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ORIGINAL ARTICLE

Association of food insecurity with frailty among older adults in India

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Abstract
Background Past investigations in different nations have demonstrated that food insecurity may lead to frailty among older adults; however, there is no evidence concerning these associations in India. Our investigation tries to fill this gap utilizing WAVE I of WHO SAGE 2007 information.
Objectives To examine the independent effect of food insecurity on frailty. To assess differences in frailty and other correlates between food secure and insecure older individuals.
Methods The Fried phenotype approach was used to create a frailty index using the presence of five indicators among older adults: exhaustion, weight loss, physical activity, weakness, and walking speed. Respondents were called robust, pre-frail, or frail based on the presence of zero, one, or two or more indicators from the five indicators, respectively. Individuals were classified as food insecure based on their responses to two five-point Likert scale-type questions: if they had less food than required because there was not enough food and if they had been hungry but did not eat because they could not afford food in more than 1 or 2 months in the last 12 months. Bivariate analysis was performed to determine the differences in all the correlates and frailty among older adults with food security and insecurity. Step-by-step logistic regression analysis was performed to estimate the effect of food insecurity on frailty.
Results Bivariate results show that from a total of 6650 adults aged 50 years or older, 16.05% are food insecure, and of them, 19% are frail. In addition, frailty is significantly associated with food insecurity ($p < 0.001$). These findings are further corroborated by multivariate analysis results showing that food insecure older adults have higher odds of being frail compared to their counterparts (OR = 1.31, 95% CI 1.10; 1.65, $P < 0.001$) in the adjusted model for all the correlates. Education and wealth are also among major factors aggravating frailty among older adults.
Conclusion Based on our results, we conclude that, after controlling for correlates, food insecurity is associated with frailty, which further prevents older adults from accessing nutritious food and causes them to lose their independence. Thus, the government needs to introduce focused sustenance programs for the elderly population who do not have regular access to food and are frail to prevent early disability and mortality.

Keywords Food insecurity · Frailty · SAGE · India · Older adults

Background

India's population aged 60 years and over is expected to rise from 9% of the total population today to 19% of the population by 2050 (DESA 2015). Also, the older population is growing three times faster compared to the overall population in India (Giridhar et al. 2014). In spite of India's current economic development, the living status of a majority of older Indians is poor (Husain and Ghosh 2011). Only 11% of the older population has a pension, and saving is also difficult because of low earnings (World Bank 2001; Uppal and Sarma 2007). Poverty in old age is significantly high (Mahal and Berman 2001), particularly because of out-of-pocket expenditures for health care, which modify the utilization of non-health goods and services (Whithead et al. 2001). Besides, insufficient income is a reason for inadequate food intake, dietary intake, and nutritional status and a reason for

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worry in the elderly population (Hadley et al. 2007a, b). As a result, extended years of life are not healthy since dietary intake plays an important role in physiological, cognitive, and social health (WHO 2002). Studies mostly exist on food insecurity among children and younger adults; however, food insecurity among elderly persons is not even examined. Therefore, we cannot expect any study on the association of food insecurity and frailty among older adults in India. This is very important to address since the proportion of elderly is projected to dramatically increase in the twenty-first century (Agarwal et al. 2016).

Food security is the condition in which all people can meet their food preferences and dietary needs through physical, social, and economic access to sufficient and nutritious food to live a healthy and active life (Sharkey 2011). India's Global Hunger Index was 28.5 in 2016, falling from 38.5 in 2000, but is still serious despite consistently decreasing over the years (Von Grebmer et al. 2016). Also, in 2016 India ranked 97th out of 118 countries on the Global Food Security Index (GFSI), which considered the issues of affordability, availability, and quality and safety across the set of 113 countries. Food insecurity causes malnutrition among older adults, which can result in functional impairment and health problems and can deprive them of their autonomous and independent life (Bartali et al. 2012; Lee and Frongillo 2001; Quandt and Rao 1999; Roe 1990; Wolfe et al. 1996). A number studies have shown the impact of food insecurity on dietary intake among older adults (Tanumihardjo et al. 2007). Many chronic diseases are the result of food insecurity among older adults (Seligman et al. 2010; Tanumihardjo et al. 2007). Specifically, when controlling for a number of correlates, food insecurity is found to be significantly related to type 2 diabetes (Holben and Pheley 2006; Seligman et al. 2010; Seligman et al. 2007). In individuals with diabetes, food insecurity is associated with diminished health-related quality of life (Maddigan et al. 2006). In addition, food insecurity makes a consistent nutritious diet regimen challenging, lowers the scores for self-efficacy, and causes extreme mental suffering in managing diabetes (Seligman et al. 2010). Also, there is a chain of health outcomes due to food insecurity, for example, food insecurity influences obesity, which is further related to oral health and anorexia, which can further give rise to hypertension and diabetes (Córdova-Villalobos et al. 2008). Food insecurity also makes individuals miss or procrastinate about their medications as their priority is getting enough food for the coming days (Miner et al. 2013; Sullivan et al. 2010), which can further worsen their health conditions (Aikens and Piette 2013; Egede et al. 2014). The nature of food security is cyclic, for example, in the beginning, sufficient food is followed by the absence of enough food toward the end of the month; this can cause a weight increase over a period of time, which additionally impacts the development of chronic diseases and health outcomes (Laraia 2013).

With an aging population, more than a quarter of individuals older than 85 years are expected to be frail worldwide (Clegg et al. 2013). Frailty is an age-associated accumulation of deficits in multiple body parts so that frail older adults are more vulnerable to stressors and inclined to adverse health problems (Xue 2011). In cold weather, a frail individual will have a high likelihood of contracting pneumonia compared to an individual who is not frail. The concept of frailty is increasingly being acknowledged in clinical and research settings because of its predictive nature for adverse outcomes (Partridge et al. 2012) and also because of its impact on the individual, family, and society (Latham et al. 2003; Kenny et al. 2010). There is also a need to determine the factors that contribute to frailty to enhance the care of the elderly who encounter the ill impacts of this condition (Gobbens et al. 2010). The concept of frailty remains questionable despite being increasingly agreed upon by researchers and health care providers concerning its important impact on individuals, their families, health care providers, and society (Karunananthan et al. 2009). Frailty remains an advancing idea lacking both a specific definition and analytic criteria to be utilized as a part of clinical practice and epidemiological inquiries (Bergman et al. 2007; Hogan 2003). The concept of food insecurity and frailty is important as food insecurity might make individuals frail, which may result in disability, causing older adults to lose their autonomous life and become dependent on others. To the best of our knowledge, there are no studies on the relationship between food insecurity and frailty in older adults. We attempt to fill this gap using data from WAVE 1 of the SAGE study in the Indian setting.

Methods and materials

Data source

We used the individual level data from the 2010 Wave 1 of the World Health Organization (WHO) Study on Global Aging and Adult Health (SAGE) in India. SAGE incorporates data for many socioeconomic and health indicators for individuals aged 18 years and above with a special focus on older adults. The SAGE study collected information on several health behavior domains: chronic conditions, health care utilization, psychological health, cognition, functional health, social networks, self-rated health and quality of life, and impact of caregiving. Additionally, the health status of study participants was assessed using anthropometric measurements, physical tests, cognition tests, and blood tests. The SAGE study was carried out from 2007 to 2010 in six states of India: Assam, Karnataka, Maharashtra, Rajasthan, Uttar Pradesh, and West Bengal. For our study purposes, we analyzed individual-level data and included respondents aged 50 years and above. The study completed effective interviews of 11,320 individuals,

including: 1046 males aged 18–49, 3624 females aged 18–49, and 6560 older adults (3311 male and 3249 female) aged 50-plus years. SAGE states were chosen to reflect variation in geographical regions, demographic and health transition, and economic development in the country covering a nationally representative total sample of 11,230 respondents aged 18 years and older. More information about the sampling design and survey weights is available at http://apps.who.int/healthinfo/systems/ surveydata/index.php/catalog.

Variable description

Frailty Frailty was measured using a modified version of the index developed by Fried and colleagues (Fried et al. 2001). Weakness, weight loss, walking speed, exhaustion, and physical activity were used as symptoms to create a frailty index: (1) scored in the bottom quintile for hand grip strength [adjusted for gender and body mass index (BMI)]; (2) instead of weight loss we used lower weight because of unavailability of data. An individual was classified as having lower weight if his/her BMI was in the lowest quintile for both the sexes. (3) If the individual scored in the bottom quintile for the 4-meters timed walk at a usual walking pace speed (adjusted for gender and height); (4) individuals were asked whether they have enough energy for their daily activities. Those who responded "a little" or "not at all" scored 1 and rest zero for the variable exhaustion. (5) We did not assess physical activity the way it was assessed by Fried and colleagues using the Minnesota Leisure Activity Questionnaire (Richardso et al. 1994). SAGE asks individuals about the time they spend on moderate, vigorous activities and cycling in a week based on the Global Physical Activity Questionnaire (GPAQ) (Bull et al. 2009). The total time spent on all the activities was added, and those who spent more than 300 min a week on these activities scored 1 and zero otherwise. Dichotomous variables were created for all the five symptoms, and a frailty index was created by summing all the scores. We did not use the actual cutoff point developed by Fried and colleagues as our sample differed from their non-Hispanic white sample in characteristics such as race and anthropometric measurements (height and weight). A number of studies have validated using a slightly different cutoff point to construct a valid and suitable frailty index for the study sample (Blaum et al. 2005; Masel et al. 2009; Rockwood et al. 2005).

Food insecurity The SAGE study asks two question to respondents that we have used for assessing food insecurity, "In the last 12 months, how often did you ever eat less than you wanted because there wasn't enough food?" and "In the last 12 months, were you ever hungry, but didn't eat because you couldn't afford enough food?" The reactions were then dichotomized by grouping the individuals who answered either item categorized as "food insecure" and the rest categorized as "food secure" affirmatively. Individuals who grouped under "food insecure" were given a score 1 and 0 otherwise (Joshua et al. 2017).

Socioeconomic demographic variables The background variables were: age group (50–59, 60–69, 70–79, 80+), state of residence, locality (urban or rural), religion (broadly categorized as Hindu, Muslim, and other), caste (categorized as Scheduled Castes/Scheduled Tribes, and other), gender (male or female), and marital status (currently married or cohabiting and other), education (no education, 1–5 years, 6–9 years, and 10 plus years), wealth (lowest, lower, middle, higher, and highest), and health insurance (whether having health insurance or not).

Health variables The health risk variables consist of tobacco use [current user (daily or non-daily) or non-user], alcohol consumption [current user (consumed alcohol in the last 30 days) or non-user], chronic conditions (categorized as none, one/two, and above), 1 + ADL limitations (categorized as zero, one, and two/above), and falls over the last one year.

Biomarkers Separately, three systolic and diastolic blood pressure measurements were collected for the SAGE study from each respondent, and the average of the second and third readings was used in the analysis. In addition, waist circumference, grip strength, and BMI were used as biomarkers. All the biomarkers used in the study were continuous variables.

Statistical analysis

A two-step analysis was performed. At the first stage, to comprehend differentials in socioeconomic and demographic variables, health risk variables, and biomarkers, we performed a bivariate analysis. At the second stage, we estimated multivariate analysis (binary logistic regressions) to assess the impact of food insecurity on frailty after stepwise adjusting for the group of covariates. The model is formulated below:

$$Logit\ (\mathrm{p}\ (\mathrm{Yi} = 1)) = \beta 0 + \beta 1 \mathrm{Xi} + \beta 2 FoodInseci + \varepsilon \mathrm{i}$$

Here, Yi is the binary outcome variable (to be categorized as being frail or not) related to a vector of control variables (age, sex, education level, wealth quintile, place of residence, state, chronic diseases, alcohol consumption, smoking tobacco, and biomarkers) and food insecurity, and ε is assumed to be a zero mean error term. Odds ratios (OR) with 95% CI were calculated. We used five different models to better understand the impact of food insecurity after adjusting for four different groups of covariates on frailty. Model 1 looks at the unadjusted impact of food insecurity on frailty; model 2 is adjusted for demographic and spatial factors (age, sex, caste, religion,

marital status, state, locality) followed by socioeconomic variables in model 3 (education, wealth, and health insurance). Further, we controlled for health risk variables (chronic conditions, tobacco, alcohol, 1 + ADL limitations, and falls over the last year) in the model 4. Finally, biomarkers (vision, systolic and diastolic blood pressure, waist circumference, grip strength, and BMI) were adjusted along with all other predictors in model 5 to assess the adjusted effect of all the covariates on frailty. We estimated five logit models after stepwise adjusting for the group of covariates to examine effects of food insecurity on frailty.

Results

Among older adults, most (35.26%) of the respondents had low weight; 30.73% were physically inactive, 27.43% were exhausted, and 23.19% experienced slowness and 21.74% weakness (Table 1). The 9850 respondents were classified into two categories based on food insecurity: older adults who were food insecure (16.05%) and those who were food secure (83.95%). Of the females 16.57% and among males 15.53% were food insecure. A higher proportion of older adults who were food insecure were exclusively from the lowest quintile of the wealth index and had fewer years of schooling. Food insecurity declines as the number of years of schooling increases ($p < 0.001$): 20.33% of individuals with no schooling, 15.79% with 1–5 years of schooling, 11.14% with 6–9 years of schooling, and 6.6% with 10+ years of schooling were food insecure. Wealth is a protective factor against food insecurity: 36.36% of the poorest people were food insecure, whereas only 2.98% of the richest people were food insecure ($p < 0.001$). Only 7% of individuals having health insurance were food insecure compared to 17% among those without any health insurance ($p < 0.001$). There was also spatial variation in food insecurity. In Rajasthan, only 5.23% of individuals were food insecure compared to 28% in Assam, 22.08% in West Bengal, 18.02% in Uttar Pradesh, and 18.63% in Karnataka ($p < 0.001$); 18.52% of the rural and 8.83% of the urban older adults were food insecure ($p < 0.001$). Caste is also a factor contributing to food insecurity: 23.97% of SC/ST people were food insecure compared to 13.73% among the others ($p < 0.001$). Religion also significantly contributes in food insecurity. Twenty percent of Muslims are food insecure compared to 17% among others and 15.9% among Hindus ($p < 0.001$). Fifteen percent of the currently married subjects were food insecure compared to 22% of the others ($p < 0.001$).

Among the frail older adults, 19% were food insecure compared to 10% of non-frail older adults ($p < 0.001$) (Table 2). Now, if we look at the food insecurity among frailty symptoms, we see that 24% of the respondents who reported exhaustion were food insecure, which was 14% in the respondents with no exhaustion ($p < 0.001$). Among the respondents in the weight loss category, 22% were food insecure and 13% in those with no weight loss ($p < 0.001$). Seventeen percent of physically inactive individuals were food insecure and 15% among the physically active. Food insecurity significantly differed among older adults who reported slowness (17.77%) than among those who were food secure (15.33%). Food insecurity was 19% among smokers compared to 14% among non-smokers ($p < 0.001$). Food insecurity was present in 20% of the respondents who reported 1 + ADL limitations compared to 13% among those who are had zero 1 + ADl ($p < 0.001$). Systolic and diastolic blood pressure did not differ significantly between the food insecure and food secure groups of respondents. Also, waist circumference did not differ between those with food insecurity and those with food security. Grip strength and BMI differed significantly between the food insecure and food secure groups ($p < 0.001$) (Table 3).

Percentage of frailty was 28.37% among those who were severely food insecure, and the frailty prevalence decreased as we moved to moderately (24.95%), mild (21.71%), and not at all food insecure (17.1%) older adults (Fig. 1). Frailty prevalence differs significantly among different levels of food insecurity ($p < 0.001$; $\chi^2 = 93.1634$).

Discussion

The purpose of the present investigation was to decide whether there was a relationship of food insecurity with frailty, and our study results show an association between the two. Our outcomes demonstrated that in the aggregate sample, 16.05% of the older individuals were food insecure, which is very high. Likewise, our investigation uncovered that the chances of being frail are higher for food insecure older adults for the unadjusted model. After the model is adjusted for demographic and spatial factors, the odds of being frail are 1.87 times among food insecure older adults, which further decreases to 1.50, 1.43, and 1.31 when the model is adjusted for socioeconomic status, health risk factors, and biomarkers, respectively. This shows a decreasing and independent association between food insecurity and frailty. We hypothesize that the relationship between food insecurity and frailty may be bi-directional in that food insecurity could lead to symptoms of frailty, while symptoms of frailty could also lead to the development or worsening of food insecurity. As a first step, we set out to explore the associations between frailty and food insecurity in an aging population. Future studies can look at how functional impairments among older adults impede individual's food intake ability.

Elderly individuals have different well-being attributes and nutritional requirements from people in other younger ages. Additionally, food insecurity is an altogether different phenomenon in these older adults. They have particular

Table 1 Prevalence of food insecurity with regard to socio-economic, demographic, and spatial factors

Variables	Food secure (n = 5504, 83.95%)	Food Insecure (n = 1052, 16.05%)	$F/\chi 2$	P
Sex				
Men	2795 (84.47)	514 (15.53)	1.305	0.253
Women	2709 (83.43)	538 (16.57)		
Age Groups				
50–59	2476 (84.25)	463 (15.75)		
60–69	1865 (83.52)	368 (16.48)	3.112	0.375
70–79	878 (83.14)	178 (16.86)		
80+	285 (86.89)	43 (13.11)		
Years of Schooling				
No schooling	2688 (79.67)	686 (20.33)		
1–5 Years	1077 (84.21)	202 (15.79)	129.292	0.000[a]***
6–9 Years	758 (88.86)	95 (11.14)		
10+ years	962 (93.4)	68 (6.6)		
Wealth Quintile				
Poorest	835 (63.64)	477 (36.36)		
Poorer	1026 (78.26)	285 (21.74)		
Middle	1151 (87.66)	162 (12.34)	696.029	0.000[a]***
Richer	1221 (93.21)	89 (6.79)		
Richest	1271 (97.02)	39 (2.98)		
Health Insurance				
Yes	284 (92.68)	22 (7.32)	10.282	0.001[a]***
No	5200 (83.20)	1050 (16.80)		
State				
Karnataka	751 (81.37)	172 (18.63)		
Maharashtra	974 (88.79)	123 (11.21)		
Rajasthan	1305 (94.77)	72 (5.23)	251.688	0.000[a]***
Uttar Pradesh	1074 (81.98)	236 (18.02)		
Assam	486 (71.89)	190 (28)		
West Bengal	914 (77.92)	259 (22.08)		
Residence				
Rural	3976 (81.48)	904 (18.52)		
Urban	1528 (91.17)	148 (8.83)	87.026	0.000[a]***
Caste				
SC/ST	1129 (76.03)	356 (23.97)	89.545	0.000[a]***
Others	4375 (86.27)	696 (13.73)		
Religion				
Hindu	4651 (84.13)	877 (15.87)		
Muslim	630 (79.85)	159 (20.15)	30.277	0.000[a]***
Others	196 (83.01)	40 (16.99)		
Marital Status				
Currently Married	4136 (85.11)	723 (14.89)	23.325	0.000[a]***
Otherwise	1330 (78.40)	366 (21.60)		

Note: a represents categorical variable analyzed using the Chi-square test (v2); *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

sociodemographic and economic characteristics, for example, education, income, and less participation in social programs, which restrain older adults' accessibility to food security. Our studies are consistent with previous research from different nations that reported higher odds of food insecurity among older adults than among their younger counterparts. A study

Table 2 Prevalence of food insecurity with regard to frailty, health risk variables, and biomarkers

Variables	Food Security	Food insecurity	$F/\chi 2$	p
Frailty				
Frail	3824 (81.25)	882 (18.75)	78.969	0.000[a]***
Not-frail	1671 (90.34)	179 (9.66)		
Exhaustion				
Yes	1362 (75.82)	435 (24.18)	77.048	0.000[a]***
No	4107 (86.42)	646 (13.58)		
Weight Loss				
Yes	1758 (78.18)	490 (21.82)	102.262	0.000[a]***
No	3590 (86.94)	539 (13.06)		
Physically Active				
Yes	3766 (82.92)	776 (17.08)	0.262	0.609[a]
No	1710 (84.98)	302 (15.02)		
Slowness				
Yes	1269 (83.54)	250 (16.46)		
No	4209 (83.57)	827 (16.46)	4.385	0.036[a]**
Weakness				
Yes	1140 (79.91)	287 (20.09)	21.749	0.000[a]***
No	4348 (84.75)	782 (15.25)		
Chronic disease				
None	2009 (82.93)	326 (17.07)		
One-two	1669 (83.53)	347 (16.47)	2.637	0.268
Above	1801 (84.63)	398 (15.37)		
Consume alcohol				
No	4671 (84.67)	846 (15.33)		
Yes	833 (80.17)	234 (19.83)	13.098	0.000[a]***
Smoke				
No	2822 (86.14)	454 (13.86)	34.442	0.000[a]***
Yes	2656 (80.99)	623 (19.01)		
Falls over the last year				
No	5179 (84.08)	947 (15.92)	23.944	0.000[a]***
Yes	325 (76.23)	105 (23.77)		
1 + ADL Limitations				
Zero	3113 (86.86)	471 (13.14)	55.55	0.000[a]***
One	2365 (79.61)	605 (20.39)		
Biomarker				
Systolic Blood Pressure	120.76 (28.42)	120.80 (26.79)	0.25	0.6148
Diastolic Blood Pressure	79.17 (19.16)	79.68 (17.73)	1.88	0.1705
Waste circumference	87.73 (74.65)	80.94 (58.72)	2.43	0.1188
Grip Strength	21.58 (10.99)	19.31 (9.79)	45.56	0.000[c]***
BMI	19.26 (5.64)	20.71 (5.40)	64.12	0.000[c]***

Note: a, b and c denotes $p < 0.05$, $p < 0.01$, and $p < 0.001$ respectively

using data from older Mexican adults showed that after adjusting for correlates associated with frailty, food insecure older adults are at higher risk of being frail compared to food secure older adults. Furthermore, studies have shown higher mortality among individuals with frailty scores greater than 0.21; thus, higher food insecurity leads to higher frailty and mortality (García-González et al. 2009; Villagomez-Ornelas et al. 2014). More data and tools are needed to characterize food insecurity, and further investigation is required to strengthen these findings. Special consideration should be paid to older adults in the countries where the elderly population is increasing dramatically.

Table 3 Results of logistic regression (odds ratio) for being frail among older adults in India, 2010

Variables	Model I	Model II	Model III	Model IV	Model V
Food insecurity (no®) Yes	2.14[a](1.81;2.54)	1.87[a](1.57;2.25)	1.50[a](1.24;1.82)	1.43[a](1.21;1.77)	1.31[a](1.10;1.65)
Sex (male)					
Female		1.08(0.95;1.21)	0.89(0.78;1.02)	0.78[a](0.67;0.91)	0.53[a](0.44;0.64)
Age groups (50–59®)					
60–69		1.93[a](1.71;2.19)	1.85[a](1.63;2.10)	1.68[a](1.48;1.91)	1.42[a](1.24;1.64)
70–79		4.97[a](4.03;6.14)	4.67(3.77;5.78)	3.77[a](3.04;4.69)	3.18[a](2.51;4.03)
80+		17.45[a](9.47;32.16)	16.02(8.68;29.58)	10.93[a](5.89;20.26)	7.33[a](3.74;14.36)
State (Assam®)					
Karnataka		0.78[c](0.62;1.00)	0.69[a](0.53;0.89)	0.67[a](0.52;0.87)	0.85(0.65;1.13)
Maharashtra		0.99(0.78;1.26)	0.84(0.66;1.08)	0.88(0.69;1.13)	0.99(0.76;1.28)
Rajasthan		0.63[a](0.50;0.79)	0.51[a](0.41;0.64)	0.55[a](0.74;1.19)	0.66[a](0.51;0.85)
Uttar Pradesh		1.01(0.80;1.27)	0.88(0.69;1.12)	0.93(0.73;1.19)	0.90(0.69;1.16)
West Bengal		0.94(0.75;1.19)	0.83(0.65;1.06)	0.80[c](0.63;1.02)	0.96(0.73;1.23)
Urban		1.19[a](1.05;1.37)	0.92(0.79;1.06)	0.92(0.79;1.07)	0.89(0.76;1.05)
Caste (SC/ST®)					
Other		1.31[a](1.13;1.52)	1.06(0.91;1.24)	1.13(0.96;1.32)	1.10(0.93;1.30)
Religion (Hindu®)					
Muslim		1.43[a](1.18;1.72)	1.22[b](1.00;1.47)	1.13(0.93;1.38)	1.19[c](0.97;1.47)
Other		0.91(0.68;1.24)	0.98(0.72;1.33)	0.96(0.70;1.31)	1.19(0.85;1.66)
Marital status (yes®)					
Otherwise		0.66[a](0.57;0.77)	0.70[a](0.59;0.82)	0.70[a](0.59;0.83)	0.72[a](0.60;0.85)
Years of schooling (No®)					
1–5 years			0.74[a](0.63;0.88)	0.74[a](0.63;0.88)	0.78[a](0.65;0.94)
6–9 years			0.68[a](0.56;0.83)	0.69[a](0.57;0.84)	0.75[a](0.61;0.92)
10+ years			0.55[a](0.45;0.67)	0.58[a](0.47;0.71)	0.67(0.54;0.84)
Wealth (poorest®)					
Poorer			0.8[c](0.68;1.02)	0.83[c](0.68;1.01)	0.87(0.70;1.08)
Middle			0.62[a](0.51;0.76)	0.60[a](0.49;0.74)	0.69[a](0.55;0.86)
Richer			0.62[a](0.49;0.76)	0.60(0.48;0.74)	0.74[a](0.59;0.93)
Richest			0.56[a](0.45;0.70)	0.55[a](0.44;0.69)	0.80[c](0.63;1.02)
Health insurance (yes®)					
No			0.88(0.68;1.15)	0.92(0.71;1.21)	0.96(0.72;1.27)
Chronic disease (no®)					
One-two				1.08(0.94;1.24)	1.08(0.93;1.26)
Above				1.54[a](1.31;1.81)	1.65[a](1.38;1.96)
Consume alcohol (yes®)					
No				0.85[c](0.72;1.02)	0.93(0.77;1.12)
Tobacco (no®)					
Yes				1.05(0.92;1.20)	0.97(0.85;1.13)
Falls (no®)					
Yes				0.81[c](0.63;1.03)	0.79[c](0.61;1.03)
1 + ADL (no®)					
One				2.02[a](1.77;2.30)	2.04[a](1.78;2.35)
Biomarker					
Systolic BP					0.94[a](0.94;0.96)
Diastolic BP					0.99(0.99;1.00)
Waist circumference					0.99(0.99;1.00)
Grip strength					0.99[b](0.99;0.99)

Table 3 (continued)

Variables	Model I	Model II	Model III	Model IV	Model V
BMI					0.91[a](0.89;0.92)

®Reference category. For marital status, yes denotes currently married; a, b, and c denote $p < 0.05$, b $p < 0.01$, and $p < 0.001$, respectively

The proportion of elderly people living alone is increasing because of changes in family norms in India (Sathyanarayana et al. 2012). Elderly people living alone face transportation issues due to health problems, and this prevents them from getting food. Also, in Indian society the elderly would ideally stay quiet then ask for help. Thus, food insecurity in the elderly population can be referred to as hidden hunger since it is often overlooked in countries starting to face a growing burden of the elderly population. Reports have demonstrated that strong social groups and informal organizations in villages provide financialand other support such as transportation and cooking food for older adults (Wolfe et al. 2003). This emphasizes the requirement for strategies to improve the accessibility of food for the elderly population (Bartali et al. 2012). These investigations propose that the idea of food insecurity in elderly people may incorporate altered food use because of inadequate availability, affordability, and accessibility of food; this should be considered so the prevalence of functional impairments and resultant health problems can be decreased (Frongillo et al. 2010; New York State Department of Health and Office for the Aging, 1996).

The literature shows that a suitable eating regimen can enhance the strength of the frail elderly population. This could give an alternate point of view and move the worldview toward the anticipation of frailty, not just the treatment of its consequences (Gollub et al. 2004). The prerequisites should be extended to perceiving all angles that are shaping the well-being of the elderly population with a greater focus on intricate societies where the elderly population feels excluded. The elderly population facing food insecurity has reduced well-being (for example, frailty), which may create unfavorable results, making their consideration in present day social orders significantly more troublesome. Furthermore, organizations administrating programs need to concentrate on and include the particular needs of the elderly population, hoping to wipe out hunger in the entire population and to be successful in their objectives.

There is literature on how dietary conditions affect well-being and specifically frailty status among the elderly population (Bartali et al. 2012). There is also a requirement to include social elements in the investigation of frailty and to more profoundly investigate their potential protective role among older adults. In addition, how these social components can be effective in protecting older adults from frailty needs to be explored. The initiatives, for example, Meals on Wheels, improve the dietary intake among the elderly population (Frongillo et al. 2010). Studies have demonstrated that in lower- and middle-income nations, for instance, in Mexico, a concentrated and not summarized intervention was very successful in improving food security, which further diminishes the development of frailty and disability.

Our study has a number of strengths and limitations. The study attempted to fill the literature gap and research on food insecurity and frailty in India. It was conducted in six different states and contributes to the estimation of the current prevalence rate of food insecurity and frailty in LMICs based on cross-sectional data. To the best of our knowedge, the present examination is the first to portray this relationship in older Indian adults and may be useful in planning and carrying out food insecurity initiatives by the government. Considering the limitations, one is the cross-sectional design. Longitudinal data can be very useful in investigating the causal relationship of exposure time to food insecurity with frailty development and its outcomes. A hypothetical path from food insecurity to frailty would be consumption of high-carbohydrate/low-protein diets, which causes obesity/sarcopenia, which is further

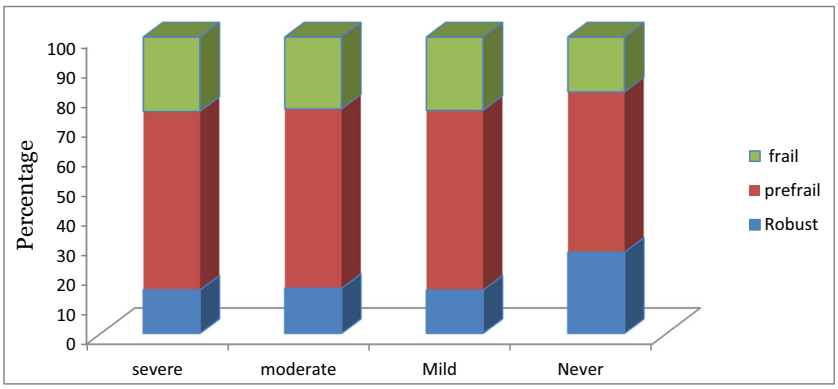

Fig. 1 Percentage distribution of frailty over food insecurity status

followed by frailty and leads to disability, hospitalization, and death (Lee and Frongillo 2001). Since a long time without a nutritious diet can make an individual vulnerable to physiological stressors, the longitudinal data can give us an idea about the exposure time to food insecurity. This is an endless loop that can be broken by strengthening strategies to upgrade dietary intakes in poor families. Longitudinal information can confirm that long-term food sustenance instability causes a health misbalance that leads to a deficiency because of a continued unhealthy eating routine. Longitudinal data will furthermore continue disentangling these factors—food instability, nutrition deficiency, physical impact, and inadequacy—and may lead to understanding of how these interactions happen and how a mediation approach can be actualized to break the cycle.

Conclusion

With the growing elderly population in India, food insecurity and the associated factors, and how food insecurity affects the physical well-being of older adults, need to be examined. The central and state governments should use WHO guidelines to address the food insecurity, dietary intake, and nutritional needs of the growing elderly population. Worldwide, there has been a huge change in the size of the elderly population due to significant improvements in life expectancy. Individuals are currently living with greater handicaps due to the increased prevalence of frailty and disability. Food insecurity among older adults can add to the development of disability and frailty and other unfavorable health outcomes, making their consideration in current social orders significantly more important. There is a basic necessity to reinforce the present nutritional framework to address the physical well-being needs of the elderly and launch policies and programs to address the hidden hunger in this ignored population.

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Compliance with ethical standards

Conflict of interest The authors have no conflict of interest.

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

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

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