, Anker SD, Bauer JM, Bernabei R, Cesari M, Chumlea WC, Doehner W, Evans J, Fried LP. Frailty consensus: a call to action. Journal of the American Medical Directors Association. 2013;14(6):392-7.
6. Calvani R, Landi F, Marzetti e, Cuore S. Frailty, physical frailty, sarcopenia: a new conceptual model. Active Ageing and Healthy Living: A Human Centered Approach in Research and Innovation as Source of Quality of Life. 2014;203:78.
7. Fried LP, Tangen CM, Walston J, Newman AB, Hirsch C, Gottdiener J, Seeman T, Tracy R, Kop WJ, Burke G, McBurnie MA. Frailty in older adults: evidence for a phenotype. The Journals of Gerontology Series A: Biological Sciences and Medical Sciences. 2001;56(3):M146-57.
8. Hoogendijk EO, Heymans MW, Deeg DJ, Huisman M. Socioeconomic inequalities in frailty among older adults: results from a 10-year longitudinal study in the Netherlands. Gerontology. 2018;64(2):157-64.
9. Karunananthan S, Bergman H, Vedel I, Retornaz F. Frailty: searching for a relevant clinical and research paradigm. La Revue de medecine interne. 2009 Feb;30(2):105.
10. Aubertin-Leheudre M, Woods AJ, Anton S, Cohen R, Pahor M. Frailty clinical phenotype: A physical and cognitive point of view. In Frailty: Pathophysiology, Phenotype and Patient Care 2015 (Vol. 83, pp. 55-64). Karger Publishers.
11. United Nations, Department of Economic and Social Affairs, Population Division. World Population Prospects 2019: Highlights. (2019) Available at https://population.un.org/wpp/Publications/Files/WPP2019_Highlights.pdf.
12. Office of the Registrar General & Census Commissioner (2011) Census of India 2011. India Ministry of Home Affairs, New Delhi, Government of India
13. United Nations Population Fund. 'Caring for Our Elders: Early Responses' - India Ageing Report – 2017. UNFPA, New Delhi, India. (2017) Available at: https://india.unfpa.org/sites/default/files/pub-pdf/India%20Ageing%20Report%20-%202017%20%28Final%20Version%29.pdf
14. Kowal P, Chatterji S, Naidoo N, Biritwum R, Fan W, Lopez Ridaura R, Maximova T, Arokiasamy P, Phaswana-Mafuya N, Williams S, Snodgrass JJ. Data resource profile: the World Health Organization Study on global AGEing and adult health (SAGE). International journal of epidemiology. 2012 Dec 1;41(6):1639-49.
15. Bull FC, Maslin TS, Armstrong T. Global physical activity questionnaire (GPAQ): nine country reliability and validity study. Journal of Physical Activity and health. 2009 Nov 1;6(6):790-804.
16. Searle SD, Mitnitski A, Gahbauer EA, Gill TM, Rockwood K. A standard procedure for creating a frailty index. BMC geriatrics. 2008 Dec;8(1):24.
17. Stringhini S, Bovet P. Socioeconomic status and risk factors for non-communicable diseases in low-income and lower-middle-income countries. The Lancet Global Health. 2017 Mar 1;5(3):e230-1.
18. Howe LD, Galobardes B, Matijasevich A, Gordon D, Johnston D, Onwujekwe O, Patel R, Webb EA, Lawlor DA, Hargreaves JR. Measuring socio-economic position for epidemiological studies in low-and middle-income countries: a methods of measurement in epidemiology paper. International journal of epidemiology. 2012 Mar 21;41(3):871-86.
19. Panza F, Lozupone M, Solfrizzi V, Sardone R, Dibello V, Di Lena L, D'Urso F, Stallone R, Petruzzi M, Giannelli G, Quaranta N. Different cognitive frailty models and health-and cognitive-related outcomes in older age: from epidemiology to prevention. Journal of Alzheimer's disease. 2018 Jan 1;62(3):993-1012
20. Malmstrom TK, Miller DK, Morley JE. A comparison of four frailty models. Journal of the American Geriatrics Society. 2014 Apr;62(4):721-6.
21. Gobbens RJ, Luijkx KG, van Assen MA. Explaining quality of life of older people in the Netherlands using a multidimensional assessment of frailty. Quality of Life Research. 2013 Oct 1;22(8):2051-61.

22. Galama TJ, Van Kippersluis H. A Theory of Socio-economic Disparities in Health over the Life Cycle. The Economic Journal. 2018 May 19;129(617):338-74.
23. Franse CB, van Grieken A, Qin L, Melis RJ, Rietjens JA, Raat H. Socioeconomic inequalities in frailty and frailty components among community-dwelling older citizens. PloS one. 2017 Nov 9;12(11):e0187946.
24. Ensrud KE, Ewing SK, Taylor BC, Fink HA, Cawthon PM, Stone KL, Hillier TA, Cauley JA, Hochberg MC, Rodondi N, Tracy JK. Comparison of 2 frailty indexes for prediction of falls, disability, fractures, and death in older women. Archives of internal medicine. 2008 Feb 25;168(4):382-9.
25. Mickey RM, Greenland S. The impact of confounder selection criteria on effect estimation. American journal of epidemiology. 1989 Jan 1;129(1):125-37.

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