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Frailty among middle-aged and older women and men in India: Findings from Wave 1 of the Longitudinal Aging Study in India

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Abstract

Objectives: Few studies have examined frailty in Indian adults, despite an increasing population of older adults and an escalating burden of chronic diseases. We aimed to study the prevalence and correlates of frailty in middle-aged and older Indian adults.

Setting: Cross-sectional data from Wave 1 of Longitudinal Ageing Study in India, conducted in 2017-2018 across all states and union territories, were used.

Participants: The final analytical sample included 57,649 participants aged 45 years and above who had information on frailty status.

Primary outcome measure: The deficits accumulation approach to measuring frailty was employed, creating a frailty index between 0 and 1, based on 40 deficits. Individuals with a frailty index of 0.25 or more were defined as 'frail'.

Results: Prevalence of frailty among 45-plus adults was 30%. 60-plus women were twice as likely to be frail compared to 60-plus men, after adjusting for a wide range of sociodemographic, economic and lifestyle factors. The sex difference was more pronounced in 45-59-year-olds. Odds of hospitalization in the last 12 months, and having falls in the past two years, were twice as high in frail adults compared to non-frail adults. Frail middle-aged and older adults had 33% and 39% higher odds, respectively, of having poor cognition than non-frail adults. The relative increase was higher in women for all three outcomes, although not statistically significant.

Conclusions: There needs to be careful consideration of sex differences when addressing frailty, particularly for optimizing frailty interventions. Frailty, although typically assessed in older adults, was shown in this study to be also prevalent and associated with adverse outcomes in middle-aged Indian adults. More research into assessment of frailty in younger populations, its trajectory and correlates may help develop public health measures for prevention of frailty.

Strengths and limitations

1. The analyses were based on a nationally representative sample of 45-plus Indian adults from all states and union territories except Sikkim – ours is the first study to provide national, as well as state-level, estimates of prevalence of frailty.
2. We examined prevalence of frailty, its risk factors and association with adverse outcomes in middle-aged adults, in addition to older adults.
3. Our frailty index was constructed using 40 deficits, including deficits pertaining to mental impairment and instrumental activities of daily living aimed at assessing cognitive functioning, thus capturing the multidimensionality of frailty.
4. Due to cross-sectional nature of data, we were unable to look at temporal associations between frailty and adverse health outcomes.
5. We were not able to define other frailty measures such as the frailty phenotype, based on the available data.

Background

Frailty is characterised by a decline in functioning across multiple physiological systems, accompanied by an increased vulnerability to stressors.[1] As a result, frail people are more likely to have adverse health outcomes when exposed to stressors than non-frail people.[2] A frailty score can help identify people with unique health needs, who need intervention to address the causes of poor health and improve outcomes in them. It can therefore be useful in clinical and community settings for risk stratification. However, there are multiple approaches and various tools to measure frailty and there is considerable disagreement between these instruments.[3] This is, in part, responsible for the marked variation in prevalence estimates across countries, and even within countries.[4]

Most studies on frailty are from high-income countries.[4] There exist several systematic reviews across geographical regions, but studies from low- and middle-income countries (LMICs) are limited and have used a variety of methods.[5] A few studies have shown that frailty prevalence and incidence are higher in LMICs compared to high-income countries.[4 6-8] However, interpretation of differences in prevalence between countries or regions is limited by the few data from LMICs. In a recent systematic review on prevalence of frailty in LMICs, only one of the 56 studies was from a low-income country and only two were from lower middle-income countries; the rest were from upper middle-income countries.[5] Robust disaggregated data on frailty in the Indian population are rare,[9-13] whilst no studies have provided subnational estimates on the prevalence of frailty.

Further, while there are many frailty studies amongst adults aged 60 years and above,[4 5 8 14-16] the extent of the problem and its significance in adults less than 60 years is poorly understood. Studies have shown that frailty is prevalent in younger adults and suggested that it be examined across the adult age spectrum.[17-19] This is especially true for India where chronic diseases develop a decade earlier than in HICs.[20] Furthermore, studies characterizing sex differences in frailty, and how frailty differently impacts health outcomes in women and men are rare in LMICs.[11 21-25]

With a rapidly aging population and a fragmented healthcare system, there is an urgent need to quantify frailty in India reliably, so as to inform the development of interventions and plan targeted service delivery. In this study, we examine frailty prevalence, its state-level and socioeconomic patterning and association, including sex-specific association, with key health outcomes in middle-aged (45-59-year-old) and older (60-year-plus) Indian adults.

Methods

Data

We used data from Wave 1 of the Longitudinal Ageing Study in India (LASI) conducted in 2017-2018.[26] LASI is a biennial panel survey, designed to provide longitudinal data on the broad domains of social, health and economic wellbeing of the elderly Indian population.[26] Data from LASI wave 1 include 65,562 45-plus individuals from all states and union territories except Sikkim and is representative of the Indian population aged 45 years and above.

Variables

Assessment of frailty

We used the frailty index measure based on a deficit accumulation approach, proposed by Rockwood and colleagues.[27] We included 40 deficits across different domains[28] – general health (1 deficit), diagnosed conditions (9 deficits), medical symptoms (4 deficits), mobility restrictions (9 deficits), basic Activities of Daily Living (ADL) and Instrumental Activities of Daily Living (IADL) limitations (13 deficits), any mental impairment (1 deficit), body mass index (1 deficit), grip strength (1 deficit) and gait speed (1 deficit). All deficits were assigned scores between 0 and 1, with 1 indicating complete deficit and 0 lack of any deficit. A detailed description is presented in **S1 Table**. **Error! Reference source not found.**The frailty index is the sum of deficit scores divided by the total number of deficits considered (40 in our case), yielding a continuous score between 0 and 1. This index will be missing for an individual with missing data on any deficit. We used a cut-off of 0.25 to define presence or

absence of frailty[29-31] – individuals with frailty index ≥0.25 were defined as 'frail' and others as 'non-frail'.

In sensitivity analyses, we explored another commonly used frailty index cut-off, 0.21[32]. Also, an alternative approach to calculating the frailty index that accounts for missing deficit scores was examined – up to 3 deficits were allowed to be missing and the frailty index for an individual was calculated by summing the non-missing health deficit scores and then dividing by the total number of deficits measured in that individual.

Covariates

Demographic, socioeconomic and lifestyle factors were included as covariates – age, sex, place of residence, educational status, living arrangement, monthly per capita consumption expenditure (MPCE), working status, food constraint, religion, caste, tobacco use, alcohol use and region. Food constraint referred to household food unavailability in the past 12 months. MPCE was defined as total monthly household consumption expenditure divided by household size. Expenditure here includes the household's per capita spending on food and non-food items, including spending on health, education, and utilities. We used consumption expenditure as our economic indicator as we consider this a better measure of living standards and poverty than income. Also, household income information was missing for 1216 45-plus adults. As part of sensitivity analyses, we examined annual per capita household income as the economic indicator.

Adverse outcomes

The respondents were asked about **number of hospitalizations** and **number of nights spent in the hospital in the last 12 months.** In addition to these count outcome variables, a binary outcome variable, **ever hospitalised in last 12 months,** was defined based on the number of hospitalizations (**S2 Table**). Another binary outcome variable, **any fall in past 2 years,** was defined based on responses to questions about having fallen down or sustaining a major injury from a fall in the past 2 years (**S2 Table**).

A composite **cognition score**, ranging from 0 to 43, was constructed by combining scores across five domains: memory, orientation, arithmetic function, executive functioning skills, and object naming (**S3 Table**). A higher score indicated better cognitive ability and **poor cognition** was defined as a score below the 10th percentile, which was 18.

Statistical analyses

Continuous variables were summarized as mean and standard deviation (SD) or median and interquartile interval (IQI) and categorical variables as frequencies and percentages. State- and national-level sampling weights were used to produce weighted prevalence estimates. Multivariable logistic regressions were used to obtain odds ratios (ORs), with 95% confidence intervals (CIs) for the association between frailty status (frail vs. non-frail) and individuals' background characteristics – sex, age, place of residence, education, consumption expenditure, living arrangement, work status, food constraint, tobacco use, alcohol use, religion, and caste, separately for the middle-aged and older participants. Age was analysed as a continuous variable, and all other variables were treated as categorical. Logistic and linear regressions were used to study associations between frailty status (frail vs. non-frail) and binary and continuous adverse outcomes, respectively. Poisson hurdle models were used for count outcomes with a high percentage of zeros – number of hospitalizations and number of nights spent in hospital in last 12 months. The Poisson hurdle model specifies a logistic regression for the zero counts and a truncated (at zero) Poisson model for the positive counts.[33] The association between frailty status and cognition score was examined using linear regression. All regressions examining associations between frailty and adverse outcomes were adjusted for participants' background characteristics. Sex differences in the associations with binary adverse outcomes were studied using the full interaction model, with all main effects and sex interactions with frailty as well as each confounding variable; sex-specific ORs were compared through women-to-men ratios of odds ratios (RORs).[34] All regressions were adjusted for state fixed effects to account for

state-level variation. All statistical analyses were carried out using Stata 13 (StataCorp LP, College Station, Texas, USA) and R version 4.2.0.[35 36]

Patient and public involvement

Patients or the public were not involved in this secondary analysis of publicly available survey data.

Results

Description of study participants

LASI included 34,098 middle-aged adults (45-59 years) and 31,464 older adults (60 years and above). 7,913 participants for whom information related to frailty was missing were excluded from analyses, resulting in a total sample of 57,649 participants. Participants were further excluded while studying associations with outcomes, because of missing outcome data (**S1 Fig**). Of the 57,649 study participants, 55% of middle-aged adults and 52% of older participants were female (**Table 1**). Around 60% of the participants had no or less than 5 years of schooling, 66% lived in the rural areas, around a quarter had never worked, and 82% and 63% reported never consuming alcohol and never using any tobacco product, respectively. There were small differences between participants with missing frailty information and those included in analyses (**S4 Table**). Participants with missing frailty data (n=7,913) were more likely to be older, residing in urban areas, living with children and/or others and not working currently.

Table 1. Characteristics of study participants.

Characteristic	**Overall**, N = 57,649	**45-60 years**, N = 30,568	**60-plus years**, N = 27,081
Sex			
Female	30,874 (54%)	16,912 (55%)	13,962 (52%)
Male	26,775 (46%)	13,656 (45%)	13,119 (48%)
Age, Median (Q1 – Q3)*	58 (50, 66)	51 (48, 55)	67 (63, 72)
Place of residence			
Rural	37,805 (66%)	19,730 (65%)	18,075 (67%)
Urban	19,844 (34%)	10,838 (35%)	9,006 (33%)
Educational status			
No schooling	26,961 (47%)	12,562 (41%)	14,399 (53%)
Less than 5 years	6,738 (12%)	3,404 (11%)	3,334 (12%)

5 to 9 years	13,280 (23%)	7,995 (26%)	5,285 (20%)
10 years or more	10,670 (19%)	6,607 (22%)	4,063 (15%)
MPCE fifths[†]			
Poorest	11,358 (20%)	5,846 (19%)	5,512 (20%)
Poorer	11,673 (20%)	6,067 (20%)	5,606 (21%)
Middle	11,676 (20%)	6,081 (20%)	5,595 (21%)
Richer	11,633 (20%)	6,276 (21%)	5,357 (20%)
Richest	11,309 (20%)	6,298 (21%)	5,011 (19%)
Living arrangement			
Living alone	2,034 (3.5%)	627 (2.1%)	1,407 (5.2%)
Living with spouse with or without children	42,607 (74%)	25,346 (83%)	17,261 (64%)
Living with children and others	10,709 (19%)	3,641 (12%)	7,068 (26%)
Living with others only	2,299 (4.0%)	954 (3.1%)	1,345 (5.0%)
Employment			
Currently working[§]	28,939 (50%)	19,365 (63%)	9,574 (35%)
Worked in the past	13,045 (23%)	2,961 (9.7%)	10,084 (37%)
Never worked	15,665 (27%)	8,242 (27%)	7,423 (27%)
Food constraint[¶]			
No	53,801 (93%)	28,624 (94%)	25,177 (93%)
Yes	3,848 (6.7%)	1,944 (6.4%)	1,904 (7.0%)
Tobacco use			
Never used tobacco	36,252 (63%)	19,919 (65%)	16,333 (60%)
Current/past user	21,373 (37%)	10,633 (35%)	10,740 (40%)
Missing	24	16	8
Alcohol use			
Never consumed	47,218 (82%)	24,848 (81%)	22,370 (83%)
Less than once a month in past 3 months	6,024 (10%)	3,123 (10%)	2,901 (11%)
One to three days per month or more frequently	4,397 (7.6%)	2,591 (8.5%)	1,806 (6.7%)
Missing	10	6	4
Caste			
Scheduled caste	9,695 (17%)	5,278 (17%)	4,417 (16%)
Scheduled tribe	10,140 (18%)	5,656 (19%)	4,484 (17%)
Other backward class	21,813 (38%)	11,461 (37%)	10,352 (38%)
None of the above/no caste or tribe/don't know/missing	16,001 (28%)	8,173 (27%)	7,828 (29%)
Religion			
Hindu	42,322 (73%)	22,482 (74%)	19,840 (73%)
Muslim	6,806 (12%)	3,625 (12%)	3,181 (12%)
Christian	5,802 (10%)	3,069 (10%)	2,733 (10%)
Other	2,719 (4.7%)	1,392 (4.6%)	1,327 (4.9%)
Region			
North	10,537 (18%)	5,536 (18%)	5,001 (18%)
Central	7,975 (14%)	4,257 (14%)	3,718 (14%)
East	10,443 (18%)	5,344 (17%)	5,099 (19%)
Northeast	7,551 (13%)	4,285 (14%)	3,266 (12%)
West	7,580 (13%)	3,977 (13%)	3,603 (13%)
South	13,563 (24%)	7,169 (23%)	6,394 (24%)

Numbers presented in table are unweighted.

[*] Q1: first quartile, Q3: third quartile.

† MPCE: monthly per capita expenditure which is defined as total monthly household consumption expenditure divided by household size. It includes household's per capita spending on food and non-food items including spending on health, education, utilities, etc.

§ Includes Temporarily laid off, on sick or other leave, or in job training

¶ Household food unavailability in the past 12 months, where household members either reduced their meal size, did not eat even though they were hungry, or did not eat for a whole day because enough food was not available in the household.

Prevalence of frailty

The observed frailty index values ranged between 0 and 0.83, with a median of 0.14 (IQI= 0.08 - 0.25) and mean of 0.18 (SD = 0.13) (**S2 Fig**, panel A). Using the cut-off of 0.25, the prevalence of frailty among adults 45 years and older was 29.5% (95% CI= 28.7 - 30.4). Prevalence was higher among older adults compared with middle-aged adults (43.2% vs. 16.2%) and among women compared to men (36.1% vs. 21.7%) (**S5 Table**).

There was substantial geographical variation in the prevalence of frailty, ranging between 8.8% in Arunachal Pradesh and 38.2% in West Bengal (**Fig 1**). For middle-aged adults, the prevalence of frailty among females was double that in males (21.4% vs. 9.6%). For the older participants, frailty prevalence was almost 20 percentage points higher in females than in males (52.2% vs. 33.2%). Among older males, the prevalence varied between 11.8% in Nagaland and 42.7% in West Bengal. In 14 out of 35 states, more than 50% of the older women were frail, with the highest prevalence in Jammu & Kashmir (69%). Region-wise, 5 out of the 7 North-eastern states covered always appeared among the bottom 8 states with lowest prevalence, for both the age groups and sexes.

Sociodemographic, economic and lifestyle factors associated with frailty

Frailty prevalence varied widely across different social strata (**S5 Table**). Females had higher odds of being frail than males (OR (95% CI) = 2.3 (2, 2.5) among middle-aged adults and 2.0 (1.8, 2.1) among older adults), after adjusting for other background characteristics

(**Fig 2**). Among middle-aged participants, Muslims had 32% (95% CI = 18 to 48%) higher odds of being frail, compared to Hindus; the difference was attenuated in the older ages (OR (95% CI) = 1.1 (1, 1.2)). Adjusted odds of being frail increased by 23% and 12% with one year increase in age, among middle-aged and older participants, respectively. While higher education was negatively associated with frailty, with more educated people having lower odds, the individuals in the two highest expenditure fifths were likely to be frailer than those in the lowest 20%. The odds of being frail were higher among participants from rural areas compared to urban areas, tobacco users compared to non-users, infrequent drinkers compared to abstainers, and among participants facing food constraint.

Association with adverse health outcomes

Six percent of the middle-aged and 8% of the older adults were hospitalised in past 12 months (**Table 2Error! Reference source not found.**). Fall in the past 2 years was recorded among 16% of middle-aged adults and 20% of older adults. The median cognition score was 27 (IQI = 22 - 32) and 7% and 15% of the middle-aged and older populations, respectively, had poor cognition, that is, were in the lowest 10% (**S2 Fig**, panel B). In both age groups, these adverse outcomes were more frequent, often double, among the frail participants compared to the non-frail. After adjusting for background characteristics of participants, frailty was associated with higher odds of all three outcomes studied – hospitalization in the last 12 months (OR (95% CI) = 2.4 (2.1, 2.7) among middle-aged adults and 2.2 (2.0, 2.4) among older adults), fall in the past two years (OR (95% CI) = 2.17 (2.01, 2.36) and 1.9 (1.77, 2.03) in middle-aged and older adults, respectively) and poor cognition (OR (95% CI) = 1.33 (1.16, 1.53) and 1.39 (1.26, 1.54) in middle-aged and older adults, respectively) (**Table 2**).

Table 2. Association between frailty and adverse outcomes – hospitalized in last 12 months, any fall in past 2 years and poor cognition.

Outcome	45–59-year-old adults				60-plus adults			
	All	Non-frail	Frail	Adjusted* OR (95% CI)	All	Non-frail	Frail	Adjusted* OR (95% CI)
Hospitalized in last 12 months								
No	28,440 (94%)	24,658 (95%)	3,782 (89%)	-	24,631 (92%)	15,364 (94%)	9,267 (89%)	-
Yes	1,681 (5.6%)	1,215 (4.7%)	466 (11%)	2.35 (2.09, 2.66)	2,038 (7.6%)	911 (5.6%)	1,127 (11%)	2.19 (1.98, 2.42)
Missing	447	393	54		412	226	186	
Any fall in past 2 years								
No	25,651 (84%)	22,605 (86%)	3,046 (71%)	-	21,712 (80%)	14,005 (85%)	7,707 (73%)	-
Yes	4,914 (16%)	3,658 (14%)	1,256 (29%)	2.17 (2.01, 2.36)	5,365 (20%)	2,495 (15%)	2,870 (27%)	1.9 (1.77, 2.03)
Missing	3	3	0		4	1	3	
Poor cognition†								
No	22,017 (93%)	19,343 (93%)	2,674 (88%)	-	15,521 (85%)	10,540 (88%)	4,981 (78%)	-
Yes	1,727 (7.3%)	1,362 (6.6%)	365 (12%)	1.33 (1.16, 1.53)	2,750 (15%)	1,375 (12%)	1,375 (22%)	1.39 (1.26, 1.54)
Missing	6,824	5,561	1,263		8,810	4,586	4,224	

*Adjusted for participants' sex, age, rural place of residence, education, consumption expenditure, living arrangement, work status, food constraint, tobacco use, alcohol use, religion, caste, and state.

† Poor cognition was defined as a cognition score below the 10th percentile, which was 18.

Being frail was associated with a 74% (95% CI = 45 – 109%) and 122% (95% CI = 83 – 170%) increase in mean number of hospitalizations in the last 12 months and a 15% (95% CI = 10 – 21%) and 18% (95% CI = 13 – 23%) increase in mean number of nights spent in the hospital in last 12 months, among the middle-aged and older adults, respectively (**Table 3**). Frailty was associated with one-unit lower cognition scores in both the age groups – the mean difference, for frailty versus not, was -1.02 (-1.2, -0.84) in middle-aged adults and -1.05 (-1.2, -0.89) in the older adults.

Table 3. Association between frailty and adverse outcomes – number of times hospitalized in last 12 months, number of nights spent in hospital in last 12 months and cognition score.

Outcome	45–59-year-old adults				60-plus adults			
	All	Non-frail	Frail	Adjusted* effect estimate (95% CI)	All	Non-frail	Frail	Adjusted* effect estimate (95% CI)
Number of times hospitalized in last 12 months								
N	30,121	25,873	4,248	Rate ratio = 1.74 (1.45, 2.09)	26,669	16,275	10,394	Rate ratio = 2.22 (1.83, 2.7)
Range	0-23	0-14	0-23		0-20	0-7	0-20	
Mean (SD)	0.07 (0.42)	0.06 (0.33)	0.16 (0.75)		0.10 (0.43)	0.06 (0.30)	0.15 (0.58)	
Median (IQR)	0 (0, 0)	0 (0, 0)	0 (0, 0)		0 (0, 0)	0 (0, 0)	0 (0, 0)	
Number of nights spent in hospital in last 12 months								
N	30,120	25,872	4,248	Rate ratio = 1.15 (1.1, 1.21)	26,669	16,275	10,394	Rate ratio = 1.18 (1.13, 1.23)
Range	0-169	0-169	0-120		0-120	0-120	0-90	
Mean (SD)	0.34 (2.57)	0.27 (2.35)	0.74 (3.64)		0.48 (2.88)	0.33 (2.43)	0.71 (3.47)	
Median (IQR)	0 (0, 0)	0 (0, 0)	0 (0, 0)		0 (0, 0)	0 (0, 0)	0 (0, 0)	
Cognition score								
N	23,744	20,705	3,039	Mean difference = -1.02 (-1.2, -0.84)	18,271	11,915	6,356	Mean difference = -1.05 (-1.2, -0.89)
Range	7-43	7-43	8-42		4-43	7-43	4-43	
Mean (SD)	28 (6)	28 (6)	26 (6)		26 (6)	27 (6)	24 (6)	
Median (IQR)	28 (24, 33)	29 (24, 33)	26 (22, 30)		26 (21, 31)	27 (22, 31)	24 (19, 29)	

*Adjusted for participants' sex, age, rural place of residence, education, consumption expenditure, living arrangement, work status, food constraint, tobacco use, alcohol use, religion, caste, and state.

Sex differences

Of the 40 deficits that were considered, men fared worse than women only for grip strength, stroke, chronic obstructive pulmonary disease and asthma; whereas more women than men had poor general health, most diagnosed conditions, medical symptoms, mobility restrictions, difficulties with normal daily self-care activities and needed supervision or assistance, were either underweight, overweight or obese, and had slow gait speed (**S6 Table**). The sex differences in mobility restrictions and ADL/IADL limitations were especially pronounced, even in the middle-aged adults.

The adjusted odds of hospitalization in the past 12 months, falls in the past 2 years and poor cognition were higher for frail compared to non-frail adults, in both women and men. In women the ORs were higher than in men, in both the age groups. Women-to-men RORs were thus higher than unity for all three outcomes, although their CIs included zero, except for falls in past 2 years in the 60-plus age group, so that chance findings could not be ruled out (**S7 Table**).

Sensitivity analyses

Of the 40 deficits considered, all deficits, except body mass index, grip strength and gait speed, were missing in <2% of the 45-plus participants; and these three measurements were missing in 10-11% of participants (**S3 Fig**). The frailty index calculated using non-missing health deficit scores made no difference to the prevalence estimates – 17% of middle-aged adults and 44% of older participants were frail using this metric (**S8 Table**). ORs for the association between frailty and adverse outcomes were also similar (**S9 Table**).

Using an alternative cut-off value of 0.21,[32 37] the prevalence of frailty increased to 37%. Even though frailty prevalence was inevitably higher using this cut-off (**S8 Table and S4 Fig**), the associations with adverse outcomes were similar (**S9 Table**).

No association between frailty and income was found after adjusting for other factors, when using household income instead of consumption expenditure as the economic indicator in

analysis exploring sociodemographic, economic and lifestyle factors associated with frailty (**S5 Fig**).

Discussion

To our knowledge, this is the first study to provide national, as well as state-level, estimates of prevalence of frailty and its association with outcomes across the age spectrum amongst 45-plus Indian adults. Our study showed that frailty is common among 45-plus Indian adults and it varies across the states. We found that women were more than twice as likely to be frail than men, after adjusting for a wide range of factors. We showed that frailty, usually assessed only in older adults, was also prevalent in 45-59-year-old middle-aged adults, and was associated with hospitalization, falls and poor cognitive functioning.

Our findings are in line with associations observed in other studies – female sex,[21] lower education[11] and tobacco use[38] are well-known determinants of frailty. Our analyses pointed out that sex-differences in mobility restrictions and ADL/IADL limitations were especially pronounced, even among the middle-aged adults. Interestingly, we found frailty to be more prevalent in upper fifths of consumption expenditure, while many studies have shown an inverse gradient with economic well-being. We hypothesize that this may be because frail people tend to incur more healthcare expenditure, resulting in higher consumption expenditure. The positive association, however, was no longer present when per capita household income was instead used as the economic indicator. Another intriguing finding was that infrequent drinking was associated with higher odds of frailty compared to abstaining, but the same was not true for frequent drinking. Other studies have shown similar associations with infrequent and frequent alcohol intakes compared to zero consumption.[19 39 40] This, however, should be treated with caution, as it can be due to residual confounding or healthy survivor bias. Our results suggest that vulnerable groups should be targeted when developing interventions to prevent and mange frailty. For achieving best results, the interventions should be customized per their needs.[41] For this,

knowledge of underlying mechanisms is essential and should be explored in future frailty research.

Frailty was associated with hospitalization, falls and poor cognition, across both the age groups and sexes. A systematic review of 13 prospective studies in community-dwelling older adults found physical frailty to be a predictor of hospitalisation.[42] The authors speculated that fall-related injuries could be one of the contributors. Another systematic review of 11 studies showed that frailty, however defined, is a significant predictor of future falls among community-dwelling older people. Fall risk according to frailty was found to be higher in men than in women. A prospective population-based study, using data from the Canadian Study of Health and Aging, showed that frailty status, defined using various criteria, is strongly associated with changes in cognition.[43]

Inclusion of over 34,000 45-59-year-olds in LASI allowed us to examine frailty, its risk factors, and its association with adverse outcomes for the first time in the middle-aged Indian population. The association between frailty and hospitalization and falls was even stronger in middle-aged adults compared to older adults. Although the prevalence of frailty increases with age, it is not limited to the elderly. Studies looking into associations between frailty and adverse outcomes in middle-aged adults are rare, and they highlight the need to identify, manage, and prevent frailty across the age spectrum.[19 44 45]

Our study has many strengths. First, our study provides frailty prevalence estimates among 45-plus adults for all Indian states and union territories (except Sikkim), in addition to a national prevalence estimate. Second, we examined prevalence of frailty, its risk factors and association with adverse outcomes in middle-aged adults, in addition to older adults. Third, our frailty index was constructed using 40 deficits, 30 being the minimum number to ensure sufficient accuracy in predicting adverse events. We included deficits pertaining to mental impairment and instrumental activities of daily living aimed at assessing cognitive functioning, thus capturing the multidimensionality of frailty. Finally, the sensitivity analyses

helped demonstrate that our findings about variation in frailty and its association with outcomes are robust to the cut-off used to define frailty.

We also recognize certain limitations. First, we were not able to define other frailty measures such as the frailty phenotype, based on available data. Given that prevalence estimates vary widely depending on the assessment method,[4 5 10 37] it would have been more informative if we were able to compare our findings using other frailty measures. Second, our cross-sectional study is unable to look at temporal associations between frailty and adverse health outcomes. LASI is designed as a panel study and data from subsequent waves will allow for examination of temporal associations in the future. Third, LASI employed a multistage cluster sampling design but variables identifying participants belonging to the same cluster have not been made publicly available, limiting our ability to account for the cluster sampling design in analyses and generate robust standard errors.[46] Fourth, there is but limited evidence to support the use of frailty index in middle-aged adults[47-49] and future research should explore suitable frailty measures and cut-offs.

Conclusion

Our study has implications for healthcare delivery planning. We show that women are significantly more likely to be frail compared with men, across both age groups studied. These high levels of frailty among women will have a significant impact on patient-reported and clinical outcomes. Strategies to mitigate frailty should consider these sex differences. Also, we have demonstrated that frailty is prevalent in 45-59-year-old middle-aged adults, exhibits social patterning and is associated with adverse outcomes, suggesting that younger adults may be identified as frail and may benefit from early detection and delivery of timely care.

Declarations

Ethics approval and consent to participate

Not applicable. We used LASI survey data available in the public domain from the International Institute for Population Sciences website. Ethics approval for LASI survey was granted by all collaborating institutions and the Indian Council for Medical Research. Written informed consent was obtained for household survey, individual survey, and dried blood spot collection.

Availability of data and materials

LASI survey data are available in the public domain from the International Institute for Population Sciences (IIPS) website. Application has to be made for access to data and access is granted after review by IIPS for legitimate academic research purposes. Link for application can be accessed at https://www.iipsindia.ac.in/content/LASI-data.

Competing interests

AG, MK and ND have no conflicts of interest to declare. MW is a consultant to Amgen, and Freeline. VJ has received grant funding from GSK, Baxter Healthcare, and Biocon and honoraria from Bayer, AstraZeneca, Boeringer Ingelheim, NephroPlus and Zydus Cadilla, under the policy of all honoraria being paid to the organization.

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Authors' contributions

AG and MK conceived the idea for the study, performed literature review, conducted data preparation, carried out statistical analyses and wrote the first draft. All authors contributed

to interpretation of the study findings. VJ, MW, ND and AG contributed to reviewing and editing the final draft. All authors have read and approved the final manuscript.

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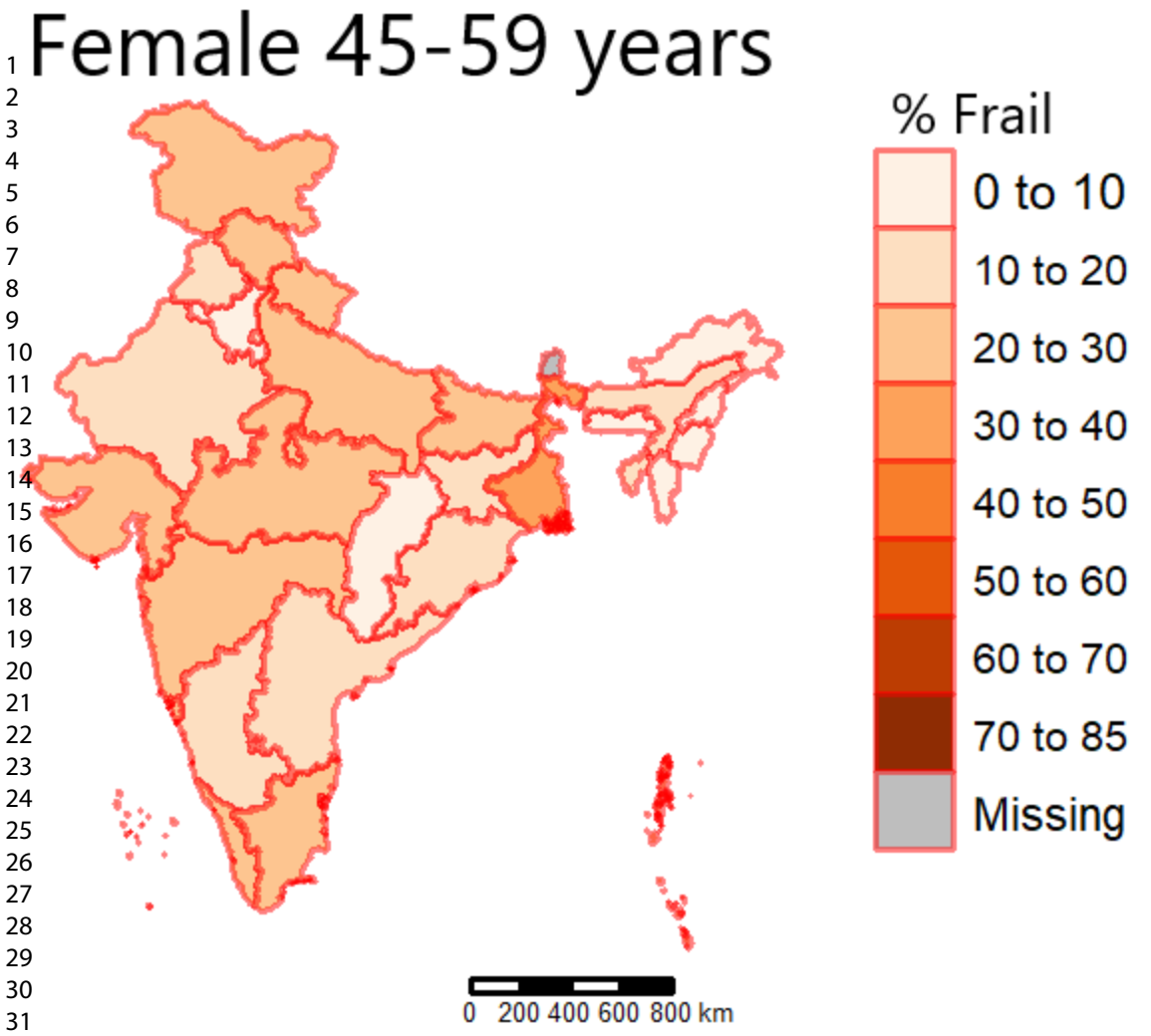
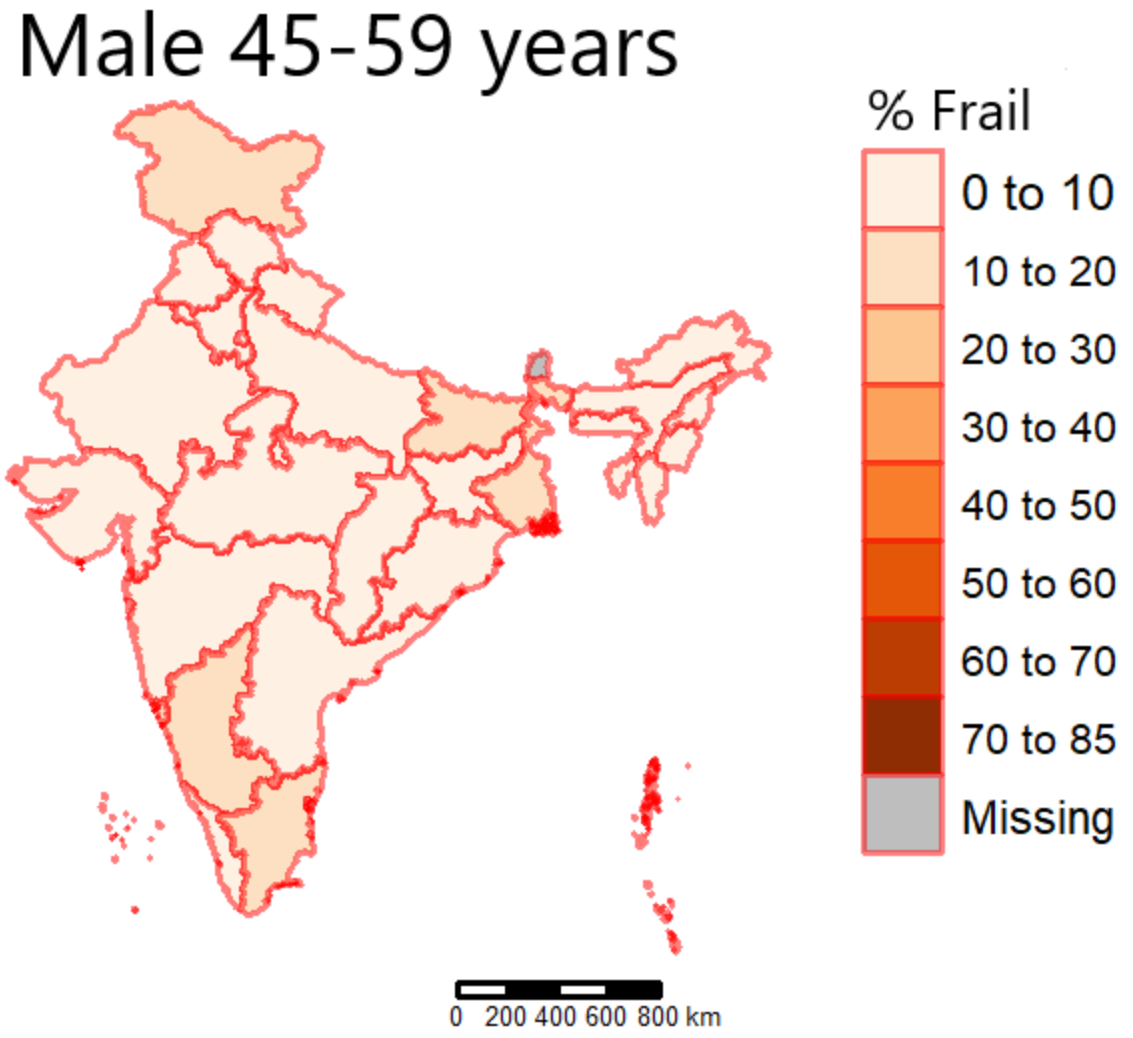
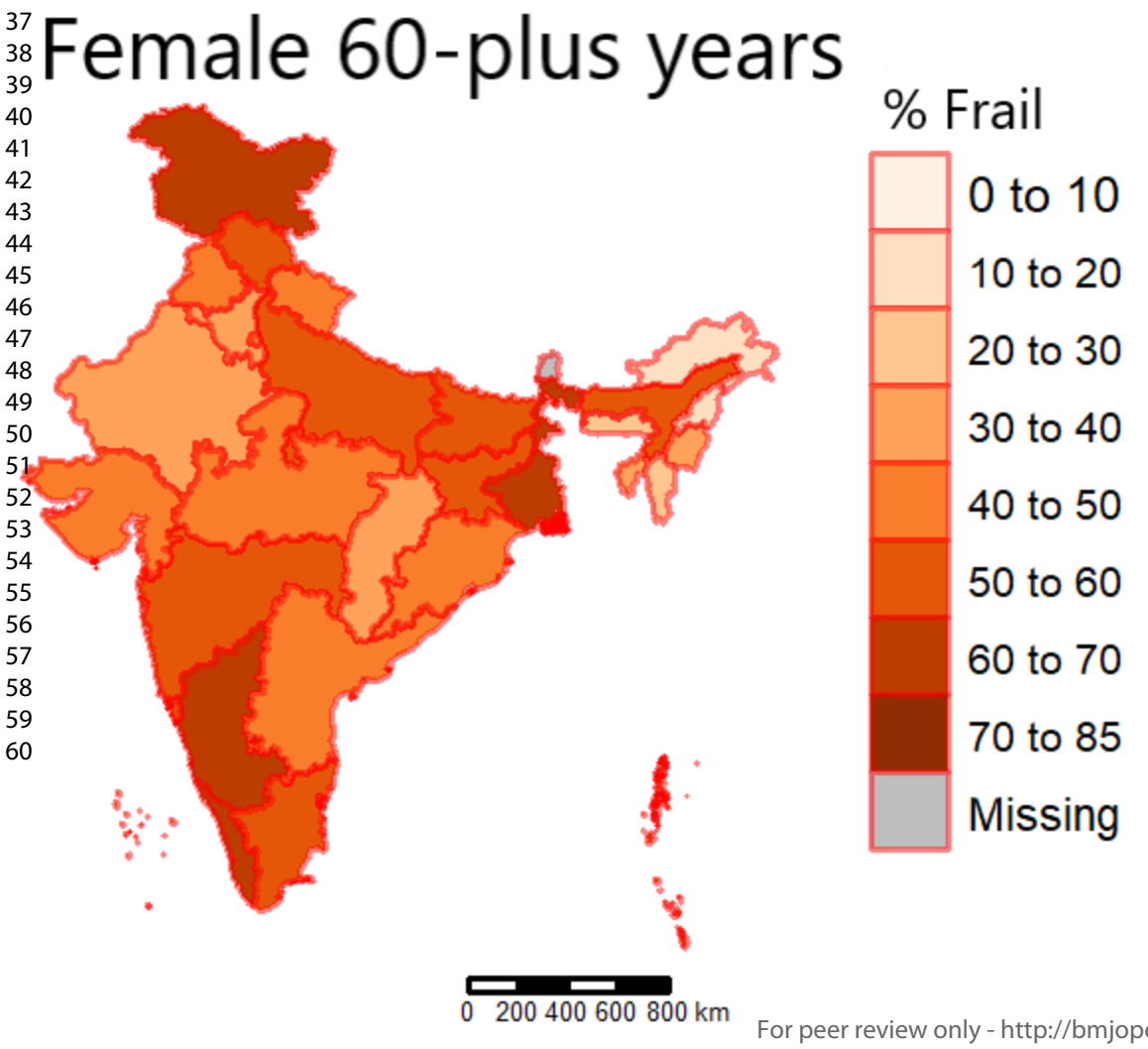
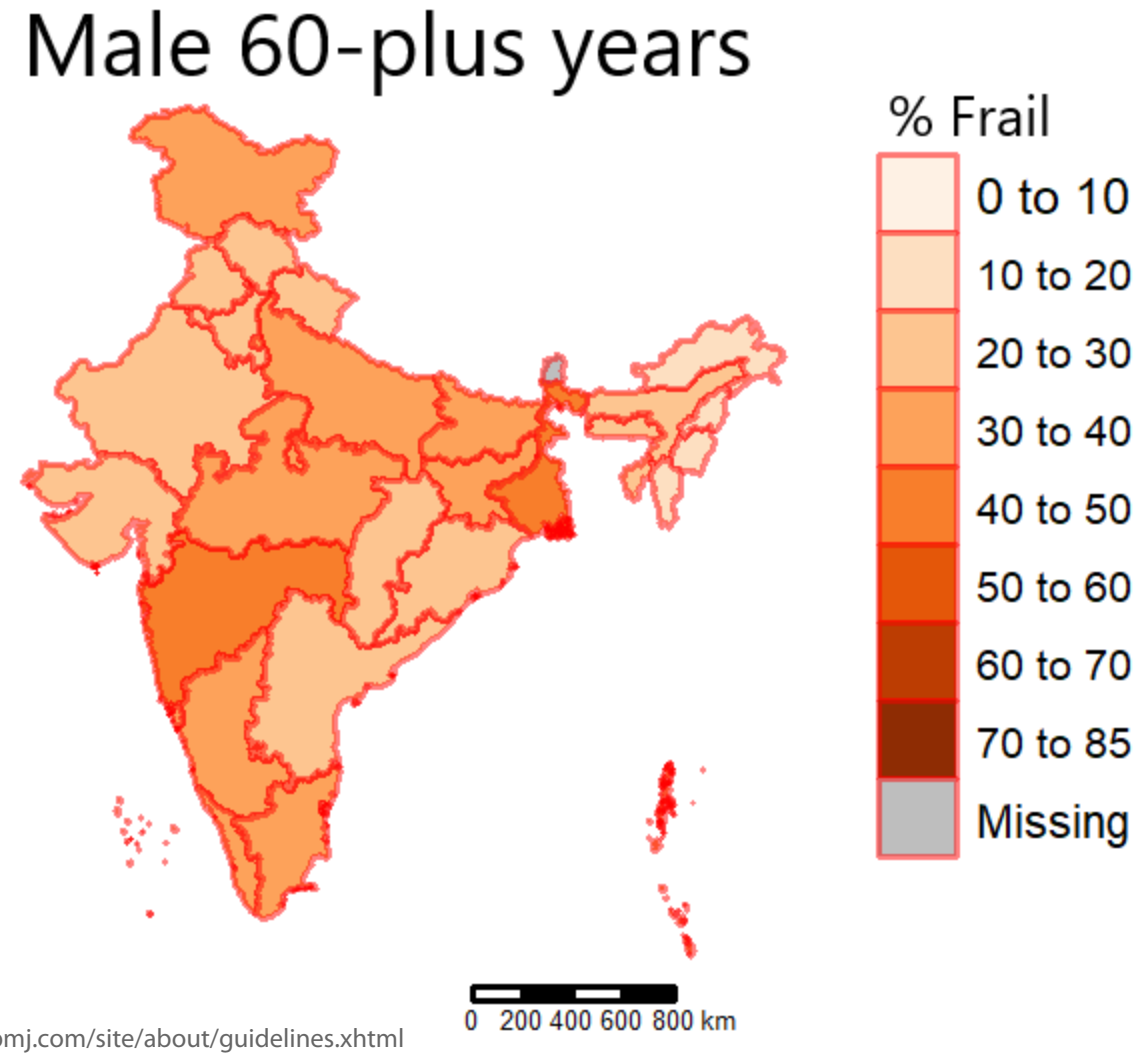
Fig 1. State-wise prevalence of frailty, by sex and age group. Individuals with frailty index ≥ 0.25 are defined as 'frail'. Prevalence estimates are weighted, using state-level individual sampling weights provided in data.

Fig 2. Forest plot of adjusted odds ratios (95% CI) for frailty, by participants' background characteristics. MPCE: monthly per capita expenditure, which is defined as total monthly household consumption expenditure divided by household size. Food constraint refers to household food unavailability in the past 12 months, where household members either reduced their meal size, did not eat even though they were hungry, or did not eat for a whole day because enough food was not available in the household.

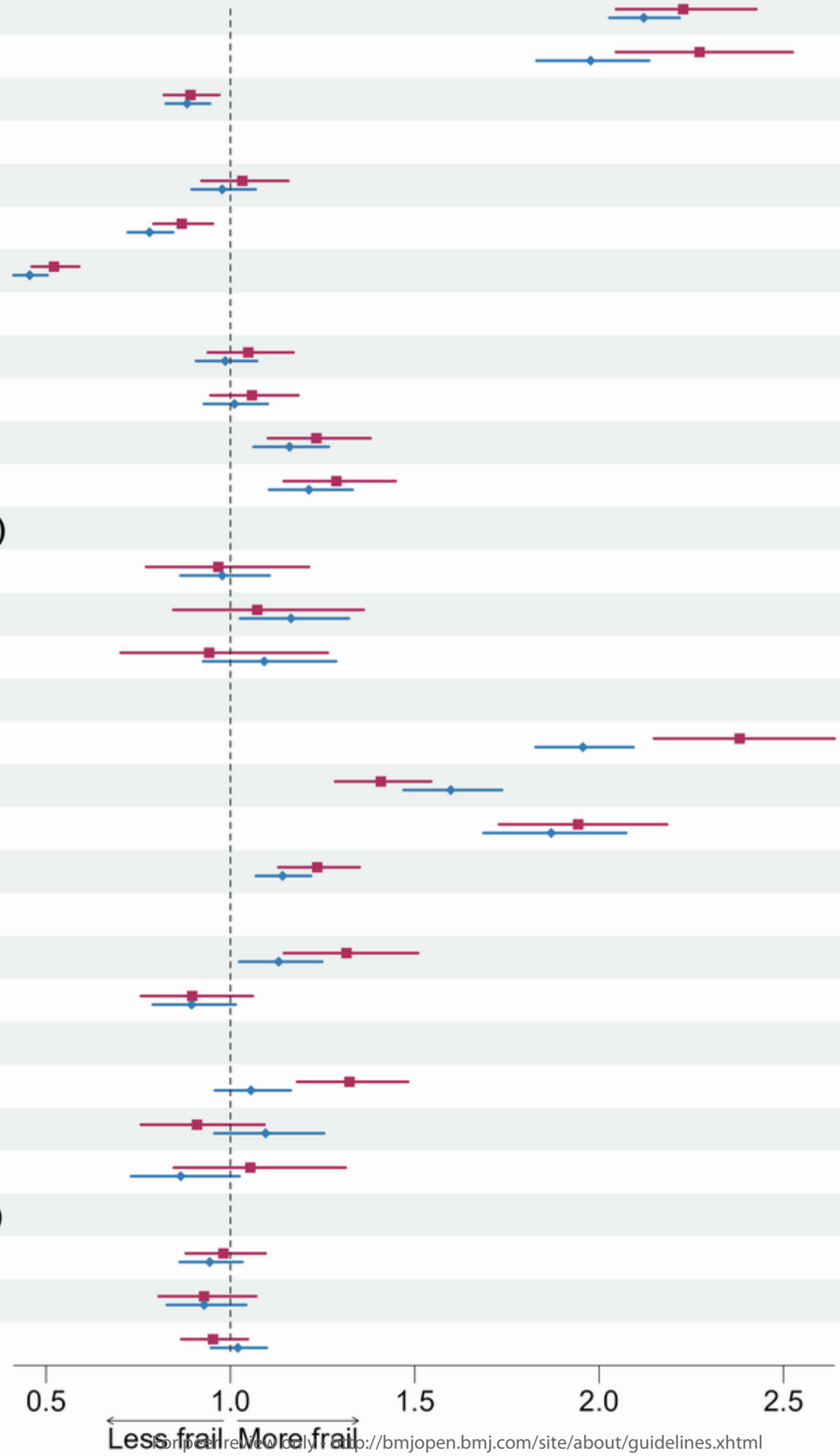


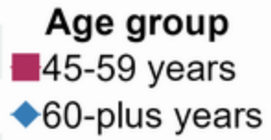






Factor	OR (95% CI) 45-59 years	60-plus years
Age (in years)	2.2 (2, 2.4)	2.1 (2, 2.2)
Female vs. Male	2.3 (2, 2.5)	2 (1.8, 2.1)
Urban vs. rural	0.9 (0.8, 1)	0.9 (0.8, 0.9)
Education (vs. no schooling)		
Less than 5 years	1 (0.9, 1.2)	1 (0.9, 1.1)
5-9 years	0.9 (0.8, 1)	0.8 (0.7, 0.8)
10 or more years	0.5 (0.5, 0.6)	0.5 (0.4, 0.5)
MPCE fifths (vs. poorest)		
Poorer	1 (0.9, 1.2)	1 (0.9, 1.1)
Middle	1.1 (0.9, 1.2)	1 (0.9, 1.1)
Richer	1.2 (1.1, 1.4)	1.2 (1.1, 1.3)
Richest	1.3 (1.1, 1.4)	1.2 (1.1, 1.3)
Living arrangement (vs. living alone)		
Living with spouse	1 (0.8, 1.2)	1 (0.9, 1.1)
Living with children	1.1 (0.8, 1.4)	1.2 (1, 1.3)
Living with others	0.9 (0.7, 1.3)	1.1 (0.9, 1.3)
Work status (vs. currently working)		
Worked in past	2.4 (2.1, 2.6)	2 (1.8, 2.1)
Never worked	1.4 (1.3, 1.5)	1.6 (1.5, 1.7)
Faces food constraint vs. not	1.9 (1.7, 2.2)	1.9 (1.7, 2.1)
Tobacco user vs. non-user	1.2 (1.1, 1.4)	1.1 (1.1, 1.2)
Alcohol use (vs. abstainer)		
Infrequent user	1.3 (1.1, 1.5)	1.1 (1, 1.2)
Frequent user	0.9 (0.8, 1.1)	0.9 (0.8, 1)
Religion (vs. Hindu)		
Muslim	1.3 (1.2, 1.5)	1.1 (1, 1.2)
Christian	0.9 (0.8, 1.1)	1.1 (1, 1.3)
Other	1.1 (0.8, 1.3)	0.9 (0.7, 1)
Caste (vs. no caste/general/missing)		
Scheduled caste	1 (0.9, 1.1)	0.9 (0.9, 1)
Scheduled tribe	0.9 (0.8, 1.1)	0.9 (0.8, 1)
Other backward class	1 (0.9, 1)	1 (0.9, 1.1)





Frailty among middle-aged and older women and men in India: Findings from Wave 1 of the Longitudinal Aging Study in India

Supplementary Table & Figure legends

S1 Table. Construction of deficits-based frailty index and distribution of deficit scores.

S2 Table. Definition of outcomes – hospitalization in last 12 months and any fall in past 2 years.

S3 Table. Construction of cognition score and distribution of its components.

S4 Table. Characteristics of excluded participants and participants included in various analyses.

S5 Table. Prevalence of frailty, overall and by participants' background characteristics.

S6 Table. Sex differences in distribution of frailty deficit scores.

S7 Table. Sex-specific associations between frailty and adverse outcomes.

S8 Table. Summary of different frailty measures, by sex and age groups.

S9 Table. Association between frailty (alternative definitions) and adverse outcomes.

S1 Fig. Flowchart presenting selection of participants for analyses.

S2 Fig. Distribution of frailty index and cognition score among 45-plus participants. A) Frailty index had a mean value of 0.18 and standard deviation (SD) of 0.13, with values ranging from 0-0.83 and a median (IQR) of 0.14 (0.08, 0.25). The dotted line presents the cut-off 0.25. B) Composite cognition score value ranges from 4 to 43, with a mean of 27.01 (SD=6.36) and a median of 27 (IQR = 22,32). Poor cognition is defined as cognition score ≤ 18 (10^{th} percentile marked as dotted line in the graph).

S3 Fig. Missingness in deficit scores. Mobility1:Walking 100 yards; Mobility2:Sitting for 2 hours or more; Mobility3:Getting up from a chair after sitting for long period; Mobility4:Climbing one flight of stairs without resting ; Mobility5:Stooping, kneeling or crouching; Mobility6:Reaching or extending arms above shoulder level (either arm); Mobility7:Pulling or pushing large objects; Mobility8:Lifting or carrying weights over 5 kilos, like a heavy bag of groceries; Mobility9:Picking up a coin from a table; Activities of Daily Living (ADL) 1:Dressing, including putting on chappals, shoes, etc.; ADL2:Walking across a room; ADL3:Bathing; ADL4:Eating; ADL5:Getting in or out of bed; ADL6:Using the toilet, including getting up and down; ADL7:Preparing a hot meal (cooking and serving); ADL8:Shopping for groceries; ADL9:Making telephone calls; ADL10:Taking medications; ADL11:Doing work around the house or garden; ADL12:Managing money, such as paying

bills and keeping track of expenses; ADL13:Getting around or finding address in unfamiliar place.

S4 Fig. Prevalence of frailty across states, in middle-aged and elderly men and women. Individuals with frailty index > 0.21 were considered as frail. Prevalence estimates are weighted, using state-level individual sampling weights provided in data.

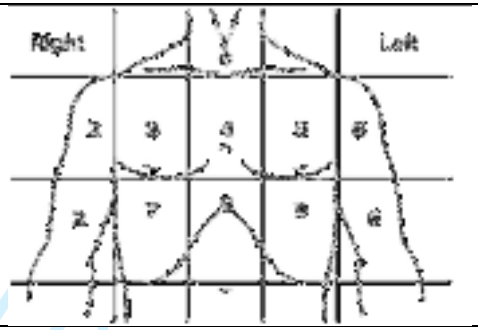
S5 Fig. Forest plot of adjusted odds ratios (95% CI) for frailty, by participants' background characteristics, using income as the economic indicator. Annual per capita household income is used as the economic indicator, instead of monthly per capita consumption expenditure. Per capita household income is computed by aggregating income from all sources (agricultural and non-agricultural business, wage/salary, pension and transfers) and dividing by the number of household members.

S1 Table. Construction of deficits-based frailty index and distribution of deficit scores.

Domain/variable	Coding criteria	Questions	Distribution in adults 45 years or older* (N=65562)
General Health (Self-reported health) (1 deficit)	Very good = 0, Good = 0.25, Fair = 0.50, Poor = 0.75, Very poor = 1	1. Now I want to ask you about your general health. Overall, how is your health in general? Would you say it is very good, good, fair, poor, or very poor? 1.Very good 2.Good 3. Fair 4. Poor 5. Very poor	Value: N (%) 0: 3050 (4.65) 0.25: 23628 (36.04) 0.5: 26924 (41.07) 0.75: 9811 (14.96) 1: 1242 (1.89) Missing: 7 (1.38)
Self-reported medically diagnosed conditions (9 deficits)			
(1) Arthritis	1 if Yes to 1. and selected a. in 2. 0 otherwise	1. Has any health professional ever diagnosed you with the following chronic conditions or diseases? Arthritis or rheumatism, Osteoporosis or other bone/joint diseases. 1. Yes 2. No 2. Have you ever been diagnosed with the following bone/joint diseases/problems? a. Arthritis b. Rheumatism c. Osteoporosis d. Other, please specify	Value: N (%) 0: 60065 (91.62) 1: 5327 (8.13) Missing: 170 (0.26)
(2) Stroke	1 if Yes to 1. 0 otherwise	1. Has any health professional ever diagnosed you with the following chronic conditions or diseases? Stroke 1. Yes 2. No	Value: N (%) 0: 64195 (97.91) 1: 1195 (1.82) Missing: 172 (0.26)

(3) Angina	Angina is defined based on symptoms. Individuals classified as having angina were those who had a history of chest pain (answer “Yes” to question 1), set off by physical exertion (answer “Yes” to questions 2 or 3), forcing them to stop or slow down (question 4),with subsequent relief (“Yes” to question 5), within 10 minutes (question 6), and located in the sternum or the left anterior chest and left arm	**Rose angina questionnaire:**[1] 1. Do you ever have any pain or discomfort in your chest? 1. Yes 2. No 2. Do you get this pain or discomfort when you walk uphill or hurry? 1. Yes 2. No 3. Unable to walk 3. Do you get it when you walk at an ordinary pace on the level? 1. Yes 2. No 4. When you get any pain or discomfort in your chest while walking or moving, what do you do? 1. Stop 2. Slow down 3. Continue at the same pace 5. Does it go away when you stop moving? 1. Yes 2. No 6. How quickly the pain subsides when it occurs? 1. 10 minutes or less 2. More than 10 minutes 7. Where do you get this pain or discomfort? (figure)	

Value	N (%)
0	61336 (93.55)
1	4005 (6.11)
Missing	221 (0.34)

	(quadrants 4, 8, or 5 and 6 in question 7). 1 if Yes to above conditions specified. 0 otherwise		
(4) Diabetes	1 if Yes to 1. 0 otherwise	1. Has any health professional ever diagnosed you with the following chronic conditions or diseases? Diabetes 1. Yes 2. No	Value | N (%) 0 | 56952 (86.87) 1 | 8429 (12.86) Missing | 181 (0.28)
(5) COPD	1 if Yes to 1. and selected a. in 2. 0 otherwise	1. Has any health professional ever diagnosed you with the following chronic conditions or diseases? Chronic lung disease such as asthma, chronic obstructive pulmonary disease/Chronic bronchitis or other chronic lung problems. 1. Yes 2. No 2. Which type of chronic lung disease do you have? a. Chronic obstructive pulmonary disease (COPD) b. Chronic Bronchitis c. Asthma d. Other, please specify	Value | N (%) 0 | 64667 (98.63) 1 | 724 (1.10) Missing | 171 (0.26)
(6) Asthma	1 if Yes to 1. and selected c. in 2. 0 otherwise	1. Has any health professional ever diagnosed you with the following chronic conditions or diseases? Chronic lung disease such as asthma, chronic obstructive pulmonary disease/Chronic bronchitis or other chronic lung problems. 1. Yes 2. No 2. Which type of chronic lung disease do you have?	Value | N (%) 0 | 62830 (95.83) 1 | 2561 (3.91) Missing | 171 (0.26)

		a. Chronic obstructive pulmonary disease (COPD) b. Chronic Bronchitis c. Asthma d. Other, please specify	
(7) Depression	Depression is defined based on symptoms using CIDI scale. a) Calculated appetite status: 1 if Yes to either 6. or 7. 0 otherwise b) Calculated CIDI score: 1 is summation of 4, 5, appetite status, 8, 9, 10, 11 c) Finally, depression status: 1 if 1. is Yes & selected either 1. or 2. category from 2. & selected either 1. or 2.	1. During the last 12 months, was there ever a time when you felt sad, blue, or depressed for two weeks or more in a row? 1. Yes 2. No 2. Please think of the two-week period during the last 12 months when these feelings were worst. During that time did the feelings of being sad, blue, or depressed usually last all day long, most of the day, about half the day, or less than half the day? 1. All day long 2. Most of the day 3. About half the day 4. Less than half the day 3. During those two weeks, did you feel this way every day, almost every day, or less often than that? 1. Every day 2. Almost every day 3. Less often Thinking about those same two weeks, 4. Did you lose interest in most things? 1. Yes 2. No 5. Did you ever feel more tired out or low in energy than is usual for you? 1. Yes 2. No 6. Did you lose your appetite?	<table><tr><td>Value</td><td>N (%)</td></tr><tr><td>0</td><td>60228 (91.86)</td></tr><tr><td>1</td><td>4058 (6.19)</td></tr><tr><td>Missing</td><td>1276 (1.95)</td></tr></table>

	category from 3. & CIDI score is >= 3. 0 otherwise	1. Yes 2. No 7. Did your appetite increase during those same two weeks? 1. Yes 2. No 8. During the same two-week period did you have a lot more trouble concentrating than usual? 1. Yes 2. No 9. People sometimes feel down on themselves, and no good or worthless. During that two-week period, did you feel this way? 1. Yes 2. No 10. Did you think a lot about death – either your own, someone else's, or death in general – during those two weeks? 1. Yes 2. No 11. Did you have more trouble falling asleep than you usually do during those two weeks? 1. Yes 2. No	
(8) Hypertension	Hypertension is defined as either self-reported or BP >=140/90 1 if Yes to 1. or 2.is > =140 or 3. is >=90,	1. Has any health professional ever diagnosed you with the following chronic conditions or diseases? Hypertension or high blood pressure. 1. Yes 2. No When the device is in the correct position and the R is relaxed, press the button to Start. Measure blood pressure and pulse three times with one minute gap between each of the measurements. No need to	Value | N (%) 0 | 34246 (52.23) 1 | 31143 (47.50) Missing | 173 (0.26)

	0 otherwise	remove the cuffs and the device between the measurements. Record measurements in CAPI. Enter 993 in systolic, diastolic and pulse reading if an unresolvable equipment problem occurs. If the average systolic reading obtained is greater than 180 and average diastolic reading is greater than 110 or either of it, fill the referral letter and give to respondent and stop the test immediately. 2. Systolic readings: average of last two readings. 3. Diastolic readings: average of last two readings.	
(9) Cataract	1 if Yes to 1. and selected b. in 2. 0 otherwise	1. Now I have some questions about your eyesight. Have you ever been diagnosed with any eye or vision problem or condition, including ordinary near sightedness or farsightedness? 1. Yes 2. No 2. With which problem or condition were you diagnosed? a. Presbyopia b. Cataract c. Glaucoma d. Myopia (Nearsightedness) e. Hypermetropia (Farsightedness) f. Other, please specify	Value: N (%) 0: 57291 (87.38) 1: 8088 (12.34) Missing: 183 (0.28)
Medical symptoms (4 deficits)			
1) Bodily aches or pains did you have?	1 if Yes to 1. & Either a., b., c. in 2. 0 otherwise	1. Are you often troubled with pain? 1. Yes 2. No 2. Do you take any medication or therapy to get relief from the pain [Multiple answers are allowed]? a. Yes, analgesics (Oral/ Injectable)	Value: N (%) 0: 48290 (73.66) 1: 17042 (25.99) Missing: 230 (0.35)

		b. Yes, therapy(ies) c. Local/external application (Ointment, cream, gel, balm, spray, oil, etc.) d. None	
2) Problem did you have with sleeping?	1 if responded 4. Frequently (5 or more nights per week), for answering any of the 4 questions listed. 0 otherwise.	Now I would like to ask you a few questions about your sleep during the past 1 month. How often do you…? Would you say Never, Rarely (1-2 nights per week), Occasionally (3-4 nights per week), or Frequently (5 or more nights per week)? 1. Never 2. Rarely (1-2 nights per week) 3. Occasionally (3-4 nights per week) 4. Frequently (5 or more nights per week) 1. How often do you have trouble falling asleep? 2. How often did you wake up during the night and had trouble getting back to sleep? 3. How often did you wake up too early in the morning and were not being able to fall asleep again? 4. How often did you feel unrested during the day, no matter how many hours of sleep you had?	Value | N (%) 0 | 57554 (87.79) 1 | 7786 (11.88) Missing | 222 (0.34)
3) Difficulty did you have in seeing (person or object) across the road?	Very good = 0, Good = 0.25, Fair = 0.50, Poor = 0.75, Very poor = 1	1. How good is your eyesight for seeing things at a distance, like recognizing a person across the street (or 20 meters away) whether or not you wear glasses, contacts, or corrective lenses? 1. Very good 2. Good 3. Fair 4. Poor 5. Very poor	Value | N (%) 0 | 4142 (6.32) 0.25 | 25786 (39.33) 0.5 | 25991 (39.64) 0.75 | 8472 (12.92) 1 | 966 (1.47) Missing | 205 (0.31)
4) Difficulty did you have in seeing	Very good = 0, Good = 0.25,	1. How good is your eyesight for seeing things up close, like reading ordinary newspaper print whether or not you wear glasses, contacts, or corrective lenses 1. Very good	Value | N (%) 0 | 3262 (4.98) 0.25 | 22743 (34.69) 0.5 | 28024 (42.74)

an object at arm's length?	Fair = 0.50, Poor = 0.75, Very poor = 1	2. Good 3. Fair 4. Poor 5. Very poor	0.75: 10198 (15.55) 1: 1072 (1.64) Missing: 263 (0.4)
Functional assessment (9 deficits)	1 = Yes, 0 = No	1. Because of physical or health problems, do you have difficulty doing any of the activities? Exclude any difficulties that you expect to last less than three months. 1. Yes 2. No	
1) Walking 100 yards			Value: N (%) 0: 50503 (77.03) 1: 14782 (22.55) Missing: 277 (0.42)
2) Sitting for 2 hours or more			Value: N (%) 0: 46098 (70.31) 1: 19187 (29.27) Missing: 277 (0.42)
3) Getting up from a chair after sitting for long period			Value: N (%) 0: 44358 (67.66) 1: 20927 (31.92) Missing: 277 (0.42)
4) Climbing one flight of stairs without resting			Value: N (%) 0: 37857 (57.74) 1: 27428 (41.84) Missing: 277 (0.42)
5) Stooping, kneeling or crouching			Value: N (%) 0: 36375 (55.48) 1: 28910 (44.10) Missing: 277 (0.42)
6) Reaching or extending arms			Value: N (%) 0: 56168 (85.67) 1: 9117 (13.91)

above shoulder level (either arm)			Missing: 277 (0.42)
7) Pulling or pushing large objects			Value: N (%) 0: 40486 (61.75) 1: 24798 (37.82) Missing: 278 (0.42)
8) Lifting or carrying weights over 5 kilos, like a heavy bag of groceries			Value: N (%) 0: 48469 (73.93) 1: 16815 (25.65) Missing: 278 (0.42)
9) Picking up a coin from a table			Value: N (%) 0: 61255 (93.43) 1: 4029 (6.15) Missing: 278 (0.42)
ADL/IADL† limitations (13 deficits)	1 = Yes, 0 = No	Now, I will ask you about a few everyday activities. Please tell me if you have any difficulty with these because of a physical, mental, emotional, or memory problem. Please exclude any difficulties you expect to last less than three months. Because of a health or memory problem, do you have any difficulty with…? 1. Yes 2. No	
1) Dressing, including putting on chappals, shoes, etc.			Value: N (%) 0: 62376 (95.14) 1: 2905 (4.43) Missing: 281 (0.43)
2) Walking across a room			Value: N (%) 0: 62466 (95.28) 1: 2815 (4.29)

			Missing	281 (0.43)
3) Bathing			Value	N (%)
			0	62462 (95.27)
			1	2819 (4.30)
			Missing	281 (0.43)
4) Eating			Value	N (%)
			0	62336 (95.08)
			1	2945 (4.49)
			Missing	281 (0.43)
5) Getting in or out of bed			Value	N (%)
			0	60712 (92.60)
			1	4569 (6.97)
			Missing	281 (0.43)
6) Using the toilet, including getting up and down			Value	N (%)
			0	58531 (89.28)
			1	6750 (10.30)
			Missing	281 (0.43)
7) Preparing a hot meal (cooking and serving)			Value	N (%)
			0	58627 (89.42)
			1	6654 (10.15)
			Missing	281 (0.43)
8) Shopping for groceries			Value	N (%)
			0	56411 (86.04)
			1	8865 (13.52)
			Missing	286 (0.44)
9) Making telephone calls			Value	N (%)
			0	53181 (81.12)
			1	12043 (18.37)
			Missing	338 (0.52)
10) Taking medications			Value	N (%)
			0	59283 (90.42)
			1	5998 (9.15)

			Missing: 281 (0.43)
11) Doing work around the house or garden			Value: N (%) 0: 55490 (84.64) 1: 9791 (14.93) Missing: 281 (0.43)
12) Managing money, such as paying bills and keeping track of expenses			Value: N (%) 0: 54799 (83.58) 1: 10482 (15.99) Missing: 281 (0.43)
13) Getting around or finding address in unfamiliar place			Value: N (%) 0: 53400 (81.45) 1: 11881 (18.12) Missing: 281 (0.43)
Any form of mental impairment (1) (Proxy variable used for mental health status)	1 if Yes to 1. & Selected b. in 2. 0 otherwise	1. Do you have any form of physical or mental impairment? 1. Yes 2. No 2. Which form of impairment do you have? a. Physical impairment such as lower body or upper body b. Mental impairment such as intellectual, cognition, or learning impairment c. Hearing impairment d. Visual impairment e. Speech impairment such as speech production, language comprehension	Value: N (%) 0: 64046 (97.69) 1: 1222 (1.86) Missing: 294 (0.45)
Body mass index (BMI) (1 deficit)	BMI >= 18.5 - <25 = 0 (Normal) BMI >= 25 - <30 = 0.5 (Overweight)	BMI is weight in kilograms divided by height in meters squared.	Value: N (%) 0: 30872 (47.09) 0.5: 12852 (19.60) 1: 15349 (23.41) Missing: 6489 (9.90)

	BMI < 18.5 = 1 (Underweight) BMI >= 30 = 1 (Obese)		
Grip strength (1 deficit)	Grip (in kg), (Left+Right hand)/2 Men: (0<BMI<=24 and grip<=29) or (24<BMI<=26 and grip <=30) or (26<BMI<=28 and grip<=30) or (28<BMI<=40 and grip<=32) = 1 (Weak grip) Women: (0<BMI<=23 and grip<=17) or (23<BMI<=26 and grip <=17.3) or (26<BMI<=29 and grip<=18) or	The LASI measured grip strength in kilograms using a handheld dynamometer (Smedley's Hand Dynamometer). Health investigators collected two readings of grip strength for both hands (dominant and non-dominant).	Value | N (%) 0 | 23368 (35.64) 1 | 35313 (53.86) Missing | 6881 (10.50)

	(29<BMI<=40 and grip<=21) = 1 (Weak grip) 1 = weak grip if fulfilled above specified conditions, 0 otherwise		
Timed walk (gait speed) (1 deficit)	Gait speed = 1 if timed walk > 10 (Slow) Gait speed = 0 if timed walk <=10 (Normal)	LASI, respondents were asked to walk 4 metres twice. The time taken to walk was recorded in seconds. Each time, and the mean time was calculated.	Value | N (%) 0 | 57032 (86.99) 1 | 1289 (1.97) Missing | 7241 (11.04)
Frailty Index Scoring: ∑(variables)/40 Score range: 0 – 1 Cut points: Robust = 0 to < 0.25, Frail = 0.25 – 1.0			Value | N (%) 0 | 42767 (65.23) 1 | 14882 (22.70) Missing | 7913 .07)

* Unweighted figures.

† ADL: Activities of Daily Living; IADL: Instrumental Activities of Daily Living

S2 Table. Definition of outcomes – hospitalization in last 12 months and any fall in past 2 years.

Survey questions	Outcome definition
Q1. In the past 12 months, have you visited any health care facility, or any health professional has visited you? *[Please identify ALL the facilities that you have visited] [Instruction: If response is 'p' freeze all other options]* **Public facility:** a. Health post/sub centers b. Primary health center/Urban Health Center c. Community health center d. District / Sub-district hospital e. Government/tertiary hospital f. Govt. AYUSH hospital **Private facility:** g. Private hospital/nursing home h. Private clinic (OPD based services) i. NGO/Charity/Trust/Church-run hospital j. Private AYUSH hospital **Others:** k. Health camp l. Mobile healthcare unit m. Pharmacy/drugstore n. Home visit o. Other, please specify _____ p. None **Q2. Over the last 12 months, how many times you were admitted as patient to a hospital/long-term care facility for at least one night?** *[Instruction for the interviewer: If respondent did not stay at hospital, enter '0']* _____Times	**Number of hospitalizations in past 12 months** was defined as response to Q2. Respondents who said 'None' to Q1 were also coded as '0'. The variable **ever hospitalised in past 12 months** was coded as 'yes' if the number of hospitalizations was 1 or more and 'no' if 0. Respondents with a non-zero response to Q2 were then asked Q3. The maximum of the responses to the two questions, Q2 and Q3, was used to construct the count variable **number of nights in hospital in past 12 months**. In addition, respondents who said 'None' to Q1 were coded as '0'.

Q3. *[Ask only if Q2 ≥ 1]* **How many nights have you spent in the hospital during the past 12 months?** Number of nights _____	
Q1. In the past two years, have you sustained any major injury? 1. Yes 2. No **Q2.** ***[Ask only if Q1=1]*** **What was the cause of that injury?** *[Multiple answers are allowed]* a. Traffic accident b. Struck by person or object c. Fire, flames, burn, electric Shock d. Drowning e. Poisoning f. Animal attack or bite g. Fall h. Other, please specify_____ **Q3.** *[Ask only if Q2≠ g]* **In the past two years, have you fallen down?** 1. Yes 2. No	Individuals having **any fall in last 2 years** were identified as those who responded 'Yes' to Q1 and identified 'Fall' in response to Q2, or those who said 'Yes' to Q3.

S3 Table. Construction of cognition score and distribution of its components.

Domain	Item	Measurement	Questions	Range	Distribution in 45-plus participants (n=65,562)	
Memory	Immediate word recall	Interviewer read out a list of 10 words and respondents were asked to repeat the words.	I will read a set of 10 words and ask you to recall as many as you can. 1. Number of words respondent (R) correctly recalls _____	0-10	0	538 (0.8)
					1	1057 (1.7)
					2	3159 (4.9)
					3	6899 (10.8)
					4	11872 (18.6)
					5	14183 (22.2)
					6	12298 (19.2)
					7	8243 (12.9)
					8	3884 (6.1)
					9	1238 (1.9)
					10	595 (0.9)
					Missing	1596
	Delayed word recall	Respondents were asked to recall the same words read out for immediate recall after some time.	1. Number of words respondent (R) correctly recalls _____	0-10	1	4399 (7.3)
					2	8068 (13.5)
					3	12022 (20)
					4	12800 (21.3)
					5	9970 (16.6)
					6	6505 (10.8)
					7	3541 (5.9)
					8	1662 (2.8)
					9	609 (1)
					10	393 (0.7)
					Missing	5593
Orientation	Time	Respondents were asked to state today's date, month and year and day of the week. For each question, the score was 0	Date 1. Correct 2. Incorrect Month	0-4	0	1345 (2.1)
					1	7306 (11.4)
					2	10485 (16.4)

		(incorrect responses) or 1 (correct responses).	1. Correct 2. Incorrect Year 1. Correct 2. Incorrect Please tell me which day of week is today. Is it Monday, Tuesday, Wednesday, Thursday, Friday, Saturday, or Sunday? 1. Correct 2. Incorrect		3: 10599 (16.6) 4: 34209 (53.5) Missing: 1618
	Place	Orientation towards place was captured based on place of interview, name of the village, street number/colony name/landmark/neighbourhood and name of the district. For each question, the score was 0 (incorrect responses) or 1 (correct responses).	What is this place used for? [plausible answers are specific answers such as living room, house, apartment, hospital, market, etc.] 1. Correct 2. Incorrect What is your address? Name of village/town/city 1. Correct 2. Incorrect Street number/ colony name/landmark/neighbourhood 1. Correct 2. Incorrect What is name of your district? 1. Correct 2. Incorrect	0-4	0: 125 (0.2) 1: 419 (0.7) 2: 1429 (2.2) 3: 6775 (10.7) 4: 54818 (86.2) Missing: 1996
Arithmetic function	Backward counting	Respondents were asked to count backward as quickly as possible from the number 20. The respondents were asked to stop after correctly counting backward from 20 to 11 or from 19 to 10. Correct counting	Please try to count backward as quickly as you can from the number, I will give you. I will tell you when to stop. Please start with 20. 1. R correctly counted (e.g., 19 – 10; 20 – 11) without error 2. R made an error(s)	0-2	0: 19815 (31) 1: 12274 (19.2) 2: 31867 (49.8) Missing: 1606

		received 2 points; counts with a mistake received 1 point. Those who could not count received 0 points.	3. R cannot count		
	Serial	Respondents were asked to subtract seven from 100 in the first step and asked to continue subtracting seven from the previous number in each subsequent step for five times. Each correct response received 1 point.	Now let's try some subtraction of numbers. One hundred minus 7 equals what? Enter the answer R gave: 1. _____ 2. R cannot count, skip next questions, and go to 'computation' And 7 from that equals what? [Interviewer: enter the answer R gave] ____ And 7 from that equals what? [Interviewer: enter the answer R gave] ____ And 7 from that equals what? [Interviewer: enter the answer R gave] ____ And 7 from that equals what? [Interviewer: enter the answer R gave] ____	0-5	0: 21325 (36.5) 1: 5131 (8.8) 2: 5791 (9.9) 3: 7776 (13.3) 4: 5778 (9.9) 5: 12599 (21.6) Missing: 7162
	Computation	This test involved the mathematical operation of division. Respondents were asked to compute the net sale price of a product after considering a discount sale of half of the original price.	A shop is having a sale and selling all items at half price. Before the sale, a sari cost 300 Rs. How much will it cost in the sale? 1. R gave the correct answer of 150 Rs 2. R gave incorrect answer If 5 people all have the winning numbers in the lottery and the prize is 1,000 Rs, how much will each of them get? 1. R gave the correct answer of 200 Rs 2. R gave incorrect answer	0-2	0: 5758 (9.3) 1: 9856 (15.9) 2: 46414 (74.8) Missing: 3534

Executive function	Executive (paper folding)	This is a three-stage command task. The respondents were instructed to take a piece of paper from the interviewer, turn it over, fold it in half, and give it back to the interviewer. Three points were given if each task was completed successfully.	When I give you a piece of paper, please turn it over, fold it in half, and give it back to me. 1. One of the tasks – turning/folding/returning actions is completed successfully 2. Two of the tasks – turning/folding/returning actions are completed successfully 3. All of the tasks – turning/folding/returning actions are completed successfully 4. None of the tasks – turning/folding/returning actions is completed successfully.	0-3	0: 3197 (5) 1: 12511 (19.5) 2: 25640 (40) 3: 22757 (35.5) Missing: 1457
	Pentagon drawing	Visio-construction is the ability to coordinate fine motor skills with visuospatial abilities, usually by reproducing geometric figures. Respondents were asked to copy two overlapping pentagons and scored 1 point for a correct drawing.	Do you see this picture? Please draw that picture on this paper. [Show the picture of two pentagons overlapped] 1. Drew picture 2. Failed to draw picture 3. Not applicable.	0-1	0: 31187 (55.5) 1: 25051 (44.5) Missing: 9324
Object naming		The interviewer points to a specific object and asks the respondent to name it. Two objects were pointed out and 1 point was given for each correct response.	What is this? [Items can be anything from cell phones, gloves, hats, rings, and umbrella that can be within close reach.] 1. Correct 2. Incorrect What is this? 1. Correct 2. Incorrect	0-2	0: 646 (1) 1: 2509 (3.9) 2: 61158 (95.1) Missing: 1249

Composite cognition score is the combined score of memory, orientation, arithmetic function, executive function, and object naming and is obtained by summing up the responses for all these items. It ranges from 0-43.

S4 Table. Characteristics of excluded participants and participants included in various analyses.

Characteristic	**45-plus adults with frailty status missing**	**Study participants** (45-plus adults with frailty status non-missing)	**Study participants with non-missing hospitalization status**	**Study participants with non-missing fall status**	**Study participants with non-missing cognition score**
	N = 7,913	N = 57,649	N = 56,790	N = 57,642	N = 42,015
Sex					
Female	4,209 (53%)	30,874 (54%)	30,422 (54%)	30,871 (54%)	20,767 (49%)
Male	3,704 (47%)	26,775 (46%)	26,368 (46%)	26,771 (46%)	21,248 (51%)
Age, Median (Q1 – Q3)*	61 (52, 70)	58 (50, 66)	58 (50, 66)	58 (50, 66)	57 (50, 65)
Place of residence					
Rural	4,619 (58%)	37,805 (66%)	37,202 (66%)	37,799 (66%)	26,212 (62%)
Urban	3,294 (42%)	19,844 (34%)	19,588 (34%)	19,843 (34%)	15,803 (38%)
Educational status					
No schooling	3,857 (49%)	26,961 (47%)	26,488 (47%)	26,958 (47%)	16,083 (38%)
Less than 5 years	740 (9.4%)	6,738 (12%)	6,653 (12%)	6,736 (12%)	4,952 (12%)
5 to 9 years	1,579 (20%)	13,280 (23%)	13,125 (23%)	13,279 (23%)	11,155 (27%)
10 years or more	1,734 (22%)	10,670 (19%)	10,524 (19%)	10,669 (19%)	9,825 (23%)
Missing	3				
MPCE quintile†					
Poorest	1,583 (20%)	11,358 (20%)	11,174 (20%)	11,356 (20%)	7,923 (19%)
Poorer	1,517 (19%)	11,673 (20%)	11,487 (20%)	11,673 (20%)	8,336 (20%)
Middle	1,487 (19%)	11,676 (20%)	11,500 (20%)	11,674 (20%)	8,405 (20%)
Richer	1,577 (20%)	11,633 (20%)	11,451 (20%)	11,631 (20%)	8,727 (21%)
Richest	1,749 (22%)	11,309 (20%)	11,178 (20%)	11,308 (20%)	8,624 (21%)
Living arrangement					
Living alone	279 (3.5%)	2,034 (3.5%)	2,008 (3.5%)	2,034 (3.5%)	1,302 (3.1%)
Living with spouse with or without children	5,270 (67%)	42,607 (74%)	41,988 (74%)	42,604 (74%)	32,345 (77%)

Living with children and others	1,732 (22%)	10,709 (19%)	10,527 (19%)	10,706 (19%)	6,786 (16%)
Living with others only	632 (8.0%)	2,299 (4.0%)	2,267 (4.0%)	2,298 (4.0%)	1,582 (3.8%)
Employment					
Currently working§	3,340 (42%)	28,939 (50%)	28,526 (50%)	28,935 (50%)	22,168 (53%)
Worked in the past	2,236 (28%)	13,045 (23%)	12,819 (23%)	13,043 (23%)	9,069 (22%)
Never worked	2,327 (29%)	15,665 (27%)	15,445 (27%)	15,664 (27%)	10,778 (26%)
Missing	10				
Food constraint¶					
No	7,360 (93%)	53,801 (93%)	53,018 (93%)	53,797 (93%)	39,582 (94%)
Yes	553 (7.0%)	3,848 (6.7%)	3,772 (6.6%)	3,845 (6.7%)	2,433 (5.8%)
Tobacco use					
Never used tobacco	4,894 (66%)	36,252 (63%)	35,747 (63%)	36,249 (63%)	26,313 (63%)
Current/past user	2,469 (34%)	21,373 (37%)	21,023 (37%)	21,369 (37%)	15,681 (37%)
Missing	550	24	20	24	21
Alcohol					
Never consumed	6,072 (82%)	47,218 (82%)	46,516 (82%)	47,216 (82%)	34,223 (81%)
Less than once a month in past 3 months	738 (10%)	6,024 (10%)	5,914 (10%)	6,020 (10%)	4,642 (11%)
One to three days per month or more frequently	559 (7.6%)	4,397 (7.6%)	4,354 (7.7%)	4,396 (7.6%)	3,145 (7.5%)
Missing	544	10	6	10	5
Caste					
Scheduled caste	1,264 (16%)	9,695 (17%)	9,515 (17%)	9,695 (17%)	6,854 (16%)
Scheduled tribe	1,225 (15%)	10,140 (18%)	10,041 (18%)	10,137 (18%)	6,514 (16%)
Other backward class	2,816 (36%)	21,813 (38%)	21,448 (38%)	21,810 (38%)	16,190 (39%)
None of the above/No caste or tribe/Don't know/Missing	2,608 (33%)	16,001 (28%)	15,786 (28%)	16,000 (28%)	12,457 (30%)
Religion					
Hindu	5,777 (73%)	42,322 (73%)	41,579 (73%)	42,320 (73%)	31,313 (75%)
Muslim	997 (13%)	6,806 (12%)	6,724 (12%)	6,805 (12%)	4,834 (12%)
Christian	734 (9.3%)	5,802 (10%)	5,787 (10%)	5,800 (10%)	3,831 (9.1%)
Other	405 (5.1%)	2,719 (4.7%)	2,700 (4.8%)	2,717 (4.7%)	2,037 (4.8%)

Region					
North	1,429 (18%)	10,537 (18%)	10,222 (18%)	10,535 (18%)	8,015 (19%)
Central	932 (12%)	7,975 (14%)	7,654 (13%)	7,975 (14%)	5,940 (14%)
East	1,137 (14%)	10,443 (18%)	10,443 (18%)	10,441 (18%)	7,979 (19%)
Northeast	962 (12%)	7,551 (13%)	7,546 (13%)	7,550 (13%)	5,191 (12%)
West	1,314 (17%)	7,580 (13%)	7,449 (13%)	7,579 (13%)	5,231 (12%)
South	2,139 (27%)	13,563 (24%)	13,476 (24%)	13,562 (24%)	9,659 (23%)

Numbers presented in table are unweighted.

* Q1: first quartile, Q3: third quartile.

† MPCE: monthly per capita expenditure which is defined as total monthly household consumption expenditure divided by household size. It includes household's per capita spending on food and non-food items including spending on health, education, utilities, etc.

§ Includes Temporarily laid off, on sick or other leave, or in job training

¶ Household food unavailability in the past 12 months, where household members either reduced their meal size, did not eat even though they were hungry, or did not eat for a whole day because enough food was not available in the household.

S5 Table. Prevalence of frailty, overall and by participants' background characteristics.

Characteristic	All	45-60 years	60-plus years
Overall	29.5 (28.7, 30.4)	16.2 (15.4, 16.9)	43.2 (41.9, 44.4)
Sex			
Female	36.1 (34.9, 37.4)	21.4 (20.2, 22.6)	52.2 (50.4, 54.1)
Male	21.7 (20.8, 22.7)	9.6 (8.5, 10.6)	33.2 (31.8, 34.6)
5-year age group			
45-49	11.6 (10.5, 12.7)	11.6 (10.5, 12.7)	-
50-54	16.3 (14.8, 17.7)	16.3 (14.8, 17.7)	-
55-59	21.8 (20.1, 23.5)	21.8 (20.1, 23.5)	-
60-64	29.9 (28.4, 31.5)	-	29.9 (28.4, 31.5)
65-69	39 (36.3, 41.7)	-	39 (36.3, 41.7)
70-74	52.5 (49.3, 55.8)	-	52.5 (49.3, 55.8)
75-79	53.9 (50.4, 57.3)	-	53.9 (50.4, 57.3)
80-plus	67.9 (64.2, 71.6)	-	67.9 (64.2, 71.6)
Place of residence			
Rural	30.8 (30.1, 31.5)	17.5 (16.7, 18.3)	43.7 (42.6, 44.8)
Urban	26.5 (24.3, 28.8)	13.2 (11.5, 14.9)	41.8 (38.3, 45.2)
Educational status			
No schooling	35.3 (34.4, 36.3)	19.8 (18.7, 20.9)	48 (46.6, 49.4)
Less than 5 years	34.2 (32.1, 36.2)	19.7 (17.6, 21.8)	47.6 (44.5, 50.8)
5 to 9 years	24.7 (22.6, 26.9)	15.1 (13.4, 16.8)	37.4 (33.5, 41.3)
10 years or more	15.5 (12.8, 18.2)	7.9 (6.3, 9.4)	27.3 (21.9, 32.7)
MPCE fifths *			
Poorest	29.8 (28.4, 31.2)	15 (13.4, 16.6)	44.3 (42.1, 46.4)
Poorer	29.9 (28.6, 31.3)	16.9 (15.3, 18.4)	42.9 (40.8, 45)
Middle	28.8 (27.2, 30.4)	16.1 (14.5, 17.7)	41.2 (38.8, 43.6)
Richer	30.6 (28.2, 33)	17.4 (15.2, 19.6)	44.1 (40.6, 47.7)
Richest	28.3 (25.7, 30.9)	15.5 (13.6, 17.3)	43.4 (39.4, 47.3)
Living arrangement			
Living alone	46.4 (42.8, 50)	22.7 (17.9, 27.5)	53.7 (49.5, 57.9)
Living with spouse with or without children	24.2 (23.4, 24.9)	15.5 (14.6, 16.3)	36.2 (35, 37.5)
Living with children and others	45.4 (42.9, 47.9)	21.4 (19.2, 23.6)	55.2 (52.3, 58.1)
Living with others only	36 (31, 41)	13.1 (8.5, 17.8)	50.9 (46.7, 55.1)
Employment			
Currently working†	18.4 (17.6, 19.3)	12.4 (11.5, 13.3)	29.3 (27.8, 30.8)
Worked in the past	45.9 (44.4, 47.4)	29.9 (27.3, 32.5)	50.2 (48.5, 51.9)
Never worked	36.5 (34.2, 38.8)	20.5 (18.6, 22.3)	52.9 (49.8, 56)
Food constraint§			
No	28.3 (27.4, 29.2)	15.2 (14.4, 16)	41.8 (40.4, 43.1)
Yes	44.1 (41.7, 46.5)	28.2 (25.2, 31.2)	58.4 (55, 61.7)
Tobacco use			
Never used tobacco	30.2 (29, 31.4)	17.1 (16, 18.2)	45 (43.1, 46.8)
Current/past user	28.3 (27.3, 29.3)	14.4 (13.4, 15.4)	40.5 (39, 42)
Alcohol use			
Never consumed	31 (30, 31.9)	17.2 (16.3, 18.1)	44.9 (43.5, 46.3)
Less than once a month in past 3 months	23.5 (21.8, 25.2)	11.6 (9.8, 13.3)	35.1 (32.2, 37.9)
One to three days per month or more frequently	18.1 (16.2, 19.9)	9 (7.4, 10.5)	29.6 (26, 33.1)

Caste			
Scheduled caste	29.9 (28.5, 31.4)	17.9 (16.3, 19.5)	42.9 (40.6, 45.2)
Scheduled tribe	23.9 (22.1, 25.7)	12.9 (11.2, 14.6)	36.6 (33.5, 39.8)
Other backward class	30 (28.4, 31.6)	15.5 (14.1, 16.8)	44.8 (42.5, 47.1)
None of the above/No caste or tribe/Don't know/Missing	30.2 (29.1, 31.3)	17.2 (16, 18.5)	42.5 (40.8, 44.2)
Religion			
Hindu	29.1 (28.2, 30.1)	15.4 (14.6, 16.2)	43.1 (41.6, 44.5)
Muslim	34.4 (32.2, 36.6)	23.4 (20, 26.7)	46.1 (43.3, 49)
Christian	24 (19.5, 28.4)	10.5 (6.7, 14.3)	39.2 (34.7, 43.7)
Other	28.2 (25.4, 31.1)	16.4 (13.1, 19.7)	39.3 (35, 43.6)
Region			
North	23.6 (22.5, 24.8)	12 (10.8, 13.2)	34.9 (33.1, 36.8)
Central	27.2 (25.7, 28.6)	14.4 (12.9, 15.8)	40 (37.7, 42.3)
East	33.2 (31.9, 34.5)	20.5 (19, 22.1)	45.7 (43.7, 47.7)
Northeast	19.8 (18.3, 21.2)	8.8 (7.5, 10.1)	34.7 (32.1, 37.3)
West	32.2 (30.6, 33.8)	18.6 (16.8, 20.3)	45 (42.5, 47.6)
South	30.6 (27.8, 33.5)	15.2 (13, 17.5)	47.9 (43.9, 51.9)

Numbers presented in table are weighted, using national-level individual sampling weights provided in data.

* MPCE: monthly per capita expenditure which is defined as total monthly household consumption expenditure divided by household size. It includes household's per capita spending on food and non-food items including spending on health, education, utilities, etc.

† Includes Temporarily laid off, on sick or other leave, or in job training

§ Household food unavailability in the past 12 months, where household members either reduced their meal size, did not eat even though they were hungry, or did not eat for a whole day because enough food was not available in the household.

S6 Table. Sex differences in distribution of frailty deficit scores.

	45-59 years		60-plus years	
	Female	Male	Female	Male
Self-reported general Health				
0 (very good)	851 (4.6%)	1,167 (7.6%)	416 (2.6%)	616 (4.2%)
0.25 (good)	7,280 (39%)	7,076 (46%)	4,418 (28%)	4,854 (33%)
0.5 (fair)	8,003 (43%)	5,540 (36%)	7,160 (45%)	6,221 (42%)
0.75 (poor)	2,265 (12%)	1,342 (8.8%)	3,541 (22%)	2,663 (18%)
1 (very poor)	195 (1.0%)	138 (0.9%)	485 (3.0%)	424 (2.9%)
Self-reported medically diagnosed conditions				
Arthritis	1,568 (8.4%)	704 (4.6%)	1,833 (11%)	1,222 (8.1%)
Stroke	128 (0.7%)	225 (1.5%)	347 (2.1%)	495 (3.3%)
Angina	1,313 (7.0%)	656 (4.3%)	1,232 (7.5%)	804 (5.3%)
Diabetes	1,968 (11%)	1,601 (10%)	2,416 (15%)	2,444 (16%)
COPD	116 (0.6%)	143 (0.9%)	213 (1.3%)	252 (1.7%)
Asthma	482 (2.6%)	414 (2.7%)	792 (4.8%)	873 (5.8%)
Depression	1,278 (6.9%)	732 (4.8%)	1,162 (7.3%)	886 (6.0%)
Hypertension	7,758 (42%)	6,058 (40%)	9,524 (58%)	7,803 (52%)
Cataract	1,027 (5.5%)	553 (3.6%)	3,646 (22%)	2,862 (19%)
Medical symptoms				
Bodily aches or pains	5,300 (28%)	2,751 (18%)	5,331 (33%)	3,660 (24%)
Problem with sleeping	2,060 (11%)	1,369 (8.9%)	2,449 (15%)	1,908 (13%)
Difficulty with distance vision				
0	1,255 (6.7%)	1,559 (10%)	542 (3.3%)	786 (5.2%)
0.25	8,181 (44%)	7,683 (50%)	4,716 (29%)	5,206 (35%)
0.5	7,340 (39%)	5,011 (33%)	7,311 (45%)	6,329 (42%)
0.75	1,772 (9.5%)	991 (6.5%)	3,318 (20%)	2,391 (16%)
1	106 (0.6%)	90 (0.6%)	444 (2.7%)	326 (2.2%)
Difficulty with near vision				
0	922 (4.9%)	1,105 (7.2%)	520 (3.2%)	715 (4.8%)
0.25	7,019 (38%)	6,310 (41%)	4,477 (27%)	4,937 (33%)
0.5	7,962 (43%)	5,803 (38%)	7,646 (47%)	6,613 (44%)
0.75	2,580 (14%)	1,970 (13%)	3,228 (20%)	2,420 (16%)
1	156 (0.8%)	140 (0.9%)	436 (2.7%)	340 (2.3%)
Functional assessment (difficulty with the following)				
Walking 100 yards	3,103 (17%)	1,381 (9.0%)	6,250 (38%)	4,048 (27%)
Sitting for 2 hours or more	4,717 (25%)	2,385 (16%)	7,270 (45%)	4,815 (32%)
Getting up from a chair after sitting for long period	5,087 (27%)	2,559 (17%)	7,894 (48%)	5,387 (36%)
Climbing one flight of stairs without resting	6,870 (37%)	3,350 (22%)	10,060 (62%)	7,148 (48%)

Stooping, kneeling or crouching	7,445 (40%)	3,838 (25%)	10,144 (62%)	7,483 (50%)
Reaching or extending arms above shoulder level (either arm)	1,819 (9.8%)	964 (6.3%)	3,944 (24%)	2,390 (16%)
Pulling or pushing large objects	6,027 (32%)	2,717 (18%)	9,583 (59%)	6,471 (43%)
Lifting or carrying weights over 5 kilos, like a heavy bag of groceries	3,583 (19%)	1,419 (9.3%)	7,439 (46%)	4,374 (29%)
Picking up a coin from a table	563 (3.0%)	296 (1.9%)	1,950 (12%)	1,220 (8.1%)
ADL/IADL* limitations (difficulty with the following)				
Dressing, including putting on chappals, shoes, etc	440 (2.4%)	292 (1.9%)	1,282 (7.9%)	891 (5.9%)
Walking across a room	380 (2.0%)	208 (1.4%)	1,339 (8.2%)	888 (5.9%)
Bathing	326 (1.7%)	249 (1.6%)	1,318 (8.1%)	926 (6.2%)
Eating	390 (2.1%)	237 (1.5%)	1,394 (8.5%)	924 (6.2%)
Getting in or out of bed	864 (4.6%)	395 (2.6%)	2,024 (12%)	1,286 (8.6%)
Using the toilet, including getting up and down	1,265 (6.8%)	630 (4.1%)	2,868 (18%)	1,987 (13%)
Preparing a hot meal (cooking and serving)	810 (4.3%)	669 (4.4%)	2,963 (18%)	2,212 (15%)
Shopping for groceries	1,551 (8.3%)	630 (4.1%)	4,323 (26%)	2,361 (16%)
Making telephone calls	2,966 (16%)	969 (6.3%)	5,270 (32%)	2,838 (19%)
Taking medications	1,194 (6.4%)	486 (3.2%)	2,803 (17%)	1,515 (10%)
Doing work around the house or garden	1,728 (9.3%)	700 (4.6%)	4,598 (28%)	2,765 (18%)
Managing money, such as paying bills and keeping track of expenses	2,468 (13%)	604 (3.9%)	5,127 (31%)	2,283 (15%)
Getting around or finding address in unfamiliar place	3,041 (16%)	726 (4.7%)	5,677 (35%)	2,437 (16%)
Any form of mental impairment	266 (1.4%)	199 (1.3%)	431 (2.6%)	326 (2.2%)
Body mass index				
0 (normal)	8,197 (48%)	7,967 (58%)	7,118 (49%)	7,590 (56%)
0.5 (underweight/overweight)	4,531 (26%)	3,136 (23%)	2,936 (20%)	2,249 (17%)
1 (obese)	4,461 (26%)	2,731 (20%)	4,487 (31%)	3,670 (27%)
Weak grip strength	7,279 (43%)	6,807 (49%)	10,265 (71%)	10,962 (82%)
Slow gait speed	83 (0.5%)	48 (0.3%)	807 (5.7%)	351 (2.6%)

*ADL: Activities of Daily Living; IADL: Instrumental Activities of Daily Living

S7 Table. Sex-specific associations between frailty and adverse outcomes.

Outcome	45-59 years			60-plus years		
	Male OR (95% CI)	Female OR (95% CI)	Female:Male ROR (95% CI)*	Male OR (95% CI)	Female OR (95% CI)	Female:Male ROR (95% CI)*
Hospitalized in last 12 months	2.22 (1.91, 2.58)	2.6 (2.11, 3.21)	1.17 (0.91, 1.52)	2.13 (1.84, 2.46)	2.27 (1.97, 2.61)	1.07 (0.87, 1.31)
Fallen down in last 2 years	2.15 (1.96, 2.37)	2.17 (1.86, 2.54)	1.01 (0.84, 1.21)	1.75 (1.6, 1.91)	2.06 (1.86, 2.29)	1.18 (1.03, 1.35)
Poor cognition	1.29 (1.1, 1.5)	1.44 (1.00, 2.06)	1.12 (0.75, 1.66)	1.35 (1.19, 1.52)	1.56 (1.31, 1.86)	1.16 (0.93, 1.44)

* ROR, ratio of odds ratios, indicating the sex difference in the relationship between frailty and adverse outcomes. For example, odds ratios of 2.6 and 2.22 for females and males, respectively, and a female:male ROR of 1.17 for hospitalization indicates that odds of hospitalization are higher for frail adults in both sexes, but the relative increase is 17% higher in females.

S8 Table. Summary of different frailty measures, by sex and age groups.

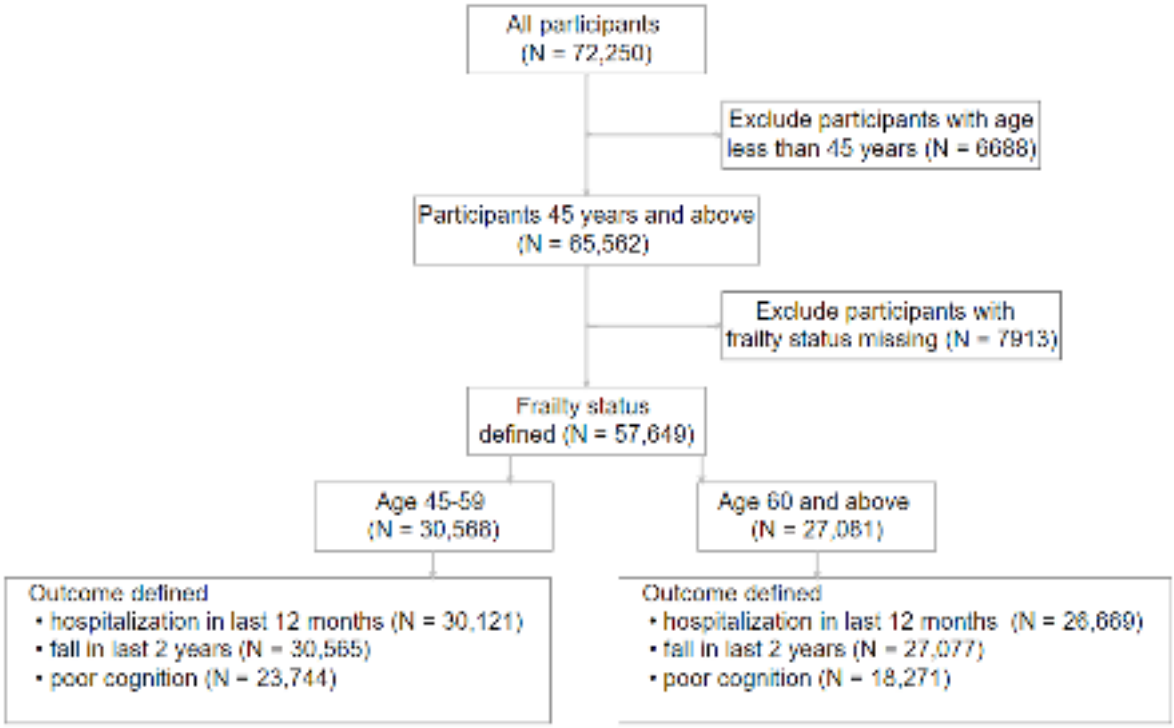
	Frailty index			Frail: frailty index ≥ 0.25			Frail: frailty index > 0.21			Frail: Frailty index based on non-missing deficits* ≥ 0.25		
	45-59 years	60-plus years	Overall	45-59 years	60-plus years	Overall	45-59 years	60-plus years	Overall	45-59 years	60-plus years	Overall
Overall	0.14 (0.14, 0.15)	0.24 (0.24, 0.25)	0.19 (0.19, 0.2)	16.2 (15.4, 16.9)	43.2 (41.9, 44.4)	29.5 (28.7, 30.4)	22.6 (21.7, 23.6)	52.2 (51, 53.4)	37.2 (36.4, 38.1)	16.7 (15.7, 17.7)	44.5 (43.3, 45.6)	30.5 (29.7, 31.4)
Male	0.12 (0.12, 0.12)	0.21 (0.21, 0.22)	0.17 (0.16, 0.17)	9.6 (8.5, 10.6)	33.2 (31.8, 34.6)	21.7 (20.8, 22.7)	13.8 (12.7, 15)	42.2 (40.7, 43.6)	28.4 (27.3, 29.4)	10.8 (8.9, 12.6)	34.8 (33.4, 36.1)	23.1 (22, 24.2)
Female	0.17 (0.16, 0.17)	0.27 (0.27, 0.28)	0.22 (0.21, 0.22)	21.4 (20.2, 22.6)	52.2 (50.4, 54.1)	36.1 (34.9, 37.4)	29.6 (28.2, 31)	61.3 (59.6, 63)	44.8 (43.5, 46.1)	21.5 (20.3, 22.6)	53.1 (51.5, 54.8)	36.8 (35.6, 38)

*Frailty index for an individual was calculated by summing the non-missing health deficit scores and then dividing by the total number of deficits measured in that individual (up to 3 were allowed to be missing). CI: confidence interval

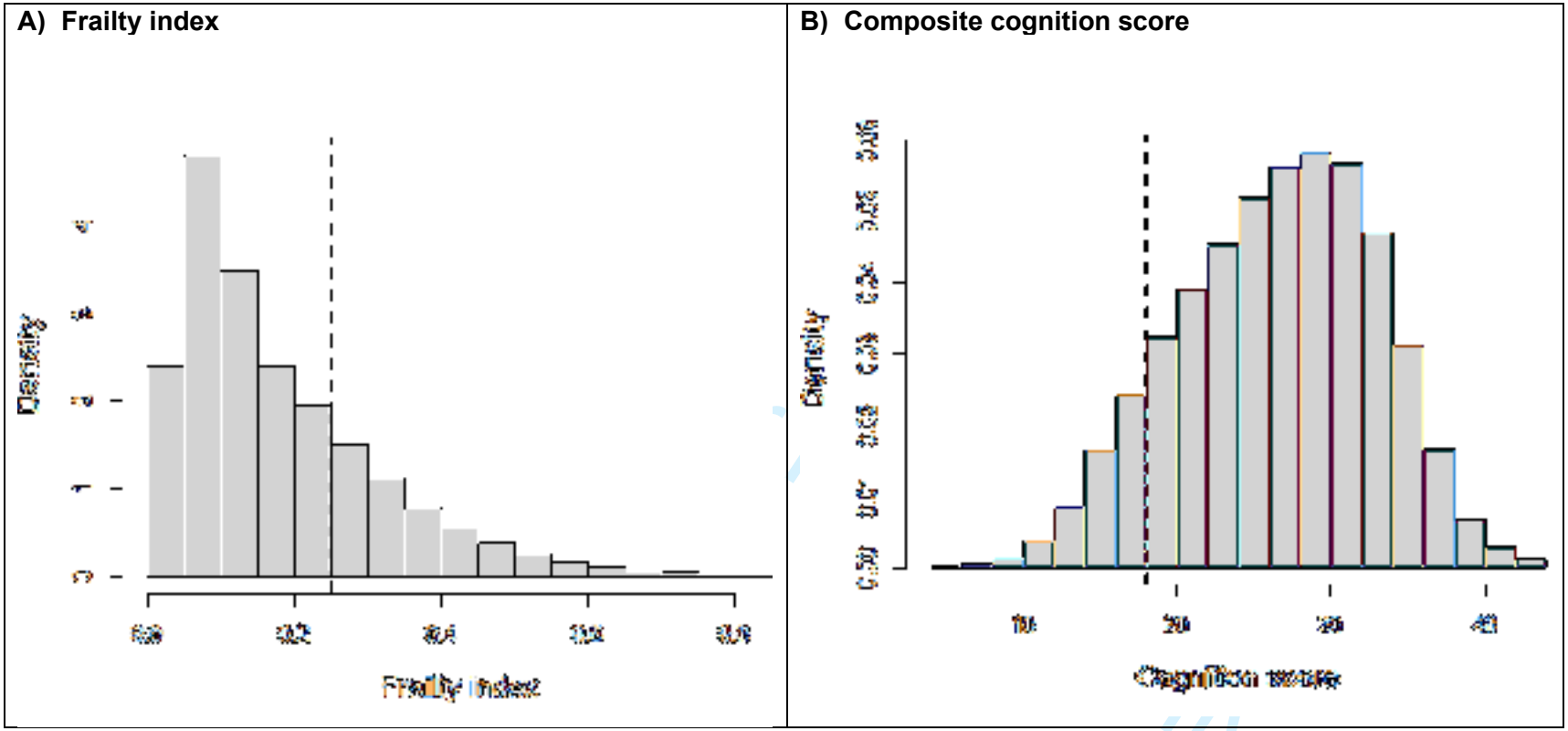
S9 Table. Association between frailty (alternative definitions) and adverse outcomes.

Outcome	Frail: frailty index > 0.21		Frail: Frailty index based on non-missing deficits* ≥ 0.25	
	45-59 years OR (95% CI)	≥ 60 years OR (95% CI)	45-59 years OR (95% CI)	≥ 60 years OR (95% CI)
Hospitalization in last 12 months	2.26 (2.02, 2.53)	2.11 (1.9, 2.33)	2.58 (2.31, 2.88)	2.37 (2.16, 2.6)
Any fall in last 2 years	1.99 (1.85, 2.14)	1.88 (1.76, 2.01)	2.18 (2.02, 2.36)	1.97 (1.85, 2.09)
Poor cognition	1.99 (1.85, 2.14)	1.35 (1.22, 1.5)	1.35 (1.19, 1.55)	1.42 (1.3, 1.56)

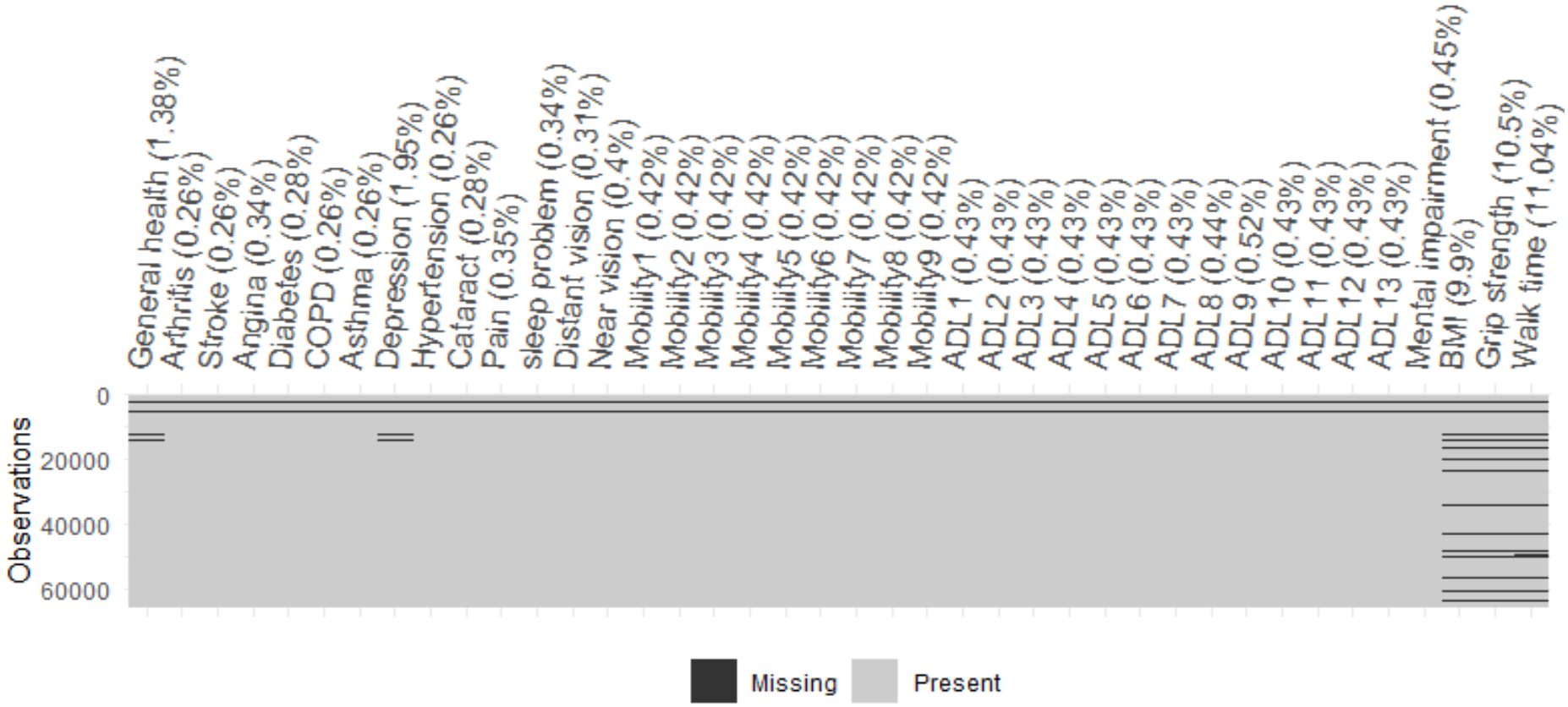
*Frailty index for an individual was calculated by summing the non-missing health deficit scores and then dividing by the total number of deficits measured in that individual (up to 3 were allowed to be missing).



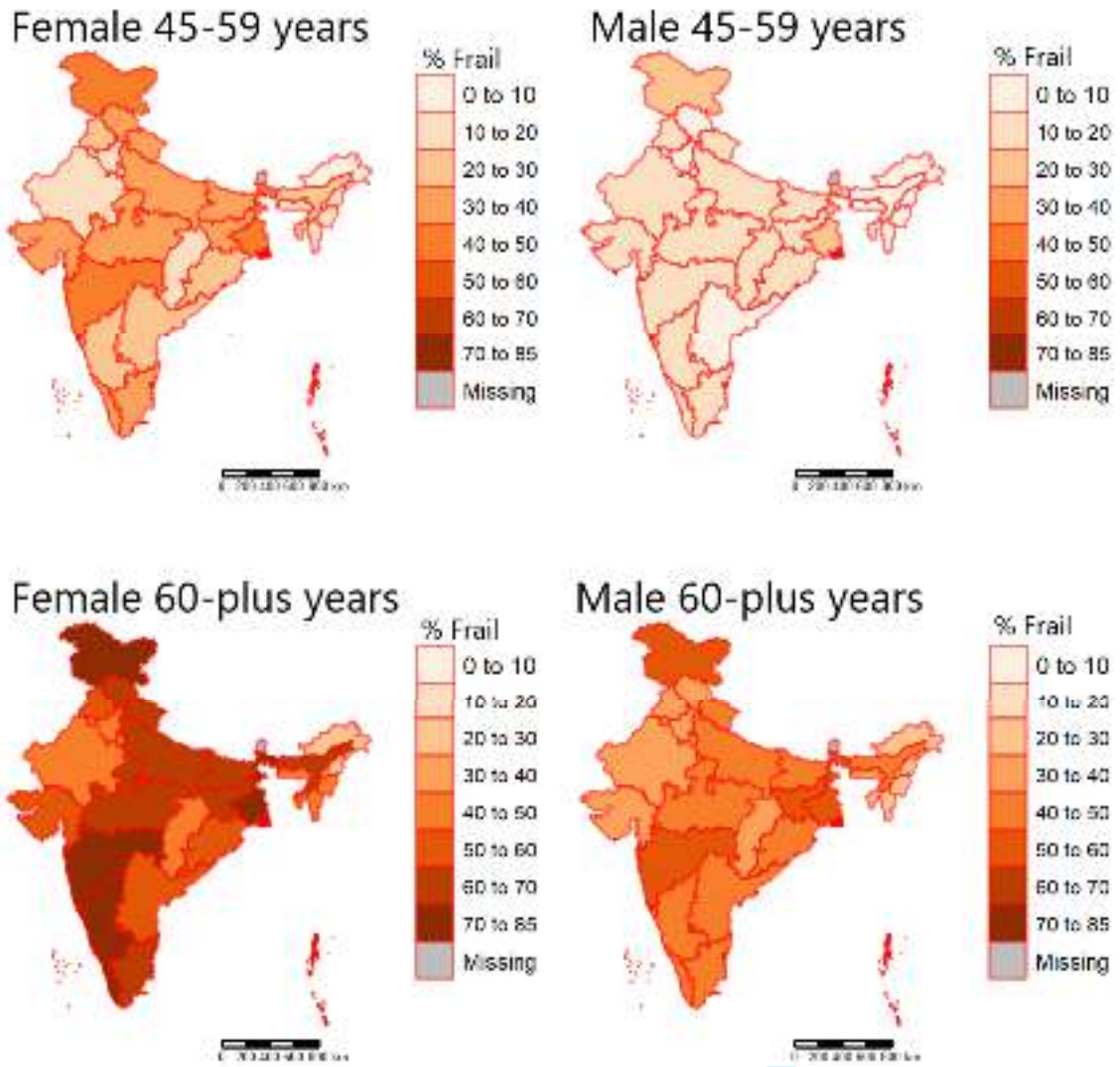
S1 Fig. Flowchart presenting selection of participants for analyses.



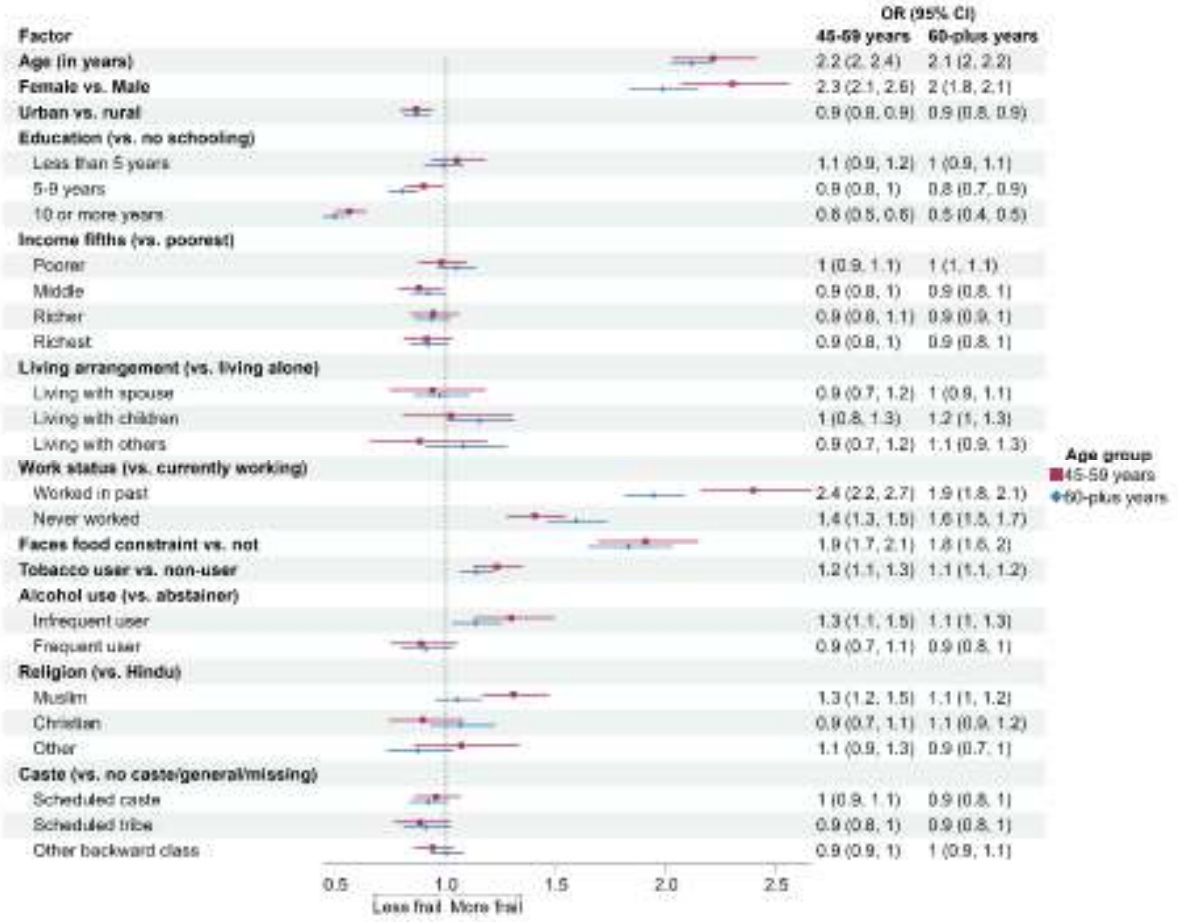
S2 Fig. Distribution of frailty index and cognition score among 45-plus participants. A) Frailty index had a mean value of 0.18 and standard deviation (SD) of 0.13, with values ranging from 0-0.83 and a median (IQR) of 0.14 (0.08, 0.25). The dotted line presents the cut-off 0.25. B) Composite cognition score value ranges from 4 to 43, with a mean of 27.01 (SD=6.36) and a median of 27 (IQR = 22,32). Poor cognition is defined as cognition score ≤ 18 (10^{th} percentile marked as dotted line in the graph).



S3 Fig. Missingness in deficit scores. BMI:Body mass index; Mobility1:Walking 100 yards; Mobility2:Sitting for 2 hours or more; Mobility3:Getting up from a chair after sitting for long period; Mobility4:Climbing one flight of stairs without resting ; Mobility5:Stooping, kneeling or crouching; Mobility6:Reaching or extending arms above shoulder level (either arm); Mobility7:Pulling or pushing large objects; Mobility8:Lifting or carrying weights over 5 kilos, like a heavy bag of groceries; Mobility9:Picking up a coin from a table; Activities of Daily Living (ADL) 1:Dressing, including putting on chappals, shoes, etc.; ADL2:Walking across a room; ADL3:Bathing; ADL4:Eating; ADL5:Getting in or out of bed; ADL6:Using the toilet, including getting up and down; ADL7:Preparing a hot meal (cooking and serving); ADL8:Shopping for groceries; ADL9:Making telephone calls; ADL10:Taking medications; ADL11:Doing work around the house or garden; ADL12:Managing money, such as paying bills and keeping track of expenses; ADL13:Getting around or finding address in unfamiliar place.



S4 Fig. Prevalence of frailty across states, in middle-aged and elderly men and women. Individuals with frailty index > 0.21 were considered as frail. Prevalence estimates are weighted, using state-level individual sampling weights provided in data.



S5 Fig. Forest plot of adjusted odds ratios (95% CI) for frailty, by participants' background characteristics, using income as the economic indicator. Annual per capita household income is used as the economic indicator, instead of monthly per capita consumption expenditure. Per capita household income is computed by aggregating income from all sources (agricultural and non-agricultural business, wage/salary, pension and transfers) and dividing by the number of household members.

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
: Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Abstract: Methods
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Abstract Methods, Results
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Background paragraphs 1-3
Objectives	3	State specific objectives, including any prespecified hypotheses	Background paragraph 4
Methods			
Study design	4	Present key elements of study design early in the paper	Methods subsection *Data*
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Methods subsection *Data*
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	Methods subsection *Data*, S1 Fig
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Methods subsection *Variables*
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Methods subsection *Variables*, S1-S3 Tables
Bias	9	Describe any efforts to address potential sources of bias	Methods subsection *Statistical analysis*
Study size	10	Explain how the study size was arrived at	Methods subsection *Data,* S1 Fig, S4 Table
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Methods subsection *Statistical analysis*
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Methods subsection *Statistical analysis*
		(*b*) Describe any methods used to examine subgroups and interactions	Methods subsection *Statistical analysis*
		(*c*) Explain how missing data were addressed	Methods subsection *Variables*, Table 1, S3 Fig
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	Methods subsection *Statistical analysis*
		(*e*) Describe any sensitivity analyses	Methods subsection *Variables*
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Results paragraph 1, S4 Table
		(b) Give reasons for non-participation at each stage	S1 Fig
		(c) Consider use of a flow diagram	S1 Fig
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Results paragraph 1, Table 1
		(b) Indicate number of participants with missing data for each variable of interest	Table 1, Table 2, S1 Table, S3 Table, S4 Table, S3 Fig
Outcome data	15*	Report numbers of outcome events or summary measures	S2 Fig panel A, S5 Table, Table 2, Table 3
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Tables 2-3, Fig 2
		(*b*) Report category boundaries when continuous variables were categorized	Tables 2-3, Fig 2
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Results subsections *Sex differences* and *Sensitivity analyses*
Discussion			
Key results	18	Summarise key results with reference to study objectives	Discussion para 1
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Discussion para 6
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Conclusion
Generalisability	21	Discuss the generalisability (external validity) of the study results	Discussion para 2-5
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Declarations subsection *Funding*

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at

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Frailty among middle-aged and older women and men in India: Findings from Wave 1 of the Longitudinal Aging Study in India

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Frailty among middle-aged and older women and men in India: Findings from Wave 1 of the Longitudinal Aging Study in India

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Abstract

Objectives: Few studies have examined frailty in Indian adults, despite an increasing population of older adults and an escalating burden of chronic diseases. We aimed to study the prevalence and correlates of frailty in middle-aged and older Indian adults.

Setting: Cross-sectional data from Wave 1 of Longitudinal Ageing Study in India, conducted in 2017-2018 across all states and union territories, were used.

Participants: The final analytical sample included 57,649 participants aged 45 years and above who had information on frailty status.

Primary outcome measure: The deficits accumulation approach to measuring frailty was employed, creating a frailty index between 0 and 1, based on 40 deficits. Individuals with a frailty index of 0.25 or more were defined as 'frail'.

Results: Prevalence of frailty among 45-plus adults was 30%. 60-plus women were twice as likely to be frail compared to 60-plus men, after adjusting for a wide range of sociodemographic, economic and lifestyle factors. The sex difference was more pronounced in 45-59-year-olds. Odds of hospitalization in the last 12 months, and having falls in the past two years, were twice as high in frail adults compared to non-frail adults. Frail middle-aged and older adults had 33% and 39% higher odds, respectively, of having poor cognition than non-frail adults. The relative increase was higher in women for all three outcomes, although not statistically significant.

Conclusions: There needs to be careful consideration of sex differences when addressing frailty, particularly for optimizing frailty interventions. Frailty, although typically assessed in older adults, was shown in this study to be also prevalent and associated with adverse outcomes in middle-aged Indian adults. More research into assessment of frailty in younger populations, its trajectory and correlates may help develop public health measures for prevention of frailty.

Strengths and limitations

1. The analyses were based on a nationally representative sample of 45-plus-year-old Indian adults from all states and union territories except Sikkim, allowing for estimation of national, as well as state-level, estimates of prevalence of frailty.
2. We examined prevalence of frailty, its risk factors and association with adverse outcomes in middle-aged adults, in addition to older adults.
3. Our frailty index was constructed using 40 deficits, including deficits pertaining to mental impairment and instrumental activities of daily living aimed at assessing cognitive functioning, thus capturing the multidimensionality of frailty.
4. Due to cross-sectional nature of data, we were unable to look at temporal associations between frailty and adverse health outcomes.
5. We were not able to define other frailty measures such as the frailty phenotype, based on the available data.

Background

Frailty is characterised by a decline in functioning across multiple physiological systems, accompanied by an increased vulnerability to stressors.[1] As a result, frail people are more likely to have adverse health outcomes when exposed to stressors than non-frail people.[2] A frailty score can help identify people with unique health needs, who need intervention to address the causes of poor health and improve outcomes in them. It can therefore be useful in clinical and community settings for risk stratification. However, there are multiple approaches and various tools to measure frailty and there is considerable disagreement between these instruments.[3] This is, in part, responsible for the marked variation in prevalence estimates across countries, and even within countries.[4]

Most studies on frailty are from high-income countries (HICs).[4] There exist several systematic reviews across geographical regions, but studies from low- and middle-income countries (LMICs) are limited and have used a variety of methods.[5] A few studies have shown that frailty prevalence and incidence are higher in LMICs compared to high-income countries.[4 6-8] In contrast, a multicounty study comparing 14 HICs and six LMICs (China, Ghana, India, Mexico, Russian Federation and South Africa) reported a higher mean frailty index in HICs compared with the LMICs.[9] However, interpretation of differences in prevalence between countries or regions is limited by the few data from LMICs. In a recent systematic review on the prevalence of frailty in LMICs, only one of the 56 studies was from a low-income country (Tanzania) and only two were from a lower middle-income country (India); the rest were from upper middle-income countries – Brazil, Colombia, Mexico, Chile, Cuba, China, Malaysia, Russia, Turkey and Lebanon.[5] Robust disaggregated data on frailty in the Indian population are rare,[10-14] whilst no studies have provided subnational estimates on the prevalence of frailty.

Further, while there are many frailty studies amongst adults aged 60 years and above,[4 5 8 15-17] the extent of the problem and its significance in adults less than 60 years is poorly understood. Studies have shown that frailty is prevalent in younger adults and suggested

that it be examined across the adult age spectrum.[18-20] This is especially true for India where chronic diseases develop a decade earlier than in HICs.[21] Furthermore, studies characterizing sex differences in frailty, and how frailty differently impacts health outcomes in women and men are rare in LMICs.[12 22-26]

With a rapidly aging population and a fragmented healthcare system, there is an urgent need to quantify frailty in India reliably, so as to inform the development of interventions and plan targeted service delivery. In this study, we examine frailty prevalence, its state-level and socioeconomic patterning and association, including sex-specific association, with key health outcomes in middle-aged (45-59-year-old) and older (60-year-plus) Indian adults.

Methods

Data

We used data from Wave 1 of the Longitudinal Ageing Study in India (LASI), conducted in 2017-2019 in all of India's states and union territories.[27] Detailed descriptions of sampling design, participants, questionnaires and response rates and are available elsewhere.[28] Briefly, LASI is a nationwide panel survey of adults aged 45 and older and their spouses, designed to provide longitudinal data on the broad domains of social, health and economic wellbeing of the elderly Indian population. Data include demographics, household economic status, mental health, functional health, biomarkers, health insurance and healthcare utilization, family and social networks, welfare programmes, work and employment, retirement, and life satisfaction. While measures in LASI are specific and sensitive to the Indian context, they have been harmonized with international surveys on ageing and retirement. LASI adopted a multistage stratified cluster sampling design. Data from LASI wave 1 include 65,562 45-plus individuals from all states and union territories except Sikkim. Data are available in the public domain and can be accessed by filling out form available at https://iipsindia.ac.in/sites/default/files/LASI_DataRequestForm_0.pdf.[29]

Variables

Assessment of frailty

We used the frailty index measure based on a deficit accumulation approach, proposed by Rockwood and colleagues.[30] We included 40 deficits across different domains[31] – general health (1 deficit), diagnosed conditions (9 deficits), medical symptoms (4 deficits), mobility restrictions (9 deficits), basic Activities of Daily Living (ADL) and Instrumental Activities of Daily Living (IADL) limitations (13 deficits), any mental impairment (1 deficit), body mass index (1 deficit), grip strength (1 deficit) and gait speed (1 deficit). All deficits were assigned scores between 0 and 1, with 1 indicating complete deficit and 0 lack of any deficit. A detailed description is presented in **S1 Table**. **Error! Reference source not found.**The frailty index is the sum of deficit scores divided by the total number of deficits considered (40 in our case), yielding a continuous score between 0 and 1. This index will be missing for an individual with missing data on any deficit. We used a cut-off of 0.25 to define presence or absence of frailty[32-34] – individuals with frailty index ≥0.25 were defined as 'frail' and others as 'non-frail'.

In sensitivity analyses, we explored another commonly used frailty index cut-off, 0.21[35]. Also, an alternative approach to calculating the frailty index that accounts for missing deficit scores was examined – up to 3 deficits were allowed to be missing and the frailty index for an individual was calculated by summing the non-missing health deficit scores and then dividing by the total number of deficits measured in that individual.

Covariates

Demographic, socioeconomic and lifestyle factors were included as covariates – age, sex, place of residence, educational status, living arrangement, monthly per capita consumption expenditure (MPCE), working status, food constraint, religion, caste, tobacco use, alcohol use and region. Food constraint referred to household food unavailability in the past 12 months. MPCE was defined as total monthly household consumption expenditure divided by household size. Expenditure here includes the household's per capita spending on food and

non-food items, including spending on health, education, and utilities. We used consumption expenditure as our economic indicator as we consider this a better measure of living standards and poverty than income. Also, household income information was missing for 1216 45-plus adults. As part of sensitivity analyses, we examined annual per capita household income as the economic indicator.

Adverse outcomes

The respondents were asked about **number of hospitalizations** and **number of nights spent in the hospital in the last 12 months.** In addition to these count outcome variables, a binary outcome variable, **ever hospitalised in last 12 months,** was defined based on the number of hospitalizations (**S2 Table**). Another binary outcome variable, **any fall in past 2 years,** was defined based on responses to questions about having fallen down or sustaining a major injury from a fall in the past 2 years (**S2 Table**).

Cognitive measures in LASI were derived from the cognition module of the Health and Retirement Study – Harmonized Cognitive Assessment Protocol.[36] A detailed description of the different cognitive domains measured in LASI is presented in **S3 Table**. A composite **cognition score**, ranging from 0 to 43, was constructed by combining scores across five domains: memory, orientation, arithmetic function, executive functioning skills, and object naming). A higher score indicated better cognitive ability and **poor cognition** was defined as a score below the 10th percentile, which was 18.

Statistical analyses

Continuous variables were summarized as mean and standard deviation (SD) or median and interquartile interval (IQI) and categorical variables as frequencies and percentages. State- and national-level sampling weights were used to produce weighted prevalence estimates. Multivariable logistic regressions were used to obtain odds ratios (ORs), with 95% confidence intervals (CIs) for the association between frailty status (frail vs. non-frail) and individuals' background characteristics – sex, age, place of residence, education,

consumption expenditure, living arrangement, work status, food constraint, tobacco use, alcohol use, religion, and caste, separately for the middle-aged and older participants. Age was analysed as a continuous variable, and all other variables were treated as categorical. Logistic and linear regressions were used to study associations between frailty status (frail vs. non-frail) and binary and continuous adverse outcomes, respectively. Poisson hurdle models were used for count outcomes with a high percentage of zeros – number of hospitalizations and number of nights spent in hospital in last 12 months. The Poisson hurdle model specifies a logistic regression for the zero counts and a truncated (at zero) Poisson model for the positive counts.[37] The association between frailty status and cognition score was examined using linear regression. All regressions examining associations between frailty and adverse outcomes were adjusted for participants' background characteristics. Sex differences in the associations with binary adverse outcomes were studied using the full interaction model, with all main effects and sex interactions with frailty as well as each confounding variable; sex-specific ORs were compared through women-to-men ratios of odds ratios (RORs).[38] All regressions were adjusted for state fixed effects to account for state-level variation. All statistical analyses were carried out using Stata 13 (StataCorp LP, College Station, Texas, USA) and R version 4.2.0.[39 40]

Patient and public involvement

Patients or the public were not involved in this secondary analysis of publicly available survey data.

Results

Description of study participants

LASI included 34,098 middle-aged adults (45-59 years) and 31,464 older adults (60 years and above). 7,913 participants for whom information related to frailty was missing were excluded from analyses, resulting in a total sample of 57,649 participants. Participants were further excluded while studying associations with outcomes, because of missing outcome

data (**S1 Fig**). There were small differences between participants with missing frailty information and those included in analyses (**S4 Table**). Participants with missing frailty data (n=7,913) were more likely to be older, residing in urban areas, living with children and/or others and not working currently. Of the 57,649 study participants, 55% of middle-aged adults and 52% of older participants were female (**Table 1**). Around 60% of the participants had no or less than 5 years of schooling, 66% lived in the rural areas, around a quarter had never worked, and 82% and 63% reported never consuming alcohol and never using any tobacco product, respectively.

Table 1. Characteristics of study participants.

Characteristic	**Overall**, N = 57,649	**45-60 years**, N = 30,568	**60-plus years**, N = 27,081
Sex			
Female	30,874 (54%)	16,912 (55%)	13,962 (52%)
Male	26,775 (46%)	13,656 (45%)	13,119 (48%)
Age, Median (Q1 – Q3)*	58 (50, 66)	51 (48, 55)	67 (63, 72)
Place of residence			
Rural	37,805 (66%)	19,730 (65%)	18,075 (67%)
Urban	19,844 (34%)	10,838 (35%)	9,006 (33%)
Educational status			
No schooling	26,961 (47%)	12,562 (41%)	14,399 (53%)
Less than 5 years	6,738 (12%)	3,404 (11%)	3,334 (12%)
5 to 9 years	13,280 (23%)	7,995 (26%)	5,285 (20%)
10 years or more	10,670 (19%)	6,607 (22%)	4,063 (15%)
MPCE fifths†			
Poorest	11,358 (20%)	5,846 (19%)	5,512 (20%)
Poorer	11,673 (20%)	6,067 (20%)	5,606 (21%)
Middle	11,676 (20%)	6,081 (20%)	5,595 (21%)
Richer	11,633 (20%)	6,276 (21%)	5,357 (20%)
Richest	11,309 (20%)	6,298 (21%)	5,011 (19%)
Living arrangement			
Living alone	2,034 (3.5%)	627 (2.1%)	1,407 (5.2%)
Living with spouse with or without children	42,607 (74%)	25,346 (83%)	17,261 (64%)
Living with children and others	10,709 (19%)	3,641 (12%)	7,068 (26%)
Living with others only	2,299 (4.0%)	954 (3.1%)	1,345 (5.0%)
Employment			
Currently working§	28,939 (50%)	19,365 (63%)	9,574 (35%)
Worked in the past	13,045 (23%)	2,961 (9.7%)	10,084 (37%)
Never worked	15,665 (27%)	8,242 (27%)	7,423 (27%)
Food constraint¶			
No	53,801 (93%)	28,624 (94%)	25,177 (93%)
Yes	3,848 (6.7%)	1,944 (6.4%)	1,904 (7.0%)
Tobacco use			
Never used tobacco	36,252 (63%)	19,919 (65%)	16,333 (60%)

Current/past user	21,373 (37%)	10,633 (35%)	10,740 (40%)
Missing	24	16	8
Alcohol use			
Never consumed	47,218 (82%)	24,848 (81%)	22,370 (83%)
Less than once a month in past 3 months	6,024 (10%)	3,123 (10%)	2,901 (11%)
One to three days per month or more frequently	4,397 (7.6%)	2,591 (8.5%)	1,806 (6.7%)
Missing	10	6	4
Caste			
Scheduled caste	9,695 (17%)	5,278 (17%)	4,417 (16%)
Scheduled tribe	10,140 (18%)	5,656 (19%)	4,484 (17%)
Other backward class	21,813 (38%)	11,461 (37%)	10,352 (38%)
None of the above/no caste or tribe/don't know/missing	16,001 (28%)	8,173 (27%)	7,828 (29%)
Religion			
Hindu	42,322 (73%)	22,482 (74%)	19,840 (73%)
Muslim	6,806 (12%)	3,625 (12%)	3,181 (12%)
Christian	5,802 (10%)	3,069 (10%)	2,733 (10%)
Other	2,719 (4.7%)	1,392 (4.6%)	1,327 (4.9%)
Region			
North	10,537 (18%)	5,536 (18%)	5,001 (18%)
Central	7,975 (14%)	4,257 (14%)	3,718 (14%)
East	10,443 (18%)	5,344 (17%)	5,099 (19%)
Northeast	7,551 (13%)	4,285 (14%)	3,266 (12%)
West	7,580 (13%)	3,977 (13%)	3,603 (13%)
South	13,563 (24%)	7,169 (23%)	6,394 (24%)

Numbers presented in table are unweighted.

* Q1: first quartile, Q3: third quartile.

† MPCE: monthly per capita expenditure which is defined as total monthly household consumption expenditure divided by household size. It includes household's per capita spending on food and non-food items including spending on health, education, utilities, etc.

§ Includes Temporarily laid off, on sick or other leave, or in job training

¶ Household food unavailability in the past 12 months, where household members either reduced their meal size, did not eat even though they were hungry, or did not eat for a whole day because enough food was not available in the household.

Prevalence of frailty

The observed frailty index values ranged between 0 and 0.83, with a median of 0.14 (IQI= 0.08 - 0.25) and mean of 0.18 (SD = 0.13) (**S2 Fig**, panel A). Using the cut-off of 0.25, the prevalence of frailty among adults 45 years and older was 29.5% (95% CI= 28.7 - 30.4).

Prevalence was higher among older adults compared with middle-aged adults (43.2% vs. 16.2%) and among women compared to men (36.1% vs. 21.7%) (**S5 Table**). For middle-aged adults, prevalence of frailty among females was double that in males (21.4% vs. 9.6%). For older participants, frailty prevalence was almost 20 percentage points higher in females than in males (52.2% vs. 33.2%).

There was substantial geographical variation in the prevalence of frailty, ranging between 8.8% in Arunachal Pradesh and 38.2% in West Bengal (**Fig 1**). Among older males, the prevalence varied between 11.8% in Nagaland and 42.7% in West Bengal. In 14 out of 35 states, more than 50% of the older women were frail, with the highest prevalence in Jammu & Kashmir (69%). Region-wise, 5 out of the 7 North-eastern states covered always appeared among the bottom 8 states with lowest prevalence, for both the age groups and sexes.

Sociodemographic, economic and lifestyle factors associated with frailty

Frailty prevalence varied widely across different social strata (**S5 Table**). Females had higher odds of being frail than males (OR (95% CI) = 2.3 (2, 2.5) among middle-aged adults and 2.0 (1.8, 2.1) among older adults), after adjusting for other background characteristics (**Fig 2**). Among middle-aged participants, Muslims had 32% (95% CI = 18 to 48%) higher odds of being frail, compared to Hindus; the difference was attenuated in the older ages (OR (95% CI) = 1.1 (1, 1.2)). Adjusted odds of being frail increased by 23% and 12% with one year increase in age, among middle-aged and older participants, respectively. While higher education was negatively associated with frailty, with more educated people having lower odds, the individuals in the two highest expenditure fifths were likely to be frailer than those in the lowest 20%. The odds of being frail were higher among participants from rural areas compared to urban areas, tobacco users compared to non-users, infrequent drinkers compared to abstainers, and among participants facing food constraint.

Association with adverse health outcomes

Six percent of the middle-aged and 8% of the older adults were hospitalised in past 12 months **Error! Reference source not found.**(**Table 2**). Fall in the past 2 years was recorded among 16% of middle-aged adults and 20% of older adults. The median cognition score was 27 (IQI = 22 - 32) and 7% and 15% of the middle-aged and older populations, respectively, had poor cognition, that is, were in the lowest 10% (**S2 Fig**, panel B). In both age groups, these adverse outcomes were more frequent, often double, among the frail participants compared to the non-frail. After adjusting for background characteristics of participants, frailty was associated with higher odds of all three outcomes studied – hospitalization in the last 12 months (OR (95% CI) = 2.4 (2.1, 2.7) among middle-aged adults and 2.2 (2.0, 2.4) among older adults), fall in the past two years (OR (95% CI) = 2.17 (2.01, 2.36) and 1.9 (1.77, 2.03) in middle-aged and older adults, respectively) and poor cognition (OR (95% CI) = 1.33 (1.16, 1.53) and 1.39 (1.26, 1.54) in middle-aged and older adults, respectively) (**Table 2**).

Table 2. Association between frailty and adverse outcomes – hospitalized in last 12 months, any fall in past 2 years and poor cognition.

Outcome	45–59-year-old adults				60-plus adults			
	All	Non-frail	Frail	Adjusted* OR (95% CI)	All	Non-frail	Frail	Adjusted* OR (95% CI)
Hospitalized in last 12 months								
No	28,440 (94%)	24,658 (95%)	3,782 (89%)	-	24,631 (92%)	15,364 (94%)	9,267 (89%)	-
Yes	1,681 (5.6%)	1,215 (4.7%)	466 (11%)	2.35 (2.09, 2.66)	2,038 (7.6%)	911 (5.6%)	1,127 (11%)	2.19 (1.98, 2.42)
Missing	447	393	54		412	226	186	
Any fall in past 2 years								
No	25,651 (84%)	22,605 (86%)	3,046 (71%)	-	21,712 (80%)	14,005 (85%)	7,707 (73%)	-
Yes	4,914 (16%)	3,658 (14%)	1,256 (29%)	2.17 (2.01, 2.36)	5,365 (20%)	2,495 (15%)	2,870 (27%)	1.9 (1.77, 2.03)
Missing	3	3	0		4	1	3	
Poor cognition†								
No	22,017 (93%)	19,343 (93%)	2,674 (88%)	-	15,521 (85%)	10,540 (88%)	4,981 (78%)	-
Yes	1,727 (7.3%)	1,362 (6.6%)	365 (12%)	1.33 (1.16, 1.53)	2,750 (15%)	1,375 (12%)	1,375 (22%)	1.39 (1.26, 1.54)
Missing	6,824	5,561	1,263		8,810	4,586	4,224	

*Adjusted for participants' sex, age, rural place of residence, education, consumption expenditure, living arrangement, work status, food constraint, tobacco use, alcohol use, religion, caste, and state.

† Poor cognition was defined as a cognition score below the 10th percentile, which was 18.

Being frail was associated with a 74% (95% CI = 45 – 109%) and 122% (95% CI = 83 – 170%) increase in mean number of hospitalizations in the last 12 months and a 15% (95% CI = 10 – 21%) and 18% (95% CI = 13 – 23%) increase in mean number of nights spent in the hospital in last 12 months, among the middle-aged and older adults, respectively (**Table 3**). Frailty was associated with one-unit lower cognition scores in both the age groups – the mean difference, for frailty versus not, was -1.02 (-1.2, -0.84) in middle-aged adults and -1.05 (-1.2, -0.89) in the older adults.

Table 3. Association between frailty and adverse outcomes – number of times hospitalized in last 12 months, number of nights spent in hospital in last 12 months and cognition score.

Outcome	45–59-year-old adults				60-plus adults			
	All	Non-frail	Frail	Adjusted* effect estimate (95% CI)	All	Non-frail	Frail	Adjusted* effect estimate (95% CI)
Number of times hospitalized in last 12 months								
N	30,121	25,873	4,248	Rate ratio = 1.74 (1.45, 2.09)	26,669	16,275	10,394	Rate ratio = 2.22 (1.83, 2.7)
Range	0-23	0-14	0-23		0-20	0-7	0-20	
Mean (SD)	0.07 (0.42)	0.06 (0.33)	0.16 (0.75)		0.10 (0.43)	0.06 (0.30)	0.15 (0.58)	
Median (IQR)	0 (0, 0)	0 (0, 0)	0 (0, 0)		0 (0, 0)	0 (0, 0)	0 (0, 0)	
Number of nights spent in hospital in last 12 months								
N	30,120	25,872	4,248	Rate ratio = 1.15 (1.1, 1.21)	26,669	16,275	10,394	Rate ratio = 1.18 (1.13, 1.23)
Range	0-169	0-169	0-120		0-120	0-120	0-90	
Mean (SD)	0.34 (2.57)	0.27 (2.35)	0.74 (3.64)		0.48 (2.88)	0.33 (2.43)	0.71 (3.47)	
Median (IQR)	0 (0, 0)	0 (0, 0)	0 (0, 0)		0 (0, 0)	0 (0, 0)	0 (0, 0)	
Cognition score								
N	23,744	20,705	3,039	Mean difference = -1.02 (-1.2, -0.84)	18,271	11,915	6,356	Mean difference = -1.05 (-1.2, -0.89)
Range	7-43	7-43	8-42		4-43	7-43	4-43	
Mean (SD)	28 (6)	28 (6)	26 (6)		26 (6)	27 (6)	24 (6)	
Median (IQR)	28 (24, 33)	29 (24, 33)	26 (22, 30)		26 (21, 31)	27 (22, 31)	24 (19, 29)	

*Adjusted for participants' sex, age, rural place of residence, education, consumption expenditure, living arrangement, work status, food constraint, tobacco use, alcohol use, religion, caste, and state.

Sex differences

Of the 40 deficits that were considered, men fared worse than women only for grip strength, stroke, chronic obstructive pulmonary disease and asthma; whereas more women than men had poor general health, most diagnosed conditions, medical symptoms, mobility restrictions, difficulties with normal daily self-care activities and needed supervision or assistance, were either underweight, overweight or obese, and had slow gait speed (**S6 Table**). The sex differences in mobility restrictions and ADL/IADL limitations were especially pronounced, even in the middle-aged adults.

The adjusted odds of hospitalization in the past 12 months, falls in the past 2 years and poor cognition were higher for frail compared to non-frail adults, in both women and men. In women the ORs were higher than in men, in both the age groups. Women-to-men RORs were thus higher than unity for all three outcomes, although their CIs included zero, except for falls in past 2 years in the 60-plus age group, so that chance findings could not be ruled out (**S7 Table**).

Sensitivity analyses

Of the 40 deficits considered, all deficits, except body mass index, grip strength and gait speed, were missing in <2% of the 45-plus participants; and these three measurements were missing in 10-11% of participants (**S3 Fig**). The frailty index calculated using non-missing health deficit scores allowed up to 3 deficits to be missing and therefore could be calculated for 64,331 participants, resulting in <2% with missing frailty index (n=1,231). There were small differences between participants with frailty index missing (n=1,231) or not (n=64,331) (S4 Table). This alternative construction made no difference to the prevalence estimates – 17% of middle-aged adults and 44% of older participants were frail using this metric (**S8 Table**). ORs for the association between frailty and adverse outcomes were also similar (**S9 Table**), suggesting that findings hold true irrespective of the proportion missing frailty information.

Using an alternative cut-off value of 0.21,[35 41] the prevalence of frailty increased to 37%. Even though frailty prevalence was inevitably higher using this cut-off (**S8 Table and S4 Fig**), the associations with adverse outcomes were similar (**S9 Table**).

No association between frailty and income was found after adjusting for other factors, when using household income instead of consumption expenditure as the economic indicator in analysis exploring sociodemographic, economic and lifestyle factors associated with frailty (**S5 Fig**).

Box 1. Key findings

1. Frailty, typically assessed in older adults, was also prevalent in middle-aged Indian adults (43.2% in 60-plus vs. 16.2% in 45-59-year-olds).
2. The odds of frailty were twice as high in women than in men, after adjusting for background characteristics.
3. In both age groups, after adjusting for background characteristics of participants, frailty was associated with higher odds of all three outcomes studied – hospitalization in the last 12 months (OR =2.4 and 2.2 in middle-aged and older adults, respectively), fall in the past two years (2.17 and 1.9) and poor cognition (1.33 and 1.39).
4. Associations between frailty and adverse outcomes were consistently stronger for women relative to men, although not statistically significant.

Discussion

Our study provides national, as well as state-level, estimates of prevalence of frailty and its association with outcomes across the age spectrum amongst 45-plus Indian adults. Our study showed that frailty is common among 45-plus Indian adults and it varies across the states. We found that women were more than twice as likely to be frail than men, after adjusting for a wide range of factors. We showed that frailty, usually assessed only in older adults, was also prevalent in 45-59-year-old middle-aged adults, and was associated with hospitalization, falls and poor cognitive functioning (**Box 1**).

Frailty prevalence in LMICs

Based on a nationally representative sample of 45-plus-year-old Indian adults, we estimated a frailty prevalence of 29.5%, using a frailty index with 40 deficits. A recent systematic review in 62 countries across the world reported a pooled frailty index prevalence of 24% (95% CI = 22 – 26%) based on 71 studies.[4] Region-wise, these estimates were 38% (95% CI = 37 – 39%) in Sub-Saharan Africa, 30% (95% CI = 28 – 31%) in Latin America and the Caribbean, 25% (95% CI = 19 – 32%) in Asia, 22% (95% CI = 20 – 24%) in Europe and 21% (95% CI = 11 – 33%) in Northern America. Another systematic review focussing on LMICs reported a pooled prevalence of 18.0% (95% CI = 5.8 – 35.0%) based on 4 studies using a frailty index approach.[5] Comparison, however, is difficult because prevalence estimates vary greatly by frailty assessment method, and estimates from studies using frailty indices are available only from few LMICs.[4 5] It is further compounded by differences in the cut-off value and the type of study population.

Factors associated with frailty

Our findings are in line with associations observed in other studies – female sex,[22] lower education[12] and tobacco use[42] are well-known determinants of frailty. Our analyses pointed out that sex-differences in mobility restrictions and ADL/IADL limitations were especially pronounced, even among the middle-aged adults. Interestingly, we found frailty to be more prevalent in upper fifths of consumption expenditure, while many studies have shown an inverse gradient with economic well-being. We hypothesize that this may be because frail people tend to incur more healthcare expenditure, resulting in higher consumption expenditure. The positive association, however, was no longer present when per capita household income was instead used as the economic indicator. Another intriguing finding was that infrequent drinking was associated with higher odds of frailty compared to abstaining, but the same was not true for frequent drinking. Other studies have shown similar associations with infrequent and frequent alcohol intakes compared to zero consumption.[20 43 44] This, however, should be treated with caution, as it can be due to

residual confounding or healthy survivor bias. Our results suggest that vulnerable groups should be targeted when developing interventions to prevent and mange frailty. For achieving best results, the interventions should be customized per their needs.[45] For this, knowledge of underlying mechanisms is essential and should be explored in future frailty research.

Outcomes associated with frailty

Frailty was associated with hospitalization, falls and poor cognition, across both the age groups and sexes. A systematic review of 13 prospective studies in community-dwelling older adults found physical frailty to be a predictor of hospitalisation.[46] The authors speculated that fall-related injuries could be one of the contributors. Another systematic review of 11 studies showed that frailty, however defined, is a significant predictor of future falls among community-dwelling older people. Fall risk according to frailty was found to be higher in men than in women. A prospective population-based study, using data from the Canadian Study of Health and Aging, showed that frailty status, defined using various criteria, is strongly associated with changes in cognition.[47]

Frailty in middle-aged adults

Inclusion of over 34,000 45-59-year-olds in LASI allowed us to examine frailty, its risk factors, and its association with adverse outcomes for the first time in the middle-aged Indian population. The association between frailty and hospitalization and falls was even stronger in middle-aged adults compared to older adults. Although the prevalence of frailty increases with age, it is not limited to the elderly. Studies looking into associations between frailty and adverse outcomes in middle-aged adults are rare, and they highlight the need to identify, manage, and prevent frailty across the age spectrum.[20 48 49] The frailty index has been validated in young and middle-aged adults in few studies and there exits limited evidence of predictive validity of frailty index in younger populations.[50 51] However, it is not clear if frailty, as a construct, is similar for older and younger adults.[52] Comparison of distribution of deficits in middle-aged and older adults (**S10 Table**) suggests that frailty in middle-aged adults is

probably due to long-term health problems that adversely affect their overall functioning. More studies are needed to understand how frailty can be conceptualized and measured in middle-aged and younger adults, and whether assessing frailty in them makes any difference to their health or the care they receive.

Strengths and limitations

Our study has many strengths. First, our study provides frailty prevalence estimates among 45-plus adults for all Indian states and union territories (except Sikkim), in addition to a national prevalence estimate. Second, we examined prevalence of frailty, its risk factors and association with adverse outcomes in middle-aged adults, in addition to older adults. Third, our frailty index was constructed using 40 deficits, 30 being the minimum number to ensure sufficient accuracy in predicting adverse events. We included deficits pertaining to mental impairment and instrumental activities of daily living aimed at assessing cognitive functioning, thus capturing the multidimensionality of frailty. Finally, the sensitivity analyses helped demonstrate that our findings about variation in frailty and its association with outcomes are robust to the cut-off used to define frailty.

We also recognize certain limitations. First, we were not able to define other frailty measures such as the frailty phenotype, based on available data. Given that prevalence estimates vary widely depending on the assessment method,[4 5 11 41] it would have been more informative if we were able to compare our findings using other frailty measures. Second, our cross-sectional study is unable to look at temporal associations between frailty and adverse health outcomes. LASI is designed as a panel study and data from subsequent waves will allow for examination of temporal associations in the future. Third, LASI employed a multistage cluster sampling design but variables identifying participants belonging to the same cluster have not been made publicly available, limiting our ability to account for the cluster sampling design in analyses and generate robust standard errors.[53] Fourth, there is but limited evidence to support the use of frailty index in middle-aged adults[52 54 55] and future research should explore suitable frailty measures and cut-offs.

Conclusion

Our study has implications for healthcare delivery planning. We show that women are significantly more likely to be frail compared with men, across both age groups studied. These high levels of frailty among women will have a significant impact on patient-reported and clinical outcomes. Strategies to mitigate frailty should consider these sex differences. Also, we have demonstrated that frailty is prevalent in 45-59-year-old middle-aged adults, exhibits social patterning and is associated with adverse outcomes, suggesting that younger adults may be identified as frail and may benefit from early detection and delivery of timely care. In a resource-constrained setting such as India, the focus must be on prevention and early detection of frailty. Both management of risk factors and screening for frailty have to be implemented, preferably at the primary care level. Given the strong links between social inequalities and frailty, marginalized populations must be prioritized.

Declarations

Ethics approval and consent to participate

Not applicable. We used LASI survey data available in the public domain from the International Institute for Population Sciences website. Ethics approval for LASI survey was granted by all collaborating institutions and the Indian Council for Medical Research. Written informed consent was obtained for household survey, individual survey, and dried blood spot collection.

Availability of data and materials

LASI survey data are available in the public domain from the International Institute for Population Sciences (IIPS) website. Application has to be made for access to data and access is granted after review by IIPS for legitimate academic research purposes. Link for application can be accessed at https://www.iipsindia.ac.in/content/LASI-data.

Competing interests

AG, MK and ND have no conflicts of interest to declare. MW is a consultant to Amgen, and Freeline. VJ has received grant funding from GSK, Baxter Healthcare, and Biocon and honoraria from Bayer, AstraZeneca, Boeringer Ingelheim, NephroPlus and Zydus Cadilla, under the policy of all honoraria being paid to the organization.

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Authors' contributions

AG and MK conceived the idea for the study, performed literature review, conducted data preparation, carried out statistical analyses and wrote the first draft. All authors contributed to interpretation of the study findings. VJ, MW, ND and AG contributed to reviewing and editing the final draft. All authors have read and approved the final manuscript.

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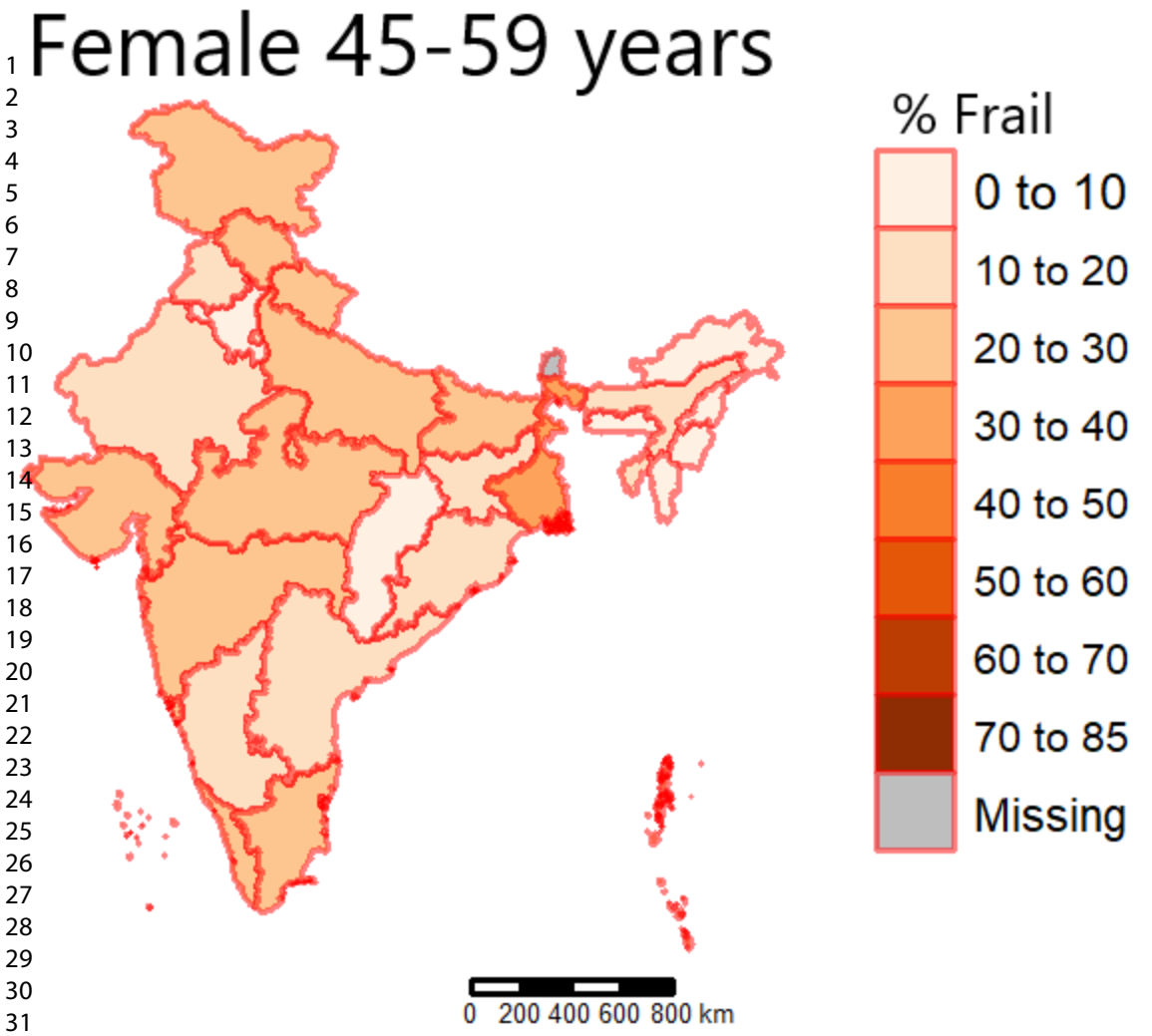
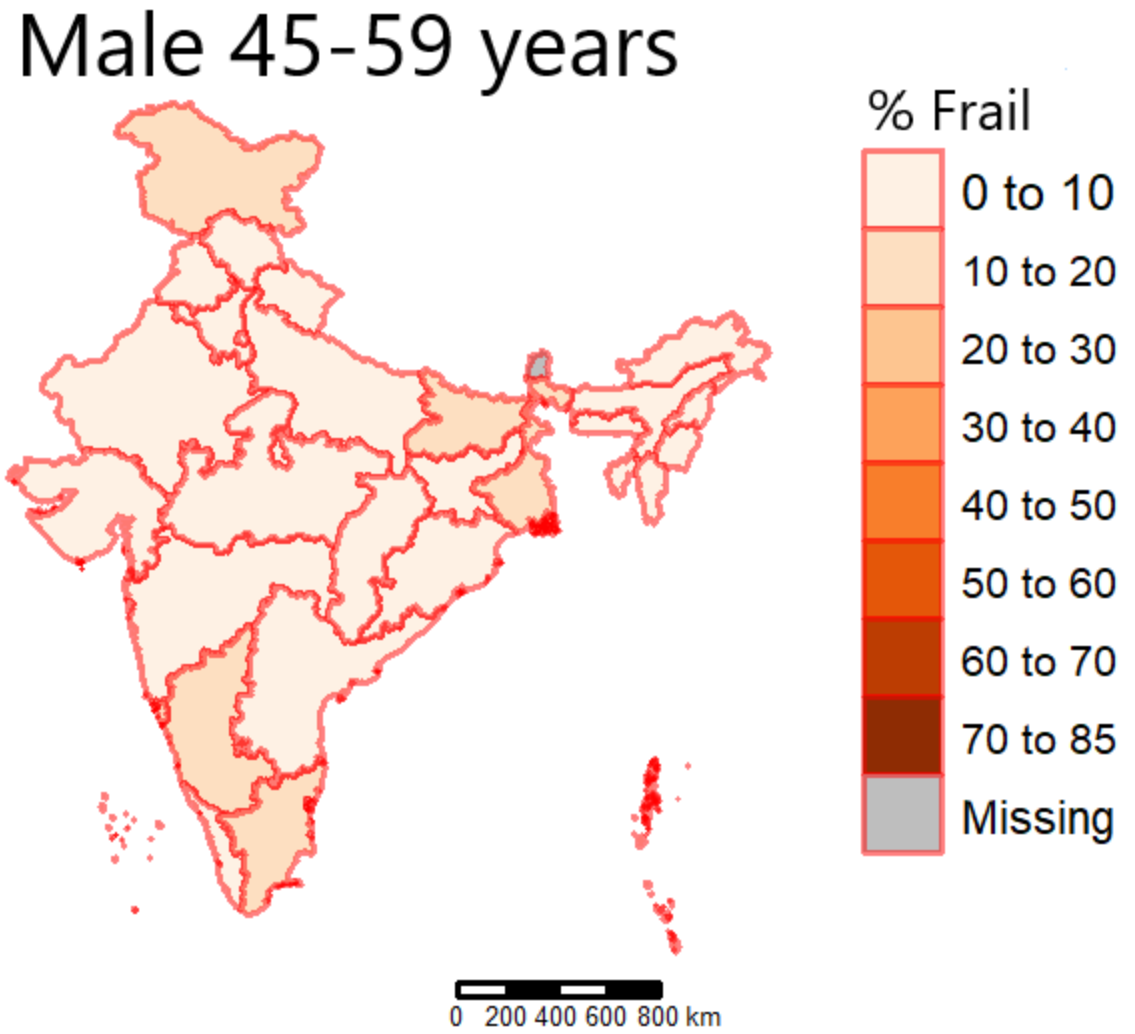
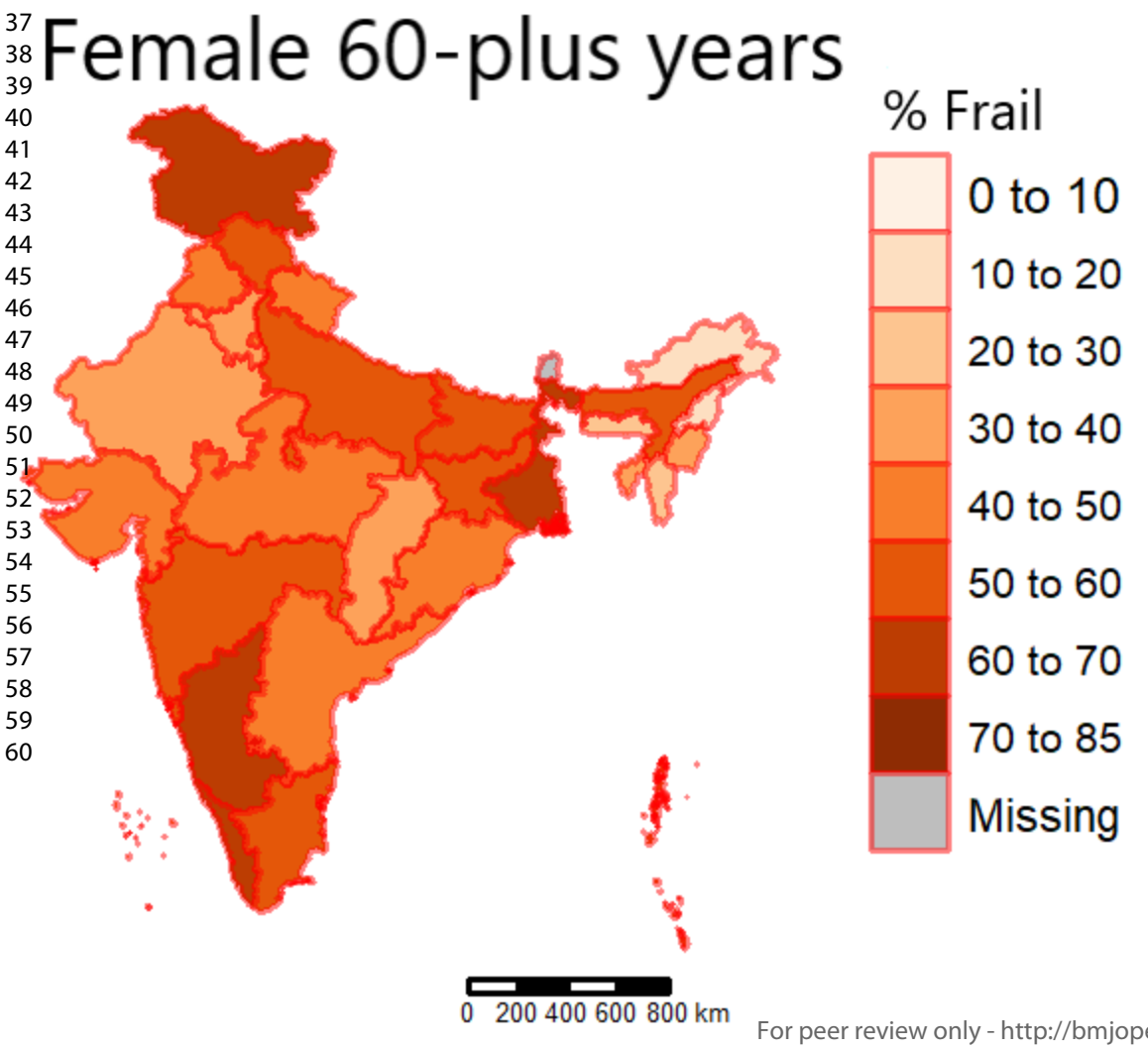
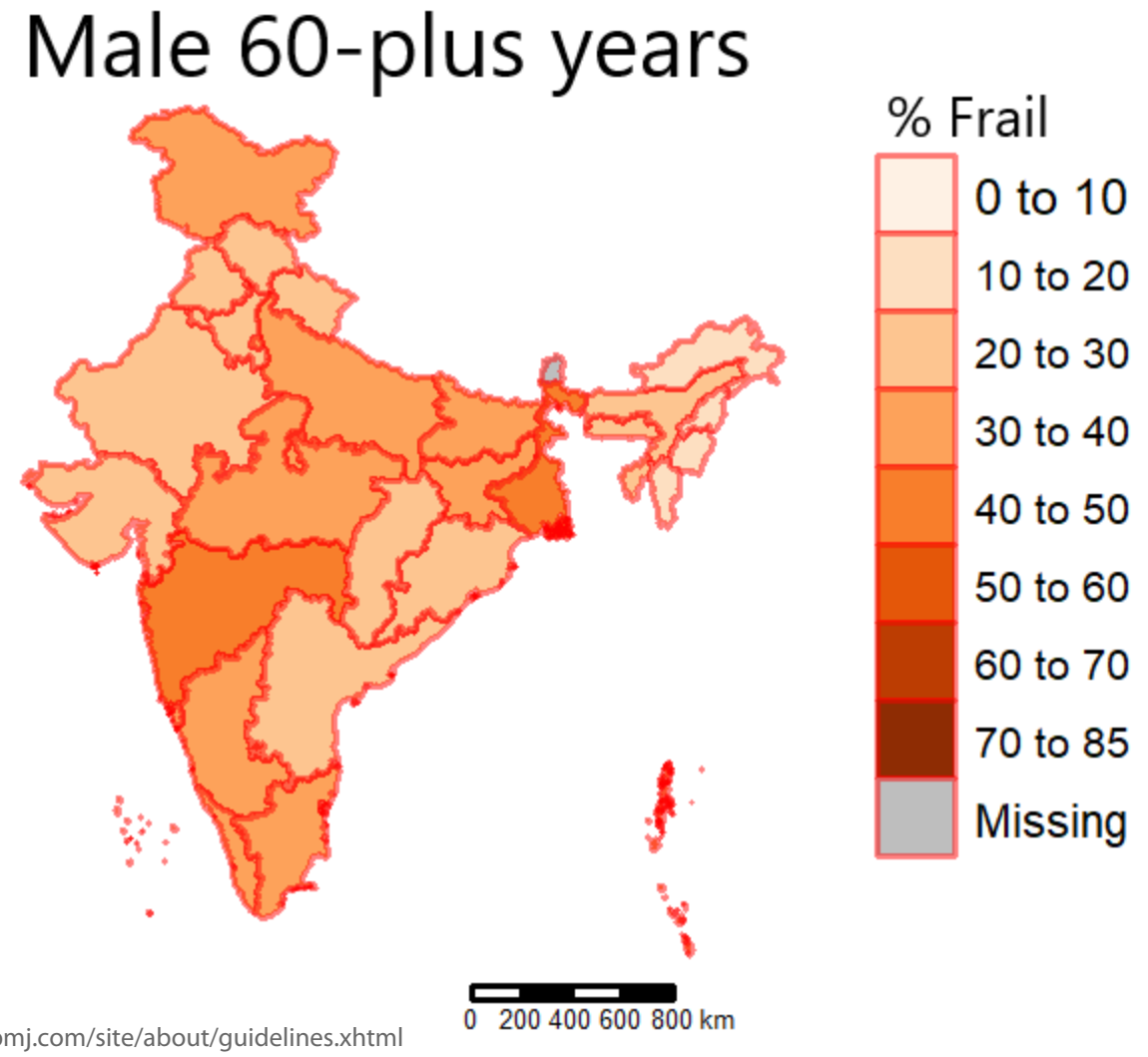
Fig 1. State-wise prevalence of frailty, by sex and age group. Individuals with frailty index ≥ 0.25 are defined as 'frail'. Prevalence estimates are weighted, using state-level individual sampling weights provided in data.

Fig 2. Forest plot of adjusted odds ratios (95% CI) for frailty, by participants' background characteristics. MPCE: monthly per capita expenditure, which is defined as total monthly household consumption expenditure divided by household size. Food constraint refers to household food unavailability in the past 12 months, where household members either reduced their meal size, did not eat even though they were hungry, or did not eat for a whole day because enough food was not available in the household.

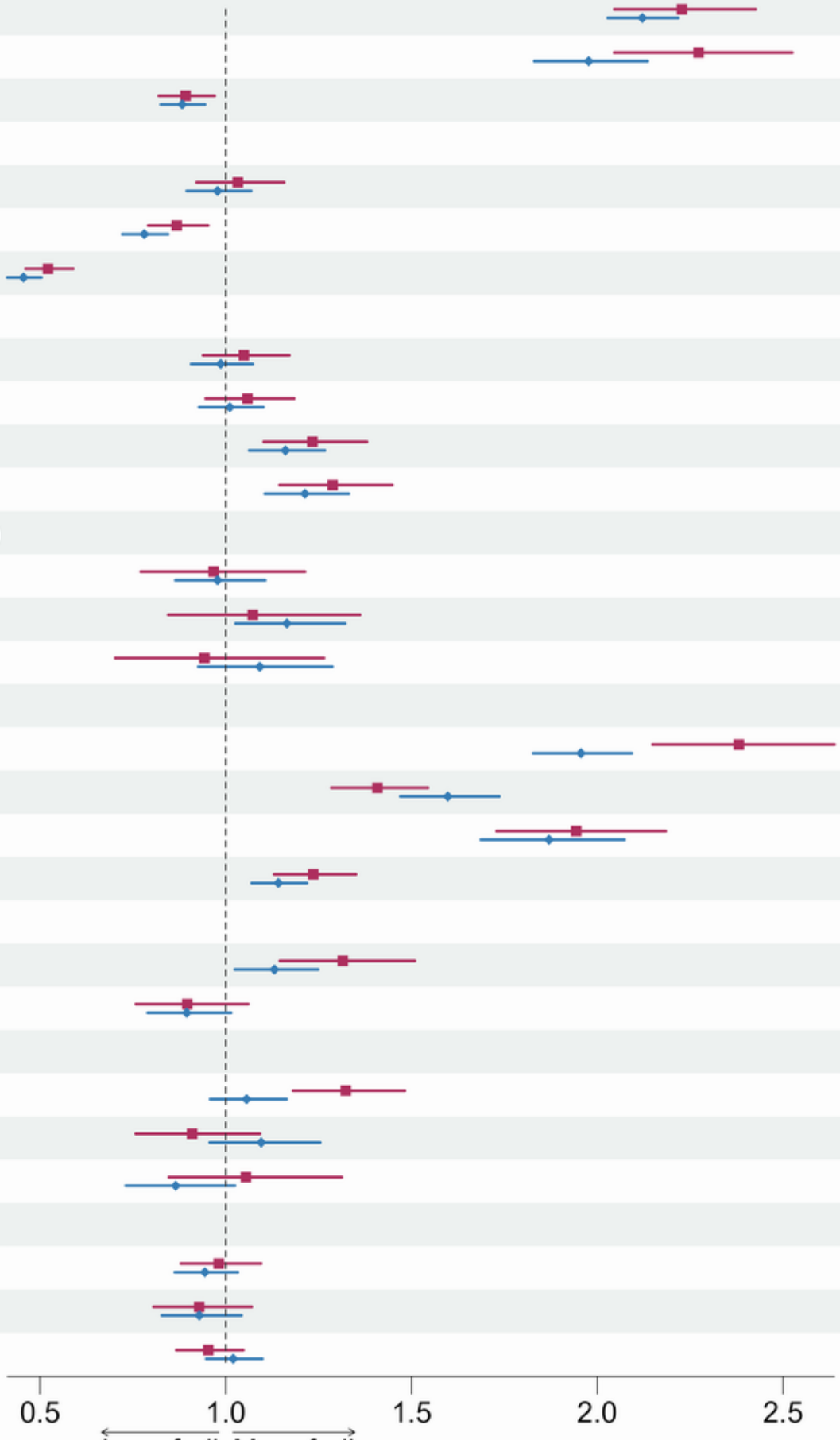


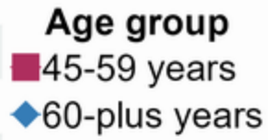






Factor	OR (95% CI) 45-59 years	60-plus years
Age (in years)	2.2 (2, 2.4)	2.1 (2, 2.2)
Female vs. Male	2.3 (2, 2.5)	2 (1.8, 2.1)
Urban vs. rural	0.9 (0.8, 1)	0.9 (0.8, 0.9)
Education (vs. no schooling)		
Less than 5 years	1 (0.9, 1.2)	1 (0.9, 1.1)
5-9 years	0.9 (0.8, 1)	0.8 (0.7, 0.8)
10 or more years	0.5 (0.5, 0.6)	0.5 (0.4, 0.5)
MPCE fifths (vs. poorest)		
Poorer	1 (0.9, 1.2)	1 (0.9, 1.1)
Middle	1.1 (0.9, 1.2)	1 (0.9, 1.1)
Richer	1.2 (1.1, 1.4)	1.2 (1.1, 1.3)
Richest	1.3 (1.1, 1.4)	1.2 (1.1, 1.3)
Living arrangement (vs. living alone)		
Living with spouse	1 (0.8, 1.2)	1 (0.9, 1.1)
Living with children	1.1 (0.8, 1.4)	1.2 (1, 1.3)
Living with others	0.9 (0.7, 1.3)	1.1 (0.9, 1.3)
Work status (vs. currently working)		
Worked in past	2.4 (2.1, 2.6)	2 (1.8, 2.1)
Never worked	1.4 (1.3, 1.5)	1.6 (1.5, 1.7)
Faces food constraint vs. not	1.9 (1.7, 2.2)	1.9 (1.7, 2.1)
Tobacco user vs. non-user	1.2 (1.1, 1.4)	1.1 (1.1, 1.2)
Alcohol use (vs. abstainer)		
Infrequent user	1.3 (1.1, 1.5)	1.1 (1, 1.2)
Frequent user	0.9 (0.8, 1.1)	0.9 (0.8, 1)
Religion (vs. Hindu)		
Muslim	1.3 (1.2, 1.5)	1.1 (1, 1.2)
Christian	0.9 (0.8, 1.1)	1.1 (1, 1.3)
Other	1.1 (0.8, 1.3)	0.9 (0.7, 1)
Caste (vs. no caste/general/missing)		
Scheduled caste	1 (0.9, 1.1)	0.9 (0.9, 1)
Scheduled tribe	0.9 (0.8, 1.1)	0.9 (0.8, 1)
Other backward class	1 (0.9, 1)	1 (0.9, 1.1)





Frailty among middle-aged and older women and men in India: Findings from Wave 1 of the Longitudinal Aging Study in India

Supplementary Table & Figure legends

S1 Table. Construction of deficits-based frailty index and distribution of deficit scores.

S2 Table. Definition of outcomes – hospitalization in last 12 months and any fall in past 2 years.

S3 Table. Construction of cognition score and distribution of its components.

S4 Table. Characteristics of excluded participants and participants included in various analyses.

S5 Table. Prevalence of frailty, overall and by participants' background characteristics.

S6 Table. Sex differences in distribution of frailty deficit scores.

S7 Table. Sex-specific associations between frailty and adverse outcomes.

S8 Table. Summary of different frailty measures, by sex and age groups.

S9 Table. Association between frailty (alternative definitions) and adverse outcomes.

S10 Table. Distribution of frailty deficit scores in middle-aged and older adults, frail and overall.

S1 Fig. Flowchart presenting selection of participants for analyses.

S2 Fig. Distribution of frailty index and cognition score among 45-plus participants. A) Frailty index had a mean value of 0.18 and standard deviation (SD) of 0.13, with values ranging from 0-0.83 and a median (IQR) of 0.14 (0.08, 0.25). The dotted line presents the cut-off 0.25. B) Composite cognition score value ranges from 4 to 43, with a mean of 27.01 (SD=6.36) and a median of 27 (IQR = 22,32). Poor cognition is defined as cognition score ≤ 18 (10^{th} percentile marked as dotted line in the graph).

S3 Fig. Missingness in deficit scores. Mobility1:Walking 100 yards; Mobility2:Sitting for 2 hours or more; Mobility3:Getting up from a chair after sitting for long period; Mobility4:Climbing one flight of stairs without resting ; Mobility5:Stooping, kneeling or crouching; Mobility6:Reaching or extending arms above shoulder level (either arm); Mobility7:Pulling or pushing large objects; Mobility8:Lifting or carrying weights over 5 kilos, like a heavy bag of groceries; Mobility9:Picking up a coin from a table; Activities of Daily Living (ADL) 1:Dressing, including putting on chappals, shoes, etc.; ADL2:Walking across a room; ADL3:Bathing; ADL4:Eating; ADL5:Getting in or out of bed; ADL6:Using the toilet, including getting up and down; ADL7:Preparing a hot meal (cooking and serving); ADL8:Shopping for groceries; ADL9:Making telephone calls; ADL10:Taking medications; ADL11:Doing work around the house or garden; ADL12:Managing money, such as paying

bills and keeping track of expenses; ADL13:Getting around or finding address in unfamiliar place.

S4 Fig. Prevalence of frailty across states, in middle-aged and elderly men and women. Individuals with frailty index > 0.21 were considered as frail. Prevalence estimates are weighted, using state-level individual sampling weights provided in data.

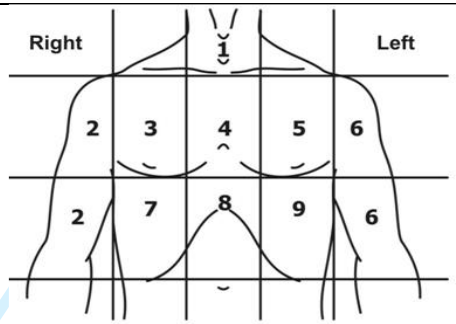
S5 Fig. Forest plot of adjusted odds ratios (95% CI) for frailty, by participants' background characteristics, using income as the economic indicator. Annual per capita household income is used as the economic indicator, instead of monthly per capita consumption expenditure. Per capita household income is computed by aggregating income from all sources (agricultural and non-agricultural business, wage/salary, pension and transfers) and dividing by the number of household members.

S1 Table. Construction of deficits-based frailty index and distribution of deficit scores.

Domain/variable	Coding criteria	Questions	Distribution in adults 45 years or older* (N=65562)
General Health (Self-reported health) (1 deficit)	Very good = 0, Good = 0.25, Fair = 0.50, Poor = 0.75, Very poor = 1	1. Now I want to ask you about your general health. Overall, how is your health in general? Would you say it is very good, good, fair, poor, or very poor? 1.Very good 2.Good 3. Fair 4. Poor 5. Very poor	Value | N (%) 0 | 3050 (4.65) 0.25 | 23628 (36.04) 0.5 | 26924 (41.07) 0.75 | 9811 (14.96) 1 | 1242 (1.89) Missing | 7 (1.38)
Self-reported medically diagnosed conditions (9 deficits)			
(1) Arthritis	1 if Yes to 1. and selected a. in 2. 0 otherwise	1. Has any health professional ever diagnosed you with the following chronic conditions or diseases? Arthritis or rheumatism, Osteoporosis or other bone/joint diseases. 1. Yes 2. No 2. Have you ever been diagnosed with the following bone/joint diseases/problems? a. Arthritis b. Rheumatism c. Osteoporosis d. Other, please specify	Value | N (%) 0 | 60065 (91.62) 1 | 5327 (8.13) Missing | 170 (0.26)
(2) Stroke	1 if Yes to 1. 0 otherwise	1. Has any health professional ever diagnosed you with the following chronic conditions or diseases? Stroke 1. Yes 2. No	Value | N (%) 0 | 64195 (97.91) 1 | 1195 (1.82) Missing | 172 (0.26)

(3) Angina	Angina is defined based on symptoms. Individuals classified as having angina were those who had a history of chest pain (answer “Yes” to question 1), set off by physical exertion (answer “Yes” to questions 2 or 3), forcing them to stop or slow down (question 4),with subsequent relief (“Yes” to question 5), within 10 minutes (question 6), and located in the sternum or the left anterior chest and left arm	**Rose angina questionnaire:**[1] 1. Do you ever have any pain or discomfort in your chest? 1. Yes 2. No 2. Do you get this pain or discomfort when you walk uphill or hurry? 1. Yes 2. No 3. Unable to walk 3. Do you get it when you walk at an ordinary pace on the level? 1. Yes 2. No 4. When you get any pain or discomfort in your chest while walking or moving, what do you do? 1. Stop 2. Slow down 3. Continue at the same pace 5. Does it go away when you stop moving? 1. Yes 2. No 6. How quickly the pain subsides when it occurs? 1. 10 minutes or less 2. More than 10 minutes 7. Where do you get this pain or discomfort? (figure)	

Value	N (%)
0	61336 (93.55)
1	4005 (6.11)
Missing	221 (0.34)

	(quadrants 4, 8, or 5 and 6 in question 7). 1 if Yes to above conditions specified. 0 otherwise		
(4) Diabetes	1 if Yes to 1. 0 otherwise	1. Has any health professional ever diagnosed you with the following chronic conditions or diseases? Diabetes 1. Yes 2. No	Value | N (%) 0 | 56952 (86.87) 1 | 8429 (12.86) Missing | 181 (0.28)
(5) COPD	1 if Yes to 1. and selected a. in 2. 0 otherwise	1. Has any health professional ever diagnosed you with the following chronic conditions or diseases? Chronic lung disease such as asthma, chronic obstructive pulmonary disease/Chronic bronchitis or other chronic lung problems. 1. Yes 2. No 2. Which type of chronic lung disease do you have? a. Chronic obstructive pulmonary disease (COPD) b. Chronic Bronchitis c. Asthma d. Other, please specify	Value | N (%) 0 | 64667 (98.63) 1 | 724 (1.10) Missing | 171 (0.26)
(6) Asthma	1 if Yes to 1. and selected c. in 2. 0 otherwise	1. Has any health professional ever diagnosed you with the following chronic conditions or diseases? Chronic lung disease such as asthma, chronic obstructive pulmonary disease/Chronic bronchitis or other chronic lung problems. 1. Yes 2. No 2. Which type of chronic lung disease do you have?	Value | N (%) 0 | 62830 (95.83) 1 | 2561 (3.91) Missing | 171 (0.26)

		a. Chronic obstructive pulmonary disease (COPD) b. Chronic Bronchitis c. Asthma d. Other, please specify	
(7) Depression	Depression is defined based on symptoms using CIDI scale. a) Calculated appetite status: 1 if Yes to either 6. or 7. 0 otherwise b) Calculated CIDI score: 1 is summation of 4, 5, appetite status, 8, 9, 10, 11 c) Finally, depression status: 1 if 1. is Yes & selected either 1. or 2. category from 2. & selected either 1. or 2.	1. During the last 12 months, was there ever a time when you felt sad, blue, or depressed for two weeks or more in a row? 1. Yes 2. No 2. Please think of the two-week period during the last 12 months when these feelings were worst. During that time did the feelings of being sad, blue, or depressed usually last all day long, most of the day, about half the day, or less than half the day? 1. All day long 2. Most of the day 3. About half the day 4. Less than half the day 3. During those two weeks, did you feel this way every day, almost every day, or less often than that? 1. Every day 2. Almost every day 3. Less often Thinking about those same two weeks, 4. Did you lose interest in most things? 1. Yes 2. No 5. Did you ever feel more tired out or low in energy than is usual for you? 1. Yes 2. No 6. Did you lose your appetite?	<table><tr><td>Value</td><td>N (%)</td></tr><tr><td>0</td><td>60228 (91.86)</td></tr><tr><td>1</td><td>4058 (6.19)</td></tr><tr><td>Missing</td><td>1276 (1.95)</td></tr></table>

	category from 3. & CIDI score is >= 3. 0 otherwise	1. Yes 2. No 7. Did your appetite increase during those same two weeks? 1. Yes 2. No 8. During the same two-week period did you have a lot more trouble concentrating than usual? 1. Yes 2. No 9. People sometimes feel down on themselves, and no good or worthless. During that two-week period, did you feel this way? 1. Yes 2. No 10. Did you think a lot about death – either your own, someone else's, or death in general – during those two weeks? 1. Yes 2. No 11. Did you have more trouble falling asleep than you usually do during those two weeks? 1. Yes 2. No	
(8) Hypertension	Hypertension is defined as either self-reported or BP >=140/90 1 if Yes to 1. or 2.is > =140 or 3. is >=90,	1. Has any health professional ever diagnosed you with the following chronic conditions or diseases? Hypertension or high blood pressure. 1. Yes 2. No When the device is in the correct position and the R is relaxed, press the button to Start. Measure blood pressure and pulse three times with one minute gap between each of the measurements. No need to	Value | N (%) 0 | 34246 (52.23) 1 | 31143 (47.50) Missing | 173 (0.26)

	0 otherwise	remove the cuffs and the device between the measurements. Record measurements in CAPI. Enter 993 in systolic, diastolic and pulse reading if an unresolvable equipment problem occurs. If the average systolic reading obtained is greater than 180 and average diastolic reading is greater than 110 or either of it, fill the referral letter and give to respondent and stop the test immediately. 2. Systolic readings: average of last two readings. 3. Diastolic readings: average of last two readings.	
(9) Cataract	1 if Yes to 1. and selected b. in 2. 0 otherwise	1. Now I have some questions about your eyesight. Have you ever been diagnosed with any eye or vision problem or condition, including ordinary near sightedness or farsightedness? 1. Yes 2. No 2. With which problem or condition were you diagnosed? a. Presbyopia b. Cataract c. Glaucoma d. Myopia (Nearsightedness) e. Hypermetropia (Farsightedness) f. Other, please specify	Value | N (%) 0 | 57291 (87.38) 1 | 8088 (12.34) Missing | 183 (0.28)
Medical symptoms (4 deficits)			
1) Bodily aches or pains did you have?	1 if Yes to 1. & Either a., b., c. in 2. 0 otherwise	1. Are you often troubled with pain? 1. Yes 2. No 2. Do you take any medication or therapy to get relief from the pain [Multiple answers are allowed]? a. Yes, analgesics (Oral/ Injectable)	Value | N (%) 0 | 48290 (73.66) 1 | 17042 (25.99) Missing | 230 (0.35)

		b. Yes, therapy(ies) c. Local/external application (Ointment, cream, gel, balm, spray, oil, etc.) d. None	
2) Problem did you have with sleeping?	1 if responded 4. Frequently (5 or more nights per week), for answering any of the 4 questions listed. 0 otherwise.	Now I would like to ask you a few questions about your sleep during the past 1 month. How often do you…? Would you say Never, Rarely (1-2 nights per week), Occasionally (3-4 nights per week), or Frequently (5 or more nights per week)? 1. Never 2. Rarely (1-2 nights per week) 3. Occasionally (3-4 nights per week) 4. Frequently (5 or more nights per week) 1. How often do you have trouble falling asleep? 2. How often did you wake up during the night and had trouble getting back to sleep? 3. How often did you wake up too early in the morning and were not being able to fall asleep again? 4. How often did you feel unrested during the day, no matter how many hours of sleep you had?	Value | N (%) 0 | 57554 (87.79) 1 | 7786 (11.88) Missing | 222 (0.34)
3) Difficulty did you have in seeing (person or object) across the road?	Very good = 0, Good = 0.25, Fair = 0.50, Poor = 0.75, Very poor = 1	1. How good is your eyesight for seeing things at a distance, like recognizing a person across the street (or 20 meters away) whether or not you wear glasses, contacts, or corrective lenses? 1. Very good 2. Good 3. Fair 4. Poor 5. Very poor	Value | N (%) 0 | 4142 (6.32) 0.25 | 25786 (39.33) 0.5 | 25991 (39.64) 0.75 | 8472 (12.92) 1 | 966 (1.47) Missing | 205 (0.31)
4) Difficulty did you have in seeing	Very good = 0, Good = 0.25,	1. How good is your eyesight for seeing things up close, like reading ordinary newspaper print whether or not you wear glasses, contacts, or corrective lenses 1. Very good	Value | N (%) 0 | 3262 (4.98) 0.25 | 22743 (34.69) 0.5 | 28024 (42.74)

an object at arm's length?	Fair = 0.50, Poor = 0.75, Very poor = 1	2. Good 3. Fair 4. Poor 5. Very poor	0.75: 10198 (15.55) 1: 1072 (1.64) Missing: 263 (0.4)
Functional assessment (9 deficits)	1 = Yes, 0 = No	1. Because of physical or health problems, do you have difficulty doing any of the activities? Exclude any difficulties that you expect to last less than three months. 1. Yes 2. No	
1) Walking 100 yards			Value: N (%) 0: 50503 (77.03) 1: 14782 (22.55) Missing: 277 (0.42)
2) Sitting for 2 hours or more			Value: N (%) 0: 46098 (70.31) 1: 19187 (29.27) Missing: 277 (0.42)
3) Getting up from a chair after sitting for long period			Value: N (%) 0: 44358 (67.66) 1: 20927 (31.92) Missing: 277 (0.42)
4) Climbing one flight of stairs without resting			Value: N (%) 0: 37857 (57.74) 1: 27428 (41.84) Missing: 277 (0.42)
5) Stooping, kneeling or crouching			Value: N (%) 0: 36375 (55.48) 1: 28910 (44.10) Missing: 277 (0.42)
6) Reaching or extending arms			Value: N (%) 0: 56168 (85.67) 1: 9117 (13.91)

above shoulder level (either arm)			Missing: 277 (0.42)
7) Pulling or pushing large objects			Value: N (%) 0: 40486 (61.75) 1: 24798 (37.82) Missing: 278 (0.42)
8) Lifting or carrying weights over 5 kilos, like a heavy bag of groceries			Value: N (%) 0: 48469 (73.93) 1: 16815 (25.65) Missing: 278 (0.42)
9) Picking up a coin from a table			Value: N (%) 0: 61255 (93.43) 1: 4029 (6.15) Missing: 278 (0.42)
ADL/IADL† limitations (13 deficits)	1 = Yes, 0 = No	Now, I will ask you about a few everyday activities. Please tell me if you have any difficulty with these because of a physical, mental, emotional, or memory problem. Please exclude any difficulties you expect to last less than three months. Because of a health or memory problem, do you have any difficulty with…? 1. Yes 2. No	
1) Dressing, including putting on chappals, shoes, etc.			Value: N (%) 0: 62376 (95.14) 1: 2905 (4.43) Missing: 281 (0.43)
2) Walking across a room			Value: N (%) 0: 62466 (95.28) 1: 2815 (4.29)

			Missing	281 (0.43)
3) Bathing			Value	N (%)
			0	62462 (95.27)
			1	2819 (4.30)
			Missing	281 (0.43)
4) Eating			Value	N (%)
			0	62336 (95.08)
			1	2945 (4.49)
			Missing	281 (0.43)
5) Getting in or out of bed			Value	N (%)
			0	60712 (92.60)
			1	4569 (6.97)
			Missing	281 (0.43)
6) Using the toilet, including getting up and down			Value	N (%)
			0	58531 (89.28)
			1	6750 (10.30)
			Missing	281 (0.43)
7) Preparing a hot meal (cooking and serving)			Value	N (%)
			0	58627 (89.42)
			1	6654 (10.15)
			Missing	281 (0.43)
8) Shopping for groceries			Value	N (%)
			0	56411 (86.04)
			1	8865 (13.52)
			Missing	286 (0.44)
9) Making telephone calls			Value	N (%)
			0	53181 (81.12)
			1	12043 (18.37)
			Missing	338 (0.52)
10) Taking medications			Value	N (%)
			0	59283 (90.42)
			1	5998 (9.15)

			Missing: 281 (0.43)
11) Doing work around the house or garden			Value: N (%) 0: 55490 (84.64) 1: 9791 (14.93) Missing: 281 (0.43)
12) Managing money, such as paying bills and keeping track of expenses			Value: N (%) 0: 54799 (83.58) 1: 10482 (15.99) Missing: 281 (0.43)
13) Getting around or finding address in unfamiliar place			Value: N (%) 0: 53400 (81.45) 1: 11881 (18.12) Missing: 281 (0.43)
Any form of mental impairment (1) (Proxy variable used for mental health status)	1 if Yes to 1. & Selected b. in 2. 0 otherwise	1. Do you have any form of physical or mental impairment? 1. Yes 2. No 2. Which form of impairment do you have? a. Physical impairment such as lower body or upper body b. Mental impairment such as intellectual, cognition, or learning impairment c. Hearing impairment d. Visual impairment e. Speech impairment such as speech production, language comprehension	Value: N (%) 0: 64046 (97.69) 1: 1222 (1.86) Missing: 294 (0.45)
Body mass index (BMI) (1 deficit)	BMI >= 18.5 - <25 = 0 (Normal) BMI >= 25 - <30 = 0.5 (Overweight)	BMI is weight in kilograms divided by height in meters squared.	Value: N (%) 0: 30872 (47.09) 0.5: 12852 (19.60) 1: 15349 (23.41) Missing: 6489 (9.90)

	BMI < 18.5 = 1 (Underweight) BMI >= 30 = 1 (Obese)		
Grip strength (1 deficit)	Grip (in kg), (Left+Right hand)/2 Men: (0<BMI<=24 and grip<=29) or (24<BMI<=26 and grip <=30) or (26<BMI<=28 and grip<=30) or (28<BMI<=40 and grip<=32) = 1 (Weak grip) Women: (0<BMI<=23 and grip<=17) or (23<BMI<=26 and grip <=17.3) or (26<BMI<=29 and grip<=18) or	The LASI measured grip strength in kilograms using a handheld dynamometer (Smedley's Hand Dynamometer). Health investigators collected two readings of grip strength for both hands (dominant and non-dominant).	<table><tr><td>Value</td><td>N (%)</td></tr><tr><td>0</td><td>23368 (35.64)</td></tr><tr><td>1</td><td>35313 (53.86)</td></tr><tr><td>Missing</td><td>6881 (10.50)</td></tr></table>

	(29<BMI<=40 and grip<=21) = 1 (Weak grip) 1 = weak grip if fulfilled above specified conditions, 0 otherwise		
Timed walk (gait speed) (1 deficit)	Gait speed = 1 if timed walk > 10 (Slow) Gait speed = 0 if timed walk <=10 (Normal)	LASI, respondents were asked to walk 4 metres twice. The time taken to walk was recorded in seconds. Each time, and the mean time was calculated.	Value | N (%) 0 | 57032 (86.99) 1 | 1289 (1.97) Missing | 7241 (11.04)
Frailty Index Scoring: ∑(variables)/40 Score range: 0 – 1 Cut points: Robust = 0 to < 0.25, Frail = 0.25 – 1.0			Value | N (%) 0 | 42767 (65.23) 1 | 14882 (22.70) Missing | 7913 .07)

* Unweighted figures.

† ADL: Activities of Daily Living; IADL: Instrumental Activities of Daily Living

S2 Table. Definition of outcomes – hospitalization in last 12 months and any fall in past 2 years.

Survey questions	Outcome definition
Q1. In the past 12 months, have you visited any health care facility, or any health professional has visited you? *[Please identify ALL the facilities that you have visited] [Instruction: If response is 'p' freeze all other options]* **Public facility:** a. Health post/sub centers b. Primary health center/Urban Health Center c. Community health center d. District / Sub-district hospital e. Government/tertiary hospital f. Govt. AYUSH hospital **Private facility:** g. Private hospital/nursing home h. Private clinic (OPD based services) i. NGO/Charity/Trust/Church-run hospital j. Private AYUSH hospital **Others:** k. Health camp l. Mobile healthcare unit m. Pharmacy/drugstore n. Home visit o. Other, please specify _____ p. None **Q2. Over the last 12 months, how many times you were admitted as patient to a hospital/long-term care facility for at least one night?** *[Instruction for the interviewer: If respondent did not stay at hospital, enter '0']* _____Times	**Number of hospitalizations in past 12 months** was defined as response to Q2. Respondents who said 'None' to Q1 were also coded as '0'. The variable **ever hospitalised in past 12 months** was coded as 'yes' if the number of hospitalizations was 1 or more and 'no' if 0. Respondents with a non-zero response to Q2 were then asked Q3. The maximum of the responses to the two questions, Q2 and Q3, was used to construct the count variable **number of nights in hospital in past 12 months**. In addition, respondents who said 'None' to Q1 were coded as '0'.

Q3. *[Ask only if Q2 ≥ 1]* **How many nights have you spent in the hospital during the past 12 months?** Number of nights ____	
Q1. In the past two years, have you sustained any major injury? 1. Yes 2. No **Q2.** ***[Ask only if Q1=1]*** **What was the cause of that injury?** *[Multiple answers are allowed]* a. Traffic accident b. Struck by person or object c. Fire, flames, burn, electric Shock d. Drowning e. Poisoning f. Animal attack or bite g. Fall h. Other, please specify_____ **Q3.** *[Ask only if Q2≠ g]* **In the past two years, have you fallen down?** 1. Yes 2. No	Individuals having **any fall in last 2 years** were identified as those who responded 'Yes' to Q1 and identified 'Fall' in response to Q2, or those who said 'Yes' to Q3.

S3 Table. Construction of cognition score and distribution of its components.

Domain	Item	Measurement	Questions	Range	Distribution in 45-plus participants (n=65,562)	
Memory	Immediate word recall	Interviewer read out a list of 10 words and respondents were asked to repeat the words.	I will read a set of 10 words and ask you to recall as many as you can. 1. Number of words respondent (R) correctly recalls _____	0-10	0	538 (0.8)
					1	1057 (1.7)
					2	3159 (4.9)
					3	6899 (10.8)
					4	11872 (18.6)
					5	14183 (22.2)
					6	12298 (19.2)
					7	8243 (12.9)
					8	3884 (6.1)
					9	1238 (1.9)
					10	595 (0.9)
					Missing	1596
	Delayed word recall	Respondents were asked to recall the same words read out for immediate recall after some time.	1. Number of words respondent (R) correctly recalls _____	0-10	1	4399 (7.3)
					2	8068 (13.5)
					3	12022 (20)
					4	12800 (21.3)
					5	9970 (16.6)
					6	6505 (10.8)
					7	3541 (5.9)
					8	1662 (2.8)
					9	609 (1)
					10	393 (0.7)
					Missing	5593
Orientation	Time	Respondents were asked to state today's date, month and year and day of the week. For each question, the score was 0	Date 1. Correct 2. Incorrect Month	0-4	0	1345 (2.1)
					1	7306 (11.4)
					2	10485 (16.4)

		(incorrect responses) or 1 (correct responses).	1. Correct 2. Incorrect Year 1. Correct 2. Incorrect Please tell me which day of week is today. Is it Monday, Tuesday, Wednesday, Thursday, Friday, Saturday, or Sunday? 1. Correct 2. Incorrect		3: 10599 (16.6) 4: 34209 (53.5) Missing: 1618
	Place	Orientation towards place was captured based on place of interview, name of the village, street number/colony name/landmark/neighbourhood and name of the district. For each question, the score was 0 (incorrect responses) or 1 (correct responses).	What is this place used for? [plausible answers are specific answers such as living room, house, apartment, hospital, market, etc.] 1. Correct 2. Incorrect What is your address? Name of village/town/city 1. Correct 2. Incorrect Street number/ colony name/landmark/neighbourhood 1. Correct 2. Incorrect What is name of your district? 1. Correct 2. Incorrect	0-4	0: 125 (0.2) 1: 419 (0.7) 2: 1429 (2.2) 3: 6775 (10.7) 4: 54818 (86.2) Missing: 1996
Arithmetic function	Backward counting	Respondents were asked to count backward as quickly as possible from the number 20. The respondents were asked to stop after correctly counting backward from 20 to 11 or from 19 to 10. Correct counting	Please try to count backward as quickly as you can from the number, I will give you. I will tell you when to stop. Please start with 20. 1. R correctly counted (e.g., 19 – 10; 20 – 11) without error 2. R made an error(s)	0-2	0: 19815 (31) 1: 12274 (19.2) 2: 31867 (49.8) Missing: 1606

		received 2 points; counts with a mistake received 1 point. Those who could not count received 0 points.	3. R cannot count		
	Serial	Respondents were asked to subtract seven from 100 in the first step and asked to continue subtracting seven from the previous number in each subsequent step for five times. Each correct response received 1 point.	Now let's try some subtraction of numbers. One hundred minus 7 equals what? Enter the answer R gave: 1. _____ 2. R cannot count, skip next questions, and go to 'computation' And 7 from that equals what? [Interviewer: enter the answer R gave] ____ And 7 from that equals what? [Interviewer: enter the answer R gave] ____ And 7 from that equals what? [Interviewer: enter the answer R gave] ____ And 7 from that equals what? [Interviewer: enter the answer R gave] ____	0-5	0: 21325 (36.5) 1: 5131 (8.8) 2: 5791 (9.9) 3: 7776 (13.3) 4: 5778 (9.9) 5: 12599 (21.6) Missing: 7162
	Computation	This test involved the mathematical operation of division. Respondents were asked to compute the net sale price of a product after considering a discount sale of half of the original price.	A shop is having a sale and selling all items at half price. Before the sale, a sari cost 300 Rs. How much will it cost in the sale? 1. R gave the correct answer of 150 Rs 2. R gave incorrect answer If 5 people all have the winning numbers in the lottery and the prize is 1,000 Rs, how much will each of them get? 1. R gave the correct answer of 200 Rs 2. R gave incorrect answer	0-2	0: 5758 (9.3) 1: 9856 (15.9) 2: 46414 (74.8) Missing: 3534

Executive function	Executive (paper folding)	This is a three-stage command task. The respondents were instructed to take a piece of paper from the interviewer, turn it over, fold it in half, and give it back to the interviewer. Three points were given if each task was completed successfully.	When I give you a piece of paper, please turn it over, fold it in half, and give it back to me. 1. One of the tasks – turning/folding/returning actions is completed successfully 2. Two of the tasks – turning/folding/returning actions are completed successfully 3. All of the tasks – turning/folding/returning actions are completed successfully 4. None of the tasks – turning/folding/returning actions is completed successfully.	0-3	0: 3197 (5) 1: 12511 (19.5) 2: 25640 (40) 3: 22757 (35.5) Missing: 1457
	Pentagon drawing	Visio-construction is the ability to coordinate fine motor skills with visuospatial abilities, usually by reproducing geometric figures. Respondents were asked to copy two overlapping pentagons and scored 1 point for a correct drawing.	Do you see this picture? Please draw that picture on this paper. [Show the picture of two pentagons overlapped] 1. Drew picture 2. Failed to draw picture 3. Not applicable.	0-1	0: 31187 (55.5) 1: 25051 (44.5) Missing: 9324
Object naming		The interviewer points to a specific object and asks the respondent to name it. Two objects were pointed out and 1 point was given for each correct response.	What is this? [Items can be anything from cell phones, gloves, hats, rings, and umbrella that can be within close reach.] 1. Correct 2. Incorrect What is this? 1. Correct 2. Incorrect	0-2	0: 646 (1) 1: 2509 (3.9) 2: 61158 (95.1) Missing: 1249

Composite cognition score is the combined score of memory, orientation, arithmetic function, executive function, and object naming and is obtained by summing up the responses for all these items. It ranges from 0-43.

S4 Table. Characteristics of excluded participants and participants included in various analyses.

	Frailty index based on 40 deficits					Frailty index defined based on non-missing deficits[#]	
Characteristic	**45-plus adults with frailty index missing**	**Study participants** (45-plus adults with frailty index non-missing)	**Study participants with non-missing hospitalization status**	**Study participants with non-missing fall status**	**Study participants with non-missing cognition score**	**Frailty index missing**	**45-plus adults with frailty index non-missing**
	N = 7,913	N = 57,649	N = 56,790	N = 57,642	N = 42,015	N = 1,231	N = 64,331
Sex							
Female	4,209 (53%)	30,874 (54%)	30,422 (54%)	30,871 (54%)	20,767 (49%)	622 (51%)	34,461 (54%)
Male	3,704 (47%)	26,775 (46%)	26,368 (46%)	26,771 (46%)	21,248 (51%)	609 (49%)	29,870 (46%)
Age, Median (Q1 – Q3)*	61 (52, 70)	58 (50, 66)	58 (50, 66)	58 (50, 66)	57 (50, 65)	65 (55, 76)	59 (51, 67)
Place of residence							
Rural	4,619 (58%)	37,805 (66%)	37,202 (66%)	37,799 (66%)	26,212 (62%)	739 (60%)	41,685 (65%)
Urban	3,294 (42%)	19,844 (34%)	19,588 (34%)	19,843 (34%)	15,803 (38%)	492 (40%)	22,646 (35%)
Educational status							
No schooling	3,857 (49%)	26,961 (47%)	26,488 (47%)	26,958 (47%)	16,083 (38%)	665 (54%)	30,153 (47%)
Less than 5 years	740 (9.4%)	6,738 (12%)	6,653 (12%)	6,736 (12%)	4,952 (12%)	137 (11%)	7,341 (11%)
5 to 9 years	1,579 (20%)	13,280 (23%)	13,125 (23%)	13,279 (23%)	11,155 (27%)	211 (17%)	14,648 (23%)
10 years or more	1,734 (22%)	10,670 (19%)	10,524 (19%)	10,669 (19%)	9,825 (23%)	216 (18%)	12,188 (19%)
Missing	3					2	1
MPCE quintile[†]							
Poorest	1,583 (20%)	11,358 (20%)	11,174 (20%)	11,356 (20%)	7,923 (19%)	289 (23%)	12,652 (20%)
Poorer	1,517 (19%)	11,673 (20%)	11,487 (20%)	11,673 (20%)	8,336 (20%)	258 (21%)	12,932 (20%)
Middle	1,487 (19%)	11,676 (20%)	11,500 (20%)	11,674 (20%)	8,405 (20%)	235 (19%)	12,928 (20%)
Richer	1,577 (20%)	11,633 (20%)	11,451 (20%)	11,631 (20%)	8,727 (21%)	222 (18%)	12,988 (20%)
Richest	1,749 (22%)	11,309 (20%)	11,178 (20%)	11,308 (20%)	8,624 (21%)	227 (18%)	12,831 (20%)
Living arrangement							
Living alone	279 (3.5%)	2,034 (3.5%)	2,008 (3.5%)	2,034 (3.5%)	1,302 (3.1%)	40 (3.2%)	2,273 (3.5%)

Living with spouse with or without children	5,270 (67%)	42,607 (74%)	41,988 (74%)	42,604 (74%)	32,345 (77%)	689 (56%)	47,188 (73%)
Living with children and others	1,732 (22%)	10,709 (19%)	10,527 (19%)	10,706 (19%)	6,786 (16%)	272 (22%)	12,169 (19%)
Living with others only	632 (8.0%)	2,299 (4.0%)	2,267 (4.0%)	2,298 (4.0%)	1,582 (3.8%)	230 (19%)	2,701 (4.2%)
Employment							
Currently working[§]	3,340 (42%)	28,939 (50%)	28,526 (50%)	28,935 (50%)	22,168 (53%)	377 (31%)	31,902 (50%)
Worked in the past	2,236 (28%)	13,045 (23%)	12,819 (23%)	13,043 (23%)	9,069 (22%)	481 (39%)	14,800 (23%)
Never worked	2,327 (29%)	15,665 (27%)	15,445 (27%)	15,664 (27%)	10,778 (26%)	365 (30%)	17,627 (27%)
Missing	10					8	2
Food constraint[¶]							
No	7,360 (93%)	53,801 (93%)	53,018 (93%)	53,797 (93%)	39,582 (94%)	1,178 (96%)	59,983 (93%)
Yes	553 (7.0%)	3,848 (6.7%)	3,772 (6.6%)	3,845 (6.7%)	2,433 (5.8%)	53 (4.3%)	4,348 (6.8%)
Tobacco use							
Never used tobacco	4,894 (66%)	36,252 (63%)	35,747 (63%)	36,249 (63%)	26,313 (63%)	451 (61%)	40,695 (63%)
Current/past user	2,469 (34%)	21,373 (37%)	21,023 (37%)	21,369 (37%)	15,681 (37%)	285 (39%)	23,557 (37%)
Missing	550	24	20	24	21	495	79
Alcohol							
Never consumed	6,072 (82%)	47,218 (82%)	46,516 (82%)	47,216 (82%)	34,223 (81%)	620 (84%)	52,670 (82%)
Less than once a month in past 3 months	738 (10%)	6,024 (10%)	5,914 (10%)	6,020 (10%)	4,642 (11%)	96 (13%)	6,666 (10%)
One to three days per month or more frequently	559 (7.6%)	4,397 (7.6%)	4,354 (7.7%)	4,396 (7.6%)	3,145 (7.5%)	21 (2.8%)	4,935 (7.7%)
Missing	544	10	6	10	5	494	60
Caste							
Scheduled caste	1,264 (16%)	9,695 (17%)	9,515 (17%)	9,695 (17%)	6,854 (16%)	195 (16%)	10,764 (17%)
Scheduled tribe	1,225 (15%)	10,140 (18%)	10,041 (18%)	10,137 (18%)	6,514 (16%)	211 (17%)	11,154 (17%)

Other backward class	2,816 (36%)	21,813 (38%)	21,448 (38%)	21,810 (38%)	16,190 (39%)	432 (35%)	24,197 (38%)
None of the above/No caste or tribe/Don't know/Missing	2,608 (33%)	16,001 (28%)	15,786 (28%)	16,000 (28%)	12,457 (30%)	393 (32%)	18,216 (28%)
Religion							
Hindu	5,777 (73%)	42,322 (73%)	41,579 (73%)	42,320 (73%)	31,313 (75%)	870 (71%)	47,229 (73%)
Muslim	997 (13%)	6,806 (12%)	6,724 (12%)	6,805 (12%)	4,834 (12%)	166 (13%)	7,637 (12%)
Christian	734 (9.3%)	5,802 (10%)	5,787 (10%)	5,800 (10%)	3,831 (9.1%)	140 (11%)	6,396 (9.9%)
Other	405 (5.1%)	2,719 (4.7%)	2,700 (4.8%)	2,717 (4.7%)	2,037 (4.8%)	55 (4.5%)	3,069 (4.8%)
Region							
North	1,429 (18%)	10,537 (18%)	10,222 (18%)	10,535 (18%)	8,015 (19%)	186 (15%)	11,780 (18%)
Central	932 (12%)	7,975 (14%)	7,654 (13%)	7,975 (14%)	5,940 (14%)	167 (14%)	8,740 (14%)
East	1,137 (14%)	10,443 (18%)	10,443 (18%)	10,441 (18%)	7,979 (19%)	189 (15%)	11,391 (18%)
Northeast	962 (12%)	7,551 (13%)	7,546 (13%)	7,550 (13%)	5,191 (12%)	150 (12%)	8,363 (13%)
West	1,314 (17%)	7,580 (13%)	7,449 (13%)	7,579 (13%)	5,231 (12%)	223 (18%)	8,671 (13%)
South	2,139 (27%)	13,563 (24%)	13,476 (24%)	13,562 (24%)	9,659 (23%)	316 (26%)	15,386 (24%)

Numbers presented in table are unweighted.

[*] Q1: first quartile, Q3: third quartile.

[†] MPCE: monthly per capita expenditure which is defined as total monthly household consumption expenditure divided by household size. It includes household's per capita spending on food and non-food items including spending on health, education, utilities, etc.

[§] Includes Temporarily laid off, on sick or other leave, or in job training

[¶] Household food unavailability in the past 12 months, where household members either reduced their meal size, did not eat even though they were hungry, or did not eat for a whole day because enough food was not available in the household.

[#]Frailty index for an individual was calculated by summing the non-missing health deficit scores and then dividing by the total number of deficits measured in that individual (up to 3 were allowed to be missing).

S5 Table. Prevalence of frailty, overall and by participants' background characteristics.

Characteristic	All	45-60 years	60-plus years
Overall	29.5 (28.7, 30.4)	16.2 (15.4, 16.9)	43.2 (41.9, 44.4)
Sex			
Female	36.1 (34.9, 37.4)	21.4 (20.2, 22.6)	52.2 (50.4, 54.1)
Male	21.7 (20.8, 22.7)	9.6 (8.5, 10.6)	33.2 (31.8, 34.6)
5-year age group			
45-49	11.6 (10.5, 12.7)	11.6 (10.5, 12.7)	-
50-54	16.3 (14.8, 17.7)	16.3 (14.8, 17.7)	-
55-59	21.8 (20.1, 23.5)	21.8 (20.1, 23.5)	-
60-64	29.9 (28.4, 31.5)	-	29.9 (28.4, 31.5)
65-69	39 (36.3, 41.7)	-	39 (36.3, 41.7)
70-74	52.5 (49.3, 55.8)	-	52.5 (49.3, 55.8)
75-79	53.9 (50.4, 57.3)	-	53.9 (50.4, 57.3)
80-plus	67.9 (64.2, 71.6)	-	67.9 (64.2, 71.6)
Place of residence			
Rural	30.8 (30.1, 31.5)	17.5 (16.7, 18.3)	43.7 (42.6, 44.8)
Urban	26.5 (24.3, 28.8)	13.2 (11.5, 14.9)	41.8 (38.3, 45.2)
Educational status			
No schooling	35.3 (34.4, 36.3)	19.8 (18.7, 20.9)	48 (46.6, 49.4)
Less than 5 years	34.2 (32.1, 36.2)	19.7 (17.6, 21.8)	47.6 (44.5, 50.8)
5 to 9 years	24.7 (22.6, 26.9)	15.1 (13.4, 16.8)	37.4 (33.5, 41.3)
10 years or more	15.5 (12.8, 18.2)	7.9 (6.3, 9.4)	27.3 (21.9, 32.7)
MPCE fifths *			
Poorest	29.8 (28.4, 31.2)	15 (13.4, 16.6)	44.3 (42.1, 46.4)
Poorer	29.9 (28.6, 31.3)	16.9 (15.3, 18.4)	42.9 (40.8, 45)
Middle	28.8 (27.2, 30.4)	16.1 (14.5, 17.7)	41.2 (38.8, 43.6)
Richer	30.6 (28.2, 33)	17.4 (15.2, 19.6)	44.1 (40.6, 47.7)
Richest	28.3 (25.7, 30.9)	15.5 (13.6, 17.3)	43.4 (39.4, 47.3)
Living arrangement			
Living alone	46.4 (42.8, 50)	22.7 (17.9, 27.5)	53.7 (49.5, 57.9)
Living with spouse with or without children	24.2 (23.4, 24.9)	15.5 (14.6, 16.3)	36.2 (35, 37.5)
Living with children and others	45.4 (42.9, 47.9)	21.4 (19.2, 23.6)	55.2 (52.3, 58.1)
Living with others only	36 (31, 41)	13.1 (8.5, 17.8)	50.9 (46.7, 55.1)
Employment			
Currently working†	18.4 (17.6, 19.3)	12.4 (11.5, 13.3)	29.3 (27.8, 30.8)
Worked in the past	45.9 (44.4, 47.4)	29.9 (27.3, 32.5)	50.2 (48.5, 51.9)
Never worked	36.5 (34.2, 38.8)	20.5 (18.6, 22.3)	52.9 (49.8, 56)
Food constraint§			
No	28.3 (27.4, 29.2)	15.2 (14.4, 16)	41.8 (40.4, 43.1)
Yes	44.1 (41.7, 46.5)	28.2 (25.2, 31.2)	58.4 (55, 61.7)
Tobacco use			
Never used tobacco	30.2 (29, 31.4)	17.1 (16, 18.2)	45 (43.1, 46.8)
Current/past user	28.3 (27.3, 29.3)	14.4 (13.4, 15.4)	40.5 (39, 42)
Alcohol use			
Never consumed	31 (30, 31.9)	17.2 (16.3, 18.1)	44.9 (43.5, 46.3)
Less than once a month in past 3 months	23.5 (21.8, 25.2)	11.6 (9.8, 13.3)	35.1 (32.2, 37.9)
One to three days per month or more frequently	18.1 (16.2, 19.9)	9 (7.4, 10.5)	29.6 (26, 33.1)

Caste			
Scheduled caste	29.9 (28.5, 31.4)	17.9 (16.3, 19.5)	42.9 (40.6, 45.2)
Scheduled tribe	23.9 (22.1, 25.7)	12.9 (11.2, 14.6)	36.6 (33.5, 39.8)
Other backward class	30 (28.4, 31.6)	15.5 (14.1, 16.8)	44.8 (42.5, 47.1)
None of the above/No caste or tribe/Don't know/Missing	30.2 (29.1, 31.3)	17.2 (16, 18.5)	42.5 (40.8, 44.2)
Religion			
Hindu	29.1 (28.2, 30.1)	15.4 (14.6, 16.2)	43.1 (41.6, 44.5)
Muslim	34.4 (32.2, 36.6)	23.4 (20, 26.7)	46.1 (43.3, 49)
Christian	24 (19.5, 28.4)	10.5 (6.7, 14.3)	39.2 (34.7, 43.7)
Other	28.2 (25.4, 31.1)	16.4 (13.1, 19.7)	39.3 (35, 43.6)
Region			
North	23.6 (22.5, 24.8)	12 (10.8, 13.2)	34.9 (33.1, 36.8)
Central	27.2 (25.7, 28.6)	14.4 (12.9, 15.8)	40 (37.7, 42.3)
East	33.2 (31.9, 34.5)	20.5 (19, 22.1)	45.7 (43.7, 47.7)
Northeast	19.8 (18.3, 21.2)	8.8 (7.5, 10.1)	34.7 (32.1, 37.3)
West	32.2 (30.6, 33.8)	18.6 (16.8, 20.3)	45 (42.5, 47.6)
South	30.6 (27.8, 33.5)	15.2 (13, 17.5)	47.9 (43.9, 51.9)

Numbers presented in table are weighted, using national-level individual sampling weights provided in data.

* MPCE: monthly per capita expenditure which is defined as total monthly household consumption expenditure divided by household size. It includes household's per capita spending on food and non-food items including spending on health, education, utilities, etc.

† Includes Temporarily laid off, on sick or other leave, or in job training

§ Household food unavailability in the past 12 months, where household members either reduced their meal size, did not eat even though they were hungry, or did not eat for a whole day because enough food was not available in the household.

S6 Table. Sex differences in distribution of frailty deficit scores.

	45-59 years		60-plus years	
	Female, N = 18,717	**Male, N = 15,381**	**Female, N = 16,366**	**Male, N = 15,098**
Self-reported general Health				
0 (very good)	851 (4.6%)	1,167 (7.6%)	416 (2.6%)	616 (4.2%)
0.25 (good)	7,280 (39%)	7,076 (46%)	4,418 (28%)	4,854 (33%)
0.5 (fair)	8,003 (43%)	5,540 (36%)	7,160 (45%)	6,221 (42%)
0.75 (poor)	2,265 (12%)	1,342 (8.8%)	3,541 (22%)	2,663 (18%)
1 (very poor)	195 (1.0%)	138 (0.9%)	485 (3.0%)	424 (2.9%)
Self-reported medically diagnosed conditions				
Arthritis	1,568 (8.4%)	704 (4.6%)	1,833 (11%)	1,222 (8.1%)
Stroke	128 (0.7%)	225 (1.5%)	347 (2.1%)	495 (3.3%)
Angina	1,313 (7.0%)	656 (4.3%)	1,232 (7.5%)	804 (5.3%)
Diabetes	1,968 (11%)	1,601 (10%)	2,416 (15%)	2,444 (16%)
COPD	116 (0.6%)	143 (0.9%)	213 (1.3%)	252 (1.7%)
Asthma	482 (2.6%)	414 (2.7%)	792 (4.8%)	873 (5.8%)
Depression	1,278 (6.9%)	732 (4.8%)	1,162 (7.3%)	886 (6.0%)
Hypertension	7,758 (42%)	6,058 (40%)	9,524 (58%)	7,803 (52%)
Cataract	1,027 (5.5%)	553 (3.6%)	3,646 (22%)	2,862 (19%)
Medical symptoms				
Bodily aches or pains	5,300 (28%)	2,751 (18%)	5,331 (33%)	3,660 (24%)
Problem with sleeping	2,060 (11%)	1,369 (8.9%)	2,449 (15%)	1,908 (13%)
Difficulty with distance vision				
0	1,255 (6.7%)	1,559 (10%)	542 (3.3%)	786 (5.2%)
0.25	8,181 (44%)	7,683 (50%)	4,716 (29%)	5,206 (35%)
0.5	7,340 (39%)	5,011 (33%)	7,311 (45%)	6,329 (42%)
0.75	1,772 (9.5%)	991 (6.5%)	3,318 (20%)	2,391 (16%)
1	106 (0.6%)	90 (0.6%)	444 (2.7%)	326 (2.2%)
Difficulty with near vision				
0	922 (4.9%)	1,105 (7.2%)	520 (3.2%)	715 (4.8%)
0.25	7,019 (38%)	6,310 (41%)	4,477 (27%)	4,937 (33%)
0.5	7,962 (43%)	5,803 (38%)	7,646 (47%)	6,613 (44%)
0.75	2,580 (14%)	1,970 (13%)	3,228 (20%)	2,420 (16%)
1	156 (0.8%)	140 (0.9%)	436 (2.7%)	340 (2.3%)
Functional assessment (difficulty with the following)				
Walking 100 yards	3,103 (17%)	1,381 (9.0%)	6,250 (38%)	4,048 (27%)
Sitting for 2 hours or more	4,717 (25%)	2,385 (16%)	7,270 (45%)	4,815 (32%)
Getting up from a chair after sitting for long period	5,087 (27%)	2,559 (17%)	7,894 (48%)	5,387 (36%)
Climbing one flight of stairs without resting	6,870 (37%)	3,350 (22%)	10,060 (62%)	7,148 (48%)

Stooping, kneeling or crouching	7,445 (40%)	3,838 (25%)	10,144 (62%)	7,483 (50%)
Reaching or extending arms above shoulder level (either arm)	1,819 (9.8%)	964 (6.3%)	3,944 (24%)	2,390 (16%)
Pulling or pushing large objects	6,027 (32%)	2,717 (18%)	9,583 (59%)	6,471 (43%)
Lifting or carrying weights over 5 kilos, like a heavy bag of groceries	3,583 (19%)	1,419 (9.3%)	7,439 (46%)	4,374 (29%)
Picking up a coin from a table	563 (3.0%)	296 (1.9%)	1,950 (12%)	1,220 (8.1%)
ADL/IADL* limitations (difficulty with the following)				
Dressing, including putting on chappals, shoes, etc	440 (2.4%)	292 (1.9%)	1,282 (7.9%)	891 (5.9%)
Walking across a room	380 (2.0%)	208 (1.4%)	1,339 (8.2%)	888 (5.9%)
Bathing	326 (1.7%)	249 (1.6%)	1,318 (8.1%)	926 (6.2%)
Eating	390 (2.1%)	237 (1.5%)	1,394 (8.5%)	924 (6.2%)
Getting in or out of bed	864 (4.6%)	395 (2.6%)	2,024 (12%)	1,286 (8.6%)
Using the toilet, including getting up and down	1,265 (6.8%)	630 (4.1%)	2,868 (18%)	1,987 (13%)
Preparing a hot meal (cooking and serving)	810 (4.3%)	669 (4.4%)	2,963 (18%)	2,212 (15%)
Shopping for groceries	1,551 (8.3%)	630 (4.1%)	4,323 (26%)	2,361 (16%)
Making telephone calls	2,966 (16%)	969 (6.3%)	5,270 (32%)	2,838 (19%)
Taking medications	1,194 (6.4%)	486 (3.2%)	2,803 (17%)	1,515 (10%)
Doing work around the house or garden	1,728 (9.3%)	700 (4.6%)	4,598 (28%)	2,765 (18%)
Managing money, such as paying bills and keeping track of expenses	2,468 (13%)	604 (3.9%)	5,127 (31%)	2,283 (15%)
Getting around or finding address in unfamiliar place	3,041 (16%)	726 (4.7%)	5,677 (35%)	2,437 (16%)
Any form of mental impairment	266 (1.4%)	199 (1.3%)	431 (2.6%)	326 (2.2%)
Body mass index				
0 (normal)	8,197 (48%)	7,967 (58%)	7,118 (49%)	7,590 (56%)
0.5 (underweight/overweight)	4,531 (26%)	3,136 (23%)	2,936 (20%)	2,249 (17%)
1 (obese)	4,461 (26%)	2,731 (20%)	4,487 (31%)	3,670 (27%)
Weak grip strength	7,279 (43%)	6,807 (49%)	10,265 (71%)	10,962 (82%)
Slow gait speed	83 (0.5%)	48 (0.3%)	807 (5.7%)	351 (2.6%)

*ADL: Activities of Daily Living; IADL: Instrumental Activities of Daily Living

S7 Table. Sex-specific associations between frailty and adverse outcomes.

Outcome	45-59 years			60-plus years		
	Male OR (95% CI)	Female OR (95% CI)	Female:Male ROR (95% CI)*	Male OR (95% CI)	Female OR (95% CI)	Female:Male ROR (95% CI)*
Hospitalized in last 12 months	2.22 (1.91, 2.58)	2.6 (2.11, 3.21)	1.17 (0.91, 1.52)	2.13 (1.84, 2.46)	2.27 (1.97, 2.61)	1.07 (0.87, 1.31)
Fallen down in last 2 years	2.15 (1.96, 2.37)	2.17 (1.86, 2.54)	1.01 (0.84, 1.21)	1.75 (1.6, 1.91)	2.06 (1.86, 2.29)	1.18 (1.03, 1.35)
Poor cognition	1.29 (1.1, 1.5)	1.44 (1.00, 2.06)	1.12 (0.75, 1.66)	1.35 (1.19, 1.52)	1.56 (1.31, 1.86)	1.16 (0.93, 1.44)

* ROR, ratio of odds ratios, indicating the sex difference in the relationship between frailty and adverse outcomes. For example, odds ratios of 2.6 and 2.22 for females and males, respectively, and a female:male ROR of 1.17 for hospitalization indicates that odds of hospitalization are higher for frail adults in both sexes, but the relative increase is 17% higher in females.

S8 Table. Summary of different frailty measures, by sex and age groups.

	Frailty index			Frail: frailty index ≥ 0.25			Frail: frailty index > 0.21			Frail: Frailty index based on non-missing deficits* ≥ 0.25		
	45-59 years	60-plus years	Overall	45-59 years	60-plus years	Overall	45-59 years	60-plus years	Overall	45-59 years	60-plus years	Overall
	(N= 30568)	(N= 27081)	(N= 57649)	(N= 30568)	(N= 27081)	(N= 57649)	(N= 30568)	(N= 27081)	(N= 57649)	(N= 33674)	(N= 30657)	(N= 64331)
Overall	0.14 (0.14, 0.15)	0.24 (0.24, 0.25)	0.19 (0.19, 0.2)	16.2 (15.4, 16.9)	43.2 (41.9, 44.4)	29.5 (28.7, 30.4)	22.6 (21.7, 23.6)	52.2 (51, 53.4)	37.2 (36.4, 38.1)	16.7 (15.7, 17.7)	44.5 (43.3, 45.6)	30.5 (29.7, 31.4)
Male	0.12 (0.12, 0.12)	0.21 (0.21, 0.22)	0.17 (0.16, 0.17)	9.6 (8.5, 10.6)	33.2 (31.8, 34.6)	21.7 (20.8, 22.7)	13.8 (12.7, 15)	42.2 (40.7, 43.6)	28.4 (27.3, 29.4)	10.8 (8.9, 12.6)	34.8 (33.4, 36.1)	23.1 (22, 24.2)
Female	0.17 (0.16, 0.17)	0.27 (0.27, 0.28)	0.22 (0.21, 0.22)	21.4 (20.2, 22.6)	52.2 (50.4, 54.1)	36.1 (34.9, 37.4)	29.6 (28.2, 31)	61.3 (59.6, 63)	44.8 (43.5, 46.1)	21.5 (20.3, 22.6)	53.1 (51.5, 54.8)	36.8 (35.6, 38)

*Frailty index for an individual was calculated by summing the non-missing health deficit scores and then dividing by the total number of deficits measured in that individual (up to 3 were allowed to be missing). CI: confidence interval

S9 Table. Association (OR(95% CI)) between frailty (alternative definitions) and adverse outcomes.

Outcome	Frail: frailty index > 0.21		Frail: Frailty index based on non-missing deficits* ≥ 0.25	
	45-59 years (N= 30568)	≥ 60 years (N= 27081)	45-59 years (N33674)	≥ 60 years (N= 30657)
Hospitalization in last 12 months	2.26 (2.02, 2.53)	2.11 (1.9, 2.33)	2.58 (2.31, 2.88)	2.37 (2.16, 2.6)
Any fall in last 2 years	1.99 (1.85, 2.14)	1.88 (1.76, 2.01)	2.18 (2.02, 2.36)	1.97 (1.85, 2.09)
Poor cognition	1.99 (1.85, 2.14)	1.35 (1.22, 1.5)	1.35 (1.19, 1.55)	1.42 (1.3, 1.56)

*Frailty index for an individual was calculated by summing the non-missing health deficit scores and then dividing by the total number of deficits measured in that individual (up to 3 were allowed to be missing).

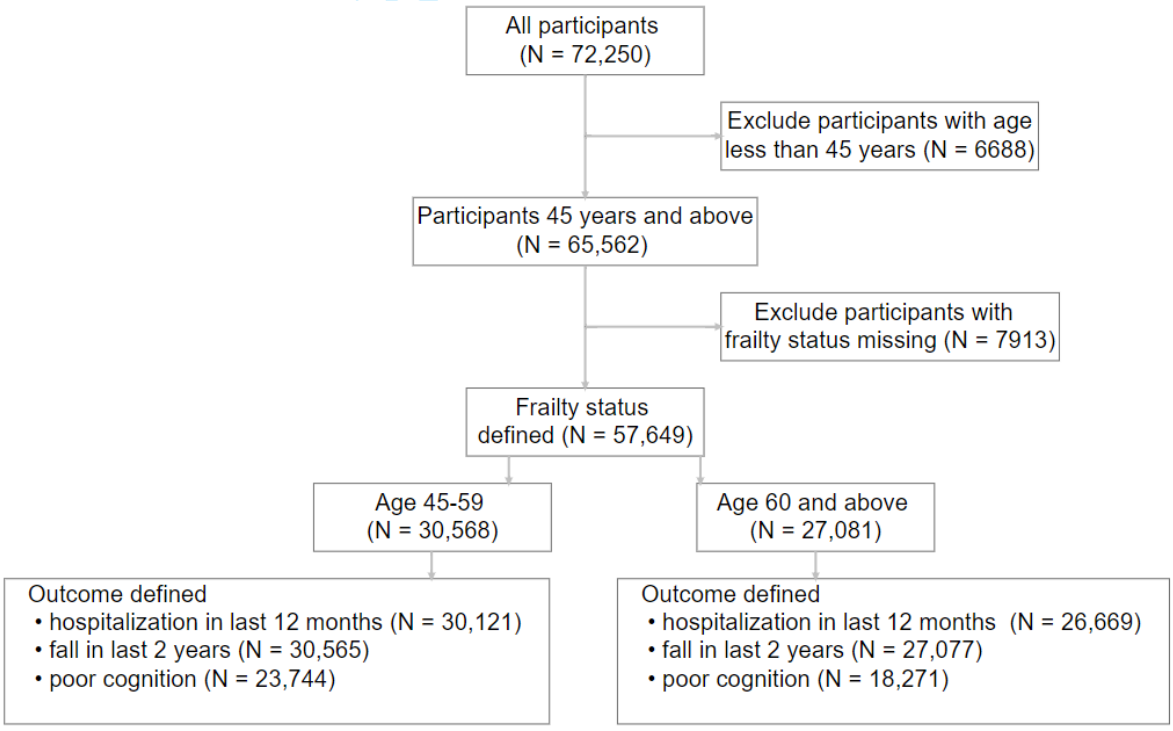
S10 Table. Distribution of frailty deficit scores in middle-aged and older adults, frail and overall.

	45-59 years		60-plus years	
	Overall	Frail	Overall	Frail
	N = 34,098	N = 4,302	N = 31,464	N = 10,580
Self-reported general Health				
0 (very good)	2,018 (6.0%)	59 (1.4%)	1,032 (3.4%)	123 (1.2%)
0.25 (good)	14,356 (42%)	677 (16%)	9,272 (30%)	1,697 (16%)
0.5 (fair)	13,543 (40%)	2,063 (48%)	13,381 (43%)	4,740 (45%)
0.75 (poor)	3,607 (11%)	1,331 (31%)	6,204 (20%)	3,490 (33%)
1 (very poor)	333 (1.0%)	172 (4.0%)	909 (3.0%)	530 (5.0%)
Self-reported medically diagnosed conditions				
Arthritis	2,272 (6.7%)	869 (20%)	3,055 (9.7%)	1,765 (17%)
Stroke	353 (1.0%)	126 (2.9%)	842 (2.7%)	433 (4.1%)
Angina	1,969 (5.8%)	679 (16%)	2,036 (6.5%)	1,122 (11%)
Diabetes	3,569 (10%)	826 (19%)	4,860 (15%)	2,058 (19%)
COPD	259 (0.8%)	81 (1.9%)	465 (1.5%)	233 (2.2%)
Asthma	896 (2.6%)	280 (6.5%)	1,665 (5.3%)	860 (8.1%)
Depression	2,010 (6.0%)	719 (17%)	2,048 (6.7%)	1,198 (11%)
Hypertension	13,816 (41%)	2,440 (57%)	17,327 (55%)	6,895 (65%)
Cataract	1,580 (4.6%)	473 (11%)	6,508 (21%)	3,101 (29%)
Medical symptoms				
Bodily aches or pains	8,051 (24%)	2,352 (55%)	8,991 (29%)	4,749 (45%)
Problem with sleeping	3,429 (10%)	1,171 (27%)	4,357 (14%)	2,428 (23%)
Difficulty with distance vision				
0	2,814 (8.3%)	187 (4.3%)	1,328 (4.2%)	243 (2.3%)
0.25	15,864 (47%)	1,329 (31%)	9,922 (32%)	2,297 (22%)

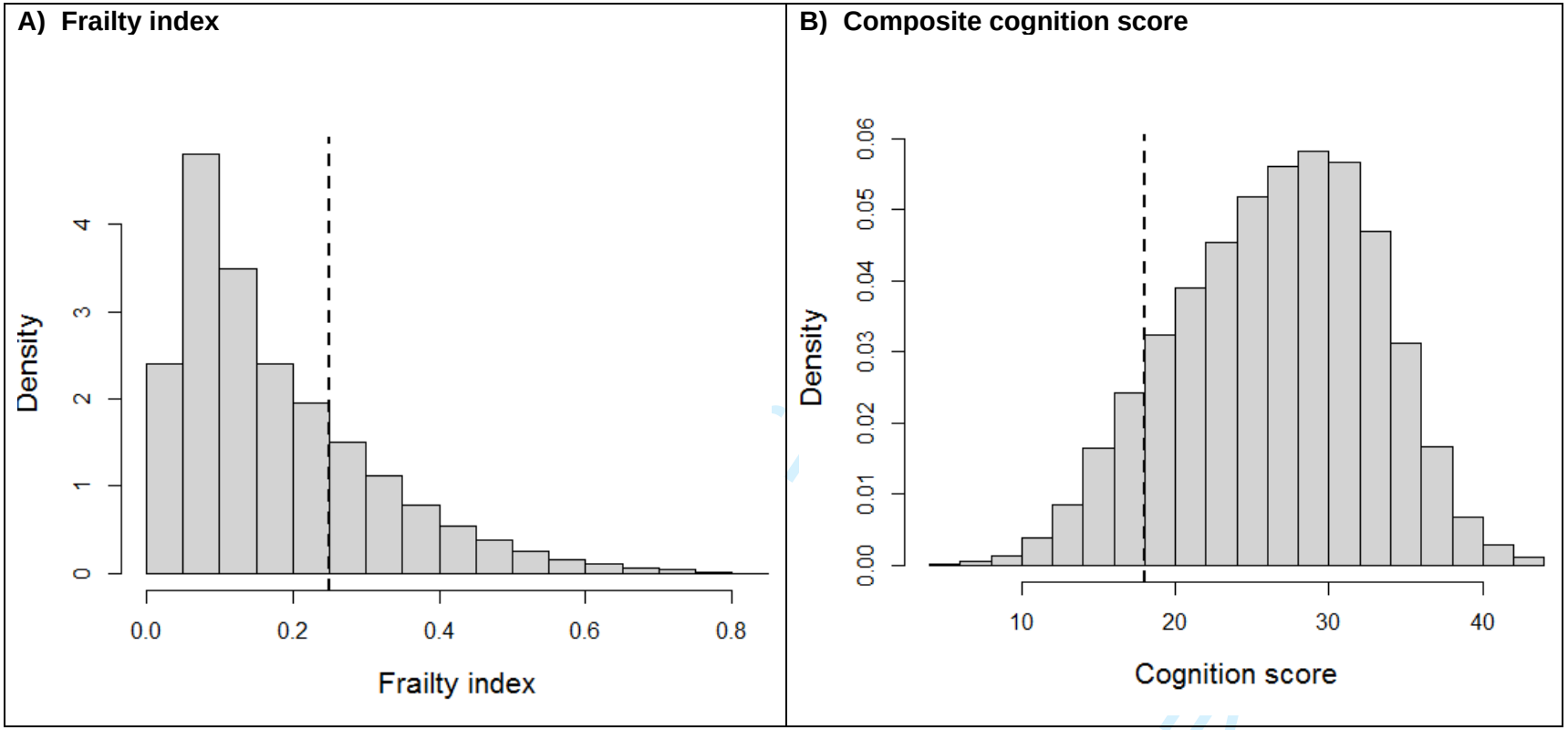
0.5	12,351 (36%)	1,917 (45%)	13,640 (43%)	4,736 (45%)
0.75	2,763 (8.1%)	806 (19%)	5,709 (18%)	2,880 (27%)
1	196 (0.6%)	63 (1.5%)	770 (2.5%)	424 (4.0%)
Difficulty with near vision				
0	2,027 (6.0%)	138 (3.2%)	1,235 (3.9%)	236 (2.2%)
0.25	13,329 (39%)	1,077 (25%)	9,414 (30%)	2,266 (21%)
0.5	13,765 (41%)	1,976 (46%)	14,259 (46%)	4,961 (47%)
0.75	4,550 (13%)	1,025 (24%)	5,648 (18%)	2,711 (26%)
1	296 (0.9%)	86 (2.0%)	776 (2.5%)	406 (3.8%)
Functional assessment (difficulty with the following)				
Walking 100 yards	4,484 (13%)	2,385 (55%)	10,298 (33%)	6,501 (61%)
Sitting for 2 hours or more	7,102 (21%)	3,206 (75%)	12,085 (39%)	7,545 (71%)
Getting up from a chair after sitting for long period	7,646 (23%)	3,371 (78%)	13,281 (42%)	8,115 (77%)
Climbing one flight of stairs without resting	10,220 (30%)	3,839 (89%)	17,208 (55%)	9,556 (90%)
Stooping, kneeling or crouching	11,283 (33%)	3,850 (89%)	17,627 (56%)	9,409 (89%)
Reaching or extending arms above shoulder level (either arm)	2,783 (8.2%)	1,581 (37%)	6,334 (20%)	4,202 (40%)
Pulling or pushing large objects	8,744 (26%)	3,475 (81%)	16,054 (51%)	9,039 (85%)
Lifting or carrying weights over 5 kilos, like a heavy bag of groceries	5,002 (15%)	2,538 (59%)	11,813 (38%)	7,367 (70%)
Picking up a coin from a table	859 (2.5%)	506 (12%)	3,170 (10%)	1,959 (19%)
ADL/IADL* limitations (difficulty with the following)				
Dressing, including putting on chappals, shoes, etc	732 (2.2%)	416 (9.7%)	2,173 (6.9%)	1,152 (11%)
Walking across a room	588 (1.7%)	359 (8.3%)	2,227 (7.1%)	1,217 (12%)
Bathing	575 (1.7%)	351 (8.2%)	2,244 (7.2%)	1,239 (12%)
Eating	627 (1.8%)	370 (8.6%)	2,318 (7.4%)	1,378 (13%)
Getting in or out of bed	1,259 (3.7%)	829 (19%)	3,310 (11%)	2,122 (20%)
Using the toilet, including getting up and down	1,895 (5.6%)	1,151 (27%)	4,855 (15%)	3,133 (30%)
Preparing a hot meal (cooking and serving)	1,479 (4.4%)	820 (19%)	5,175 (17%)	3,377 (32%)
Shopping for groceries	2,181 (6.4%)	1,234 (29%)	6,684 (21%)	4,566 (43%)
Making telephone calls	3,935 (12%)	1,397 (32%)	8,108 (26%)	4,778 (45%)
Taking medications	1,680 (4.9%)	875 (20%)	4,318 (14%)	2,773 (26%)
Doing work around the house or garden	2,428 (7.2%)	1,460 (34%)	7,363 (23%)	5,032 (48%)
Managing money, such as paying bills and keeping track of expenses	3,072 (9.0%)	1,494 (35%)	7,410 (24%)	4,883 (46%)

Getting around or finding address in unfamiliar place	3,767 (11%)	1,655 (38%)	8,114 (26%)	5,221 (49%)
Any form of mental impairment	465 (1.4%)	155 (3.6%)	757 (2.4%)	365 (3.4%)
Body mass index				
0 (normal)	16,164 (52%)	1,732 (40%)	14,708 (52%)	4,841 (46%)
0.5 (underweight/overweight)	7,667 (25%)	1,192 (28%)	5,185 (18%)	2,071 (20%)
1 (obese)	7,192 (23%)	1,378 (32%)	8,157 (29%)	3,668 (35%)
Weak grip strength	14,086 (46%)	2,675 (62%)	21,227 (76%)	9,046 (86%)
Slow gait speed	131 (0.4%)	70 (1.6%)	1,158 (4.2%)	917 (8.7%)

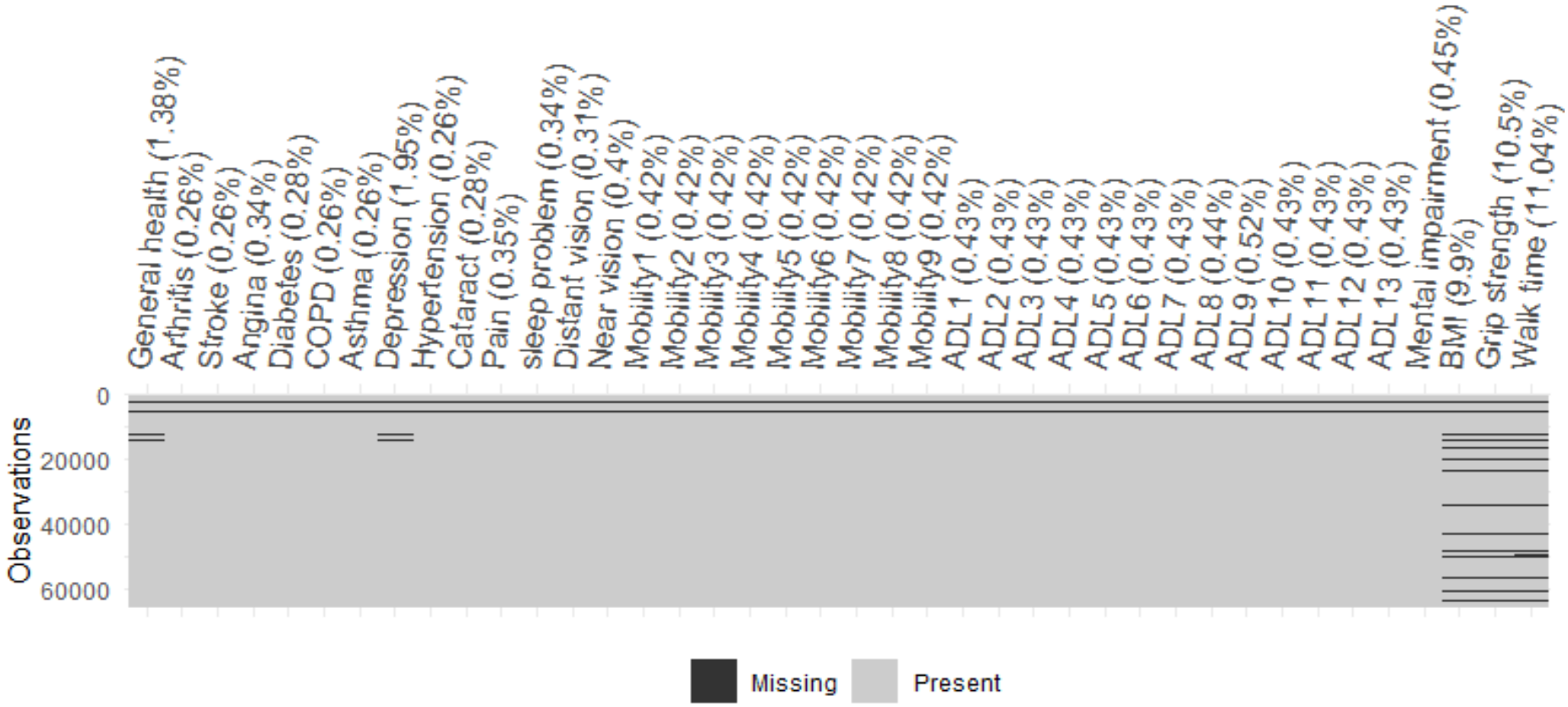
*ADL: Activities of Daily Living; IADL: Instrumental Activities of Daily Living



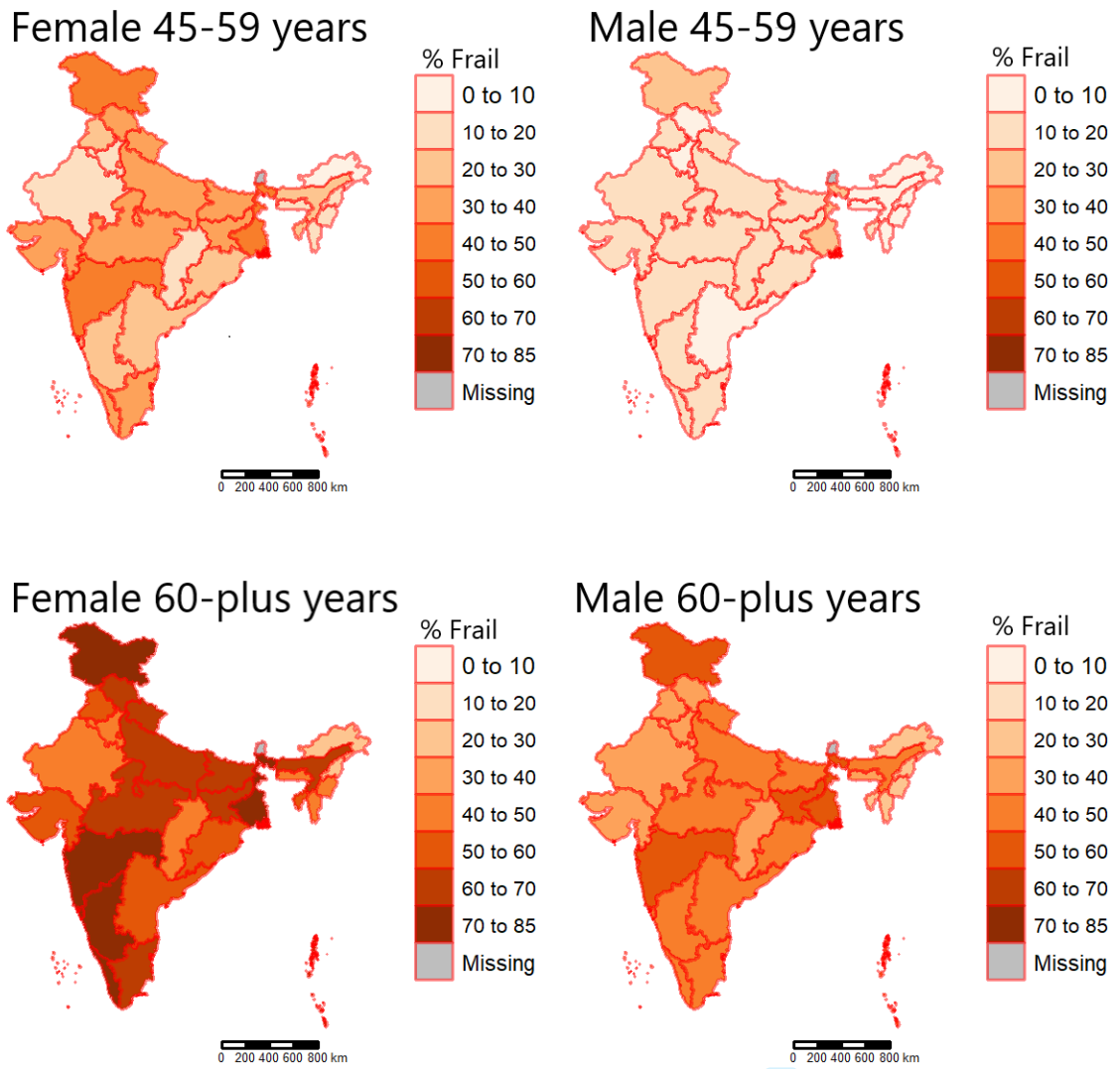
S1 Fig. Flowchart presenting selection of participants for analyses.



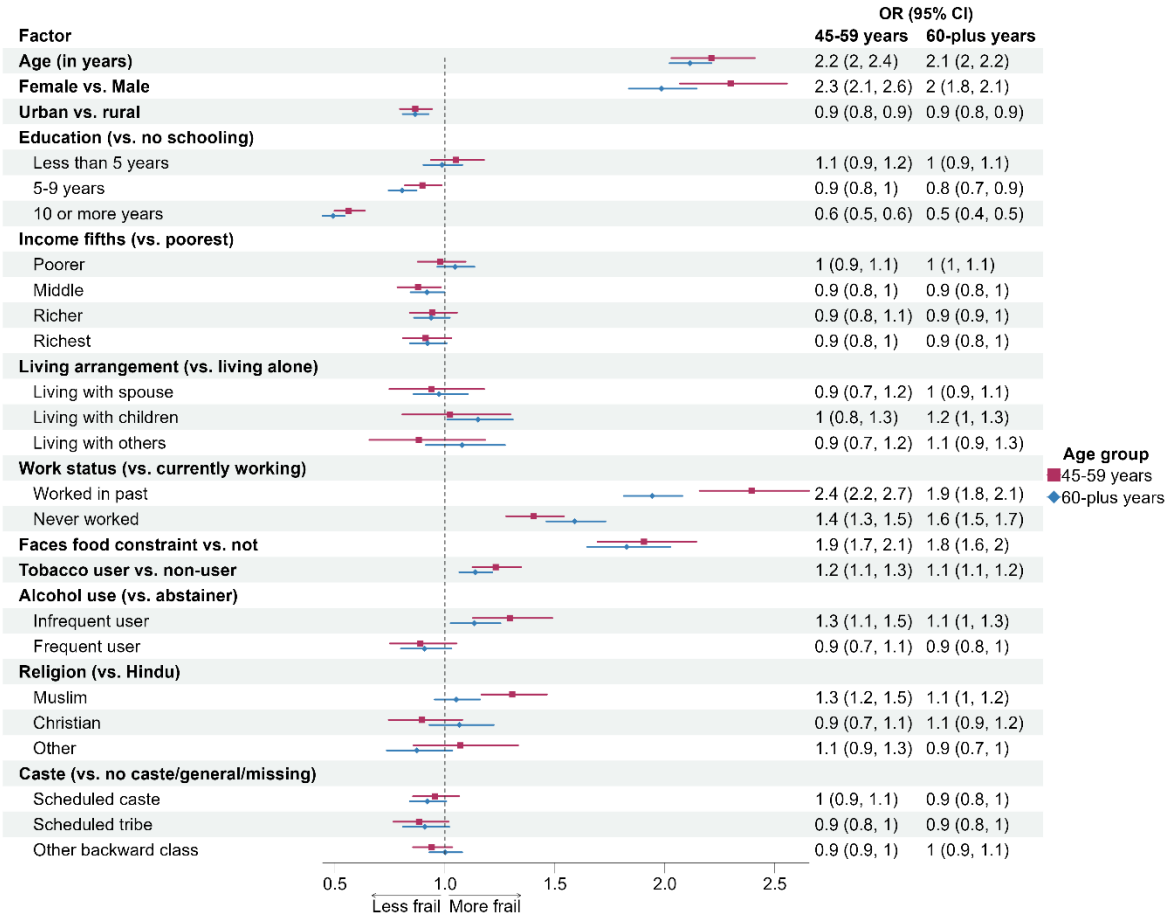
S2 Fig. Distribution of frailty index and cognition score among 45-plus participants. A) Frailty index had a mean value of 0.18 and standard deviation (SD) of 0.13, with values ranging from 0-0.83 and a median (IQR) of 0.14 (0.08, 0.25). The dotted line presents the cut-off 0.25. B) Composite cognition score value ranges from 4 to 43, with a mean of 27.01 (SD=6.36) and a median of 27 (IQR = 22,32). Poor cognition is defined as cognition score ≤ 18 (10^{th} percentile marked as dotted line in the graph).



S3 Fig. Missingness in deficit scores. BMI:Body mass index; Mobility1:Walking 100 yards; Mobility2:Sitting for 2 hours or more; Mobility3:Getting up from a chair after sitting for long period; Mobility4:Climbing one flight of stairs without resting ; Mobility5:Stooping, kneeling or crouching; Mobility6:Reaching or extending arms above shoulder level (either arm); Mobility7:Pulling or pushing large objects; Mobility8:Lifting or carrying weights over 5 kilos, like a heavy bag of groceries; Mobility9:Picking up a coin from a table; Activities of Daily Living (ADL) 1:Dressing, including putting on chappals, shoes, etc.; ADL2:Walking across a room; ADL3:Bathing; ADL4:Eating; ADL5:Getting in or out of bed; ADL6:Using the toilet, including getting up and down; ADL7:Preparing a hot meal (cooking and serving); ADL8:Shopping for groceries; ADL9:Making telephone calls; ADL10:Taking medications; ADL11:Doing work around the house or garden; ADL12:Managing money, such as paying bills and keeping track of expenses; ADL13:Getting around or finding address in unfamiliar place.



S4 Fig. Prevalence of frailty across states, in middle-aged and elderly men and women. Individuals with frailty index > 0.21 were considered as frail. Prevalence estimates are weighted, using state-level individual sampling weights provided in data.



S5 Fig. Forest plot of adjusted odds ratios (95% CI) for frailty, by participants' background characteristics, using income as the economic indicator. Annual per capita household income is used as the economic indicator, instead of monthly per capita consumption expenditure. Per capita household income is computed by aggregating income from all sources (agricultural and non-agricultural business, wage/salary, pension and transfers) and dividing by the number of household members.

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
: Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Abstract Methods (page 2)
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Abstract Methods, Results (page 2)
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Background paragraphs 1-3 (pages 4-5)
Objectives	3	State specific objectives, including any prespecified hypotheses	Background paragraph 4 (page 5)
Methods			
Study design	4	Present key elements of study design early in the paper	Methods subsection *Data* (page 5)
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Methods subsection *Data* (page 5)
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	Methods subsection *Data* (page 5) and S1 Fig
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Methods subsection *Variables (*pages 6-7)
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Methods subsection *Variables* (pages 6-7) and S1-S3 Tables
Bias	9	Describe any efforts to address potential sources of bias	Methods subsection *Statistical analysis* (pages 7-8)
Study size	10	Explain how the study size was arrived at	Methods subsection *Data (*page 5) and S1 Fig, S4 Table
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Methods subsection *Statistical analysis, (*pages 7-8)
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Methods subsection *Statistical analysis, (*pages 7-8)
		(*b*) Describe any methods used to examine subgroups and interactions	Methods subsection *Statistical analysis, (*pages 7-8)
		(*c*) Explain how missing data were addressed	Methods subsection *Variables* (pages 6-7) Table 1 (pages 9-10), S3 Fig

		(*d*) If applicable, describe analytical methods taking account of sampling strategy	Methods subsection *Statistical analysis, (*pages 7-8)
		(*e*) Describe any sensitivity analyses	Methods subsection *Variables (*pages 6-7)
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Results paragraph 1 (pages 8-9), S4 Table
		(b) Give reasons for non-participation at each stage	S1 Fig
		(c) Consider use of a flow diagram	S1 Fig
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Results paragraph 1 (pages 8-9), Table 1 (pages 9-10)
		(b) Indicate number of participants with missing data for each variable of interest	Table 1 (pages 9-10), Table 2 (page 13), S1 Table, S3 Table, S4 Table, S3 Fig
Outcome data	15*	Report numbers of outcome events or summary measures	S2 Fig panel A, S5 Table, Table 2 (page 13), Table 3
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Table 2 (page 13), Table 3 (page 15), Fig 2
		(*b*) Report category boundaries when continuous variables were categorized	Table 2 (page 13), Table 3 (page 15), Fig 2
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Results subsections *Sex differences* and *Sensitivity analyses* (pages 16-17)
Discussion			
Key results	18	Summarise key results with reference to study objectives	Box 1 (page17) and Discussion para 1 (page17)
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Discussion para 6 (page 20)
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Conclusion (page 21)

Generalisability	21	Discuss the generalisability (external validity) of the study results	Discussion para 2-6 (pages 18-20)
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Declarations subsection *Funding* (page 22)

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.