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ORIGINAL ARTICLE

Diabetes and frailty in community dwelling older adults in India: insights from the longitudinal aging study in India

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Abstract

Background Elderly patients with Diabetes Mellitus (DM) have an increased risk of frailty especially when food insecure.
Objective The study objective was to determine the prevalence and determinants of frailty among older individuals with DM in India. We also examined the relationship between DM, frailty, and food insecurity.
Methods This secondary analysis utilized data from Longitudinal Aging Study in India (LASI), a nationally representative survey conducted in 2017–18 among 31,902 individuals aged 60 years and above including 4934 patients with DM.
Results The weighted prevalence of frailty in patients with DM was 23.72% (95% CI: 21.16, 26.49). Overall prevalence of frailty was found to be significantly higher among women (28.05%) than men (22.37%). Weak grip strength (77.56%) and low physical activity (81.93%) were the most prevalent components among males and females, respectively. On adjusted analysis, a significantly higher odds of having frailty among DM cases were observed in those aged 75 and above (aOR = 1.85, 95% CI: 1.18, 2.91) and those having one or more additional comorbidities (aOR = 1.59, 95% CI: 1.03, 2.45). Those having secondary education (aOR = 0.41, 95% CI: 0.26, 0.65), graduate and above education (0.35, 95% CI: 0.19, 0.64), currently working (0.21, 95% CI: 0.12, 0.35) had significantly lower odds of having physical frailty among DM cases.
Conclusion Nearly one in four patients with DM in India have frailty characterized by weak grip strength and low physical activity linked with reduced physical capacity and mobility, in a social environment of widespread food insecurity.

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

Introduction

The World Health Organization (WHO) estimates that from 2015 to 2050, the percentage of the global population aged 60 years and older is projected to almost double, rising from 12 to 22% [1]. Frailty is a major public health challenge in the geriatric population. Frailty has been described as a biological geriatric syndrome that implies a risk of multimorbid conditions and dependence on others due to the reductions in physiological reserve capacity and impairment of defensive mechanisms against different stressors and diseases [2].

It is well-established that the presence of Diabetes (DM) is associated with an increase in the risk of frailty [3], and DM itself is one of the most widespread epidemics, and its burden continues to escalate. The clinical manifestation of both these conditions together is associated with a high risk of disability, hospitalization, and mortality in the aging population [4]. As part of its effect on accelerating the aging process, DM increases the risk that an individual will become frail as they age [5]. It is estimated that 536.6 million people worldwide have DM, with the highest prevalence in those aged between 40 and 57 years with projected burden of 783.2 million (12.2%) by 2045 [6]. According to a pooled analysis of 32 studies, the prevalence of frailty and prefrailty among older individuals with DM was estimated at 20.1% (95% CI = 16.0–24.2%) and 49.1% (95% CI = 45.1–53.1%), respectively, with significant heterogeneity between studies. There was a higher prevalence of frailty in older adults with DM than those without DM. Moreover, females were more likely to exhibit frailty compared to males [7].

There is evidence that food insecurity, a sociodemographic determinant, contributes to impaired glucose tolerance in DM patients and physical frailty, but these effects

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have not been extensively studied. Researchers have reached contradictory conclusions: While food insecurity is considered a major risk factor for DM and can deteriorate glycemic control in DM patients [8], a pooled meta-analysis study found that food insecurity has a statistically insignificant association with DM [9]. A significant association exists between food insecurity and frailty, although very little research has been focussed in the older population, where the odds ratio has been found to range from 1.31 to 2.68 [10–12]. Beyond food insecurities, several other factors play a pivotal role in the development and exacerbation of frailty in individuals with DM that include aging, menopause in females, sarcopenia, physical inactivity and chronic inflammation [13–15].

Despite the growing body of research on frailty, there has been no investigation from large scale survey data assessing the relationship between frailty, food insecurity among patients with DM. This research gap is significant because India, being a low-middle-income country, has a large geriatric population that is rapidly aging, and the country also has the highest population of people with DM worldwide. The study objective was to determine the prevalence and determinants of frailty among older individuals with DM in India. We also examined the relationship between DM, frailty, and food insecurity.

Materials and methods

Study design and Data source

This secondary analysis utilized data from Longitudinal Aging Study in India (LASI), which was a nationally representative survey conducted in 2017–18. LASI collected data from more than 72,000 people aged 45 and above, as well as their spouses (of any age), across Indian states and union territories on their existing health care practices, health behaviour and risk factors, health care utilisation, and various sociodemographic characteristics.

A multistage stratified cluster sample design was utilized, including three and four separate phases of rural and urban region selection. In each state or union territory (UT), the initial step entailed the selection of primary sampling units (PSUs), which corresponds to sub-districts (Tehsils/Talukas). The subsequent step involved the selection of villages within rural areas and wards within urban areas in the chosen PSUs. In rural regions, households were then chosen from the selected villages as the third stage. Specifically, in the third stage, one census enumeration block (CEB) was randomly chosen within each urban area and subsequently households were selected from this CEB in the fourth stage.

LASI data were gathered using research designs, tools, and advanced scientific procedures that align with international standards for comparability. All data collection procedures were standardized to maintain consistency and rigor throughout the study. More detailed information about the sampling, survey design, survey instruments and data collection is available elsewhere [16]. The total sample size of the survey was 73,396 individuals. This analysis is conducted on eligible individuals aged 60 years and above ($n = 31,902$) including 4934 patients with DM.

Outcome variable

The primary outcome for the study was physical frailty, derived from the questions based on modified Fried frailty phenotype scale [17]. Exhaustion, unintentional weight loss, weak grip strength, low physical activity, and slow walking time are the five components included in the physical frailty phenotype.

i. Exhaustion was assessed based on the question from Center for Epidemiologic Studies Depression (CES-D) scale: "During the past week, how often did you feel tired or low in energy?". Responses "often" (3 or 4 days) and "most or all of the time" (5–7 days) were put under exhausted = 1, and others were considered as not exhausted = 0.
ii. Handgrip strength was measured in kilograms using a handheld Smedley's Hand Dynamometer in LASI. The effective handgrip strength score was calculated as the mean of two successive trials in the dominant hand, and adjusted for gender and body mass index (BMI). Low grip strength was considered as Yes = 1, and remaining was considered as No = 0.
iii. Respondents were asked to walk 4 m twice, and slowness was assessed by averaging the time taken (in seconds) in completing the 4 m, with adjustments for gender and height. Individuals with a slow walk were put in the category Yes = 1, and others in No = 0.
iv. Unintentional weight loss was assessed using the question "Do you think that you have lost weight in the last 12 months because there was not enough food at your household?", with the responses being Yes = 1 or No = 0.
v. Participants were asked about their physical activity through the question "How often do you take part in sports or vigorous activities, such as running or jogging, swimming, going to a health centre or gym, cycling, or digging with a spade or shovel, heavy lifting, chopping, farm work, fast bicycling, cycling with loads: everyday, more than once a week, once a week, one to three times a month, or hardly ever or never?". Responses hardly ever or never, or 1–3 times a month

were clubbed into physically inactive = 1, and others were considered as active = 0.

Total frailty score was calculated using these five questions and a total score of 0–2 was classified as "not frail," and 3 or higher as "frail." Self-reported DM was assessed using the question "Has any health professional ever told you that you have diabetes or high blood sugar?".

Explanatory variables

Socio-demographic variables included age (recoded as 60–74, and 75 + years), sex (male and female), education (recoded as no education/less than primary, primary complete, secondary, higher, and graduate and above), marital status (never married, currently married, widowed and others including separated, divorced and deserted), work status (recoded as not working and currently working), place of residence (rural and urban), monthly per capita consumption expenditure (MPCE) quintile (Poorest, Poorer, Middle, Richer and Richest). Other potential lifestyle and health-related variables consist of tobacco consumption (no and yes, based on ever use of tobacco products) and alcohol use (no and yes, based on ever consumption of alcohol beverages). Body mass index (BMI) was according to the WHO Pan Asian classification system [18]. Additional comorbidities were assessed based on the self-reported presence or absence of diseases such as hypertension, cancer, chronic lung disease, chronic heart disease, stroke, arthritis, neurological problems and high cholesterol. Household food insecurity score was assessed based on the household food insecurity access scale (HFIAS) from Food and Nutrition Technical Assistance (FANTA). The following questions were included in LASI:

i. In the last 12 months, did you ever reduce the size of your meals or skip meals because there was not enough food at your household?
ii. In the last 12 months, did you eat enough food of your choice? Please exclude fasting/food related restrictions due to religious or health related reason.
iii. In the last 12 months, were you hungry but didn't eat because there was not enough food at your household? Please exclude fasting/food related restrictions due to religious or health related reasons.
iv. In the past 12 months did you ever not eat for a whole day because there was not enough food at your household? Please exclude fasting/food related restrictions due to religious or health related reasons.
v. Do you think that you have lost weight in the last 12 months because there was not enough food at your household?

Participants who responded affirmatively to one or more questions were considered as 1 "food insecure"; while others were considered as 0 "food secure".

Statistical analysis

Descriptive statistics and bivariate analysis were applied to describe sociodemographic and lifestyle characteristics of elderly individuals with self-reported DM. Further, multivariable binary logistic regression analysis was conducted to check for the associations between frailty status and its determinants. Both unadjusted and adjusted odds ratio (OR) were reported with a 95% confidence interval (CI). We considered a $p < 0.05$ as statistically significant. Models were checked for any outliers and multicollinearity. We accounted for the cluster-sampling design of the LASI by applying appropriate sampling weights throughout the analysis.

Further, the direct and indirect effects of independent variables on physical frailty was assessed using Karlson-Holm-Breen (KHB) method, which is appropriate for mediation analyses in nonlinear models [19], wherein the direct effect is the association of key exposure variable with presence of physical frailty after controlling for mediators and other covariates. The indirect effect refers to the mediation effect in the association of key exposure variable with physical frailty. This enables to decompose the total effect of a key exposure variable in a logistic regression model into the sum of the direct and indirect effects. A mediated percentage is calculated, which represents the percentage of the main association that can be explained by the mediator variable. For the present study, the KHB method was implemented by a user-written 'khb' command [20] in Stata version 15.1 (StataCorp, College Station, Texas, USA).

Ethics approval

The ethical approval for LASI survey was obtained from the Indian Council of Medical Research (ICMR), with written and informed consent being obtained from each respondent before participating in the survey. Datasets were obtained from the International Institute for Population Sciences (IIPS) after submitting the study proposal. No separate ethical approval is required for this secondary data analysis, since the LASI Wave 1 dataset is an anonymous publicly available dataset including no identifiable information about the participants.

Results

Weighted prevalence of DM in the LASI dataset among elderly individuals (aged ≥ 60 years) was 14.26% (95% CI: 13.14, 15.45). Table 1 represents the sample distribution of

Table 1 Socio-demographic and lifestyle characteristics of elderly with diabetes

Characteristics	Having diabetes ($N=4934$) n (weighted %)
Age (years)	
60–74	3994 (81.52)
75 and above	940 (18.48)
Sex	
Male	2486 (48.38)
Female	2448 (51.62)
Education	
No education or less than primary	622 (18.15)
Primary complete	747 (23.18)
Secondary	1146 (37.18)
Higher	345 (11.60)
Graduate and above	401 (9.89)
Marital status	
Never married	32 (0.33)
Currently married	3322 (63.83)
Widowed/Divorced/Separated/Deserted	1580 (35.84)
Work Status	
Not working	2380 (71.05)
Currently Working	880 (28.95)
Place of Residence	
Rural	2156 (46.57)
Urban	2778 (53.43)
MPCE Quintile	
Poorest	697 (15.12)
Poorer	823 (15.8)
Middle	967 (18.29)
Richer	1126 (24.65)
Richest	1321 (26.15)
BMI (kg/m^2)	
Underweight (< 18.5)	311 (7.89)
Normal (18.5–25)	2098 (46.48)
Overweight (25–30)	1430 (32.55)
Obese (> 30)	526 (13.08)
Tobacco consumption	
No	3550 (72.58)
Yes	1349 (27.42)
Alcohol use	
No	4211 (87.72)
Yes	693 (12.28)
Additional Comorbidities	
None	1044 (20.16)
1 or more	3890 (79.84)
Food insecurity	
Food secure	2689 (54.75)
Food insecure	2245 (45.25)
Reduce the size or skip meals	
No	4721 (96.23)
Yes	179 (3.77)
Have food of one's choice	
No	2076 (42.01)
Yes	2825 (57.99)
Hungry but did not eat	
No	4760 (96.54)
Yes	142 (3.46)
Not eat for a whole day	
No	4802 (97.42)
Yes	99 (2.575)
Lost weight due to lack of food	
No	4759 (96.88)
Yes	136 (3.12)

elderly individuals with DM of whom nearly 82% belonging to the 60–74-year age group. More than half of the participants were females (51.6%), currently married (63.8%), and resided in urban areas (53.4%). About 80% of the participants had one or more additional comorbidities (hypertension, cancer, chronic lung disease, chronic heart disease, stroke, arthritis, neurological problems or high cholesterol), 27% used tobacco and 12% used alcohol. Food insecurity was estimated in 45.2% (95% CI: 40.66, 49.92) of the individuals having DM.

The weighted prevalence of frailty in LASI dataset among elderly individuals was 25.37% (95% CI: 24.52, 26.23). Additionally, 3.38% (95% CI: 3.09, 3.68) of the elderly individuals had presence of both DM and frailty. Table 2 reports the prevalence of Fried frailty phenotype components by age group and gender in Indian elderly population. Overall prevalence of frailty was found to be significantly higher among women (28.05%) than men (22.37%). Weak grip strength (77.56%) and low physical activity (81.93%) were the most prevalent components among males and females, respectively.

The weighted prevalence of frailty among patients with DM was 23.72% (95% CI: 21.16, 26.49). Table 3 reports the prevalence of frailty in patients with DM by subgroups along with multivariable regression estimates of individual characteristics and their association with physical frailty. The prevalence of frailty among patients with DM was higher among those aged 75 years and above (39.41%, 95% CI: 33.43, 45.72) and females (26.57%, 95% CI: 21.98, 31.73). A large burden was observed among those who were underweight (49.15%, 95% CI: 40.94, 57.40). On unadjusted logistic regression, age, females, education level, work status, place

Table 2 Distribution of frailty phenotype by age group and gender in older adults in India, 2017–2018

Fried Frailty component	60–74 years		75 and above		Total	
	Male n (weighted %)	**Female n (weighted %)**	**Male n (weighted %)**	**Female n (weighted %)**	**Male n (weighted %)**	**Female n (weighted %)**
Exhaustion	2494 (23.64)	3288 (26.34)	904 (29.00)	1088 (34.63)	3398 (24.82)	4376 (28.12)
Weak grip strength	7670 (73.97)	6797 (61.73)	2501 (90.48)	2338 (81.24)	10,171 (77.56)	9135 (65.75)
Walk time	1164 (10.48)	2424 (20.15)	913 (33.58)	1453 (51.96)	2077 (15.50)	3877 (26.45)
Weight loss	505 (5.84)	586 (5.27)	156 (6.05)	183 (6.50)	661 (5.89)	769 (5.54)
Low physical activity	7324 (59.66)	10,122 (79.04)	2694 (82.10)	3235 (92.06)	10,018 (64.77)	13,357 (81.93)
Frailty combined	1940 (17.94)	2925 (22.85)	1218 (37.36)	1626 (46.23)	3158 (22.37)	4551 (28.05)

of residence, richest wealth quintile, BMI and additional comorbidities were found to be significantly associated with frailty status of elderly people with DM. On adjusted analysis, significantly higher odds of having frailty were observed in those aged 75 and above (aOR = 1.85, 95% CI: 1.18, 2.91) and those having one or more additional comorbidities (aOR = 1.59, 95% CI: 1.03, 2.45). Those having secondary education (aOR = 0.41, 95% CI: 0.26, 0.65), graduate and above education (0.35, 95% CI: 0.19, 0.64), currently working (0.21, 95% CI: 0.12, 0.35), and normal (aOR = 0.38, 95% CI: 0.22, 0.68) to obese BMI (0.40, 95% CI: 0.19, 0.86) had significantly lower odds of having physical frailty.

Table 4 presents the mediated multivariable regression estimates of physical frailty. Sociodemographic characteristics were included as controls. The results showed that the total effect of DM on physical frailty, aOR = 1.26 (95% CI: 1.14, 1.39), could be decomposed into a direct effect, aOR = 1.25 (95% CI: 1.13, 1.38) and indirect effect, aOR = 1.01 (95% CI: 1.01, 1.02). This association was mediated by food insecurity (percent mediated: 3.60%). Similarly, elderly individuals who had DM had higher odds of having physical frailty (aOR = 1.27, 95% CI: 1.15, 1.40) than those who did not have DM, with the association mediated by additional comorbidities (indirect effect, aOR = 1.14, 95% CI: 1.11, 1.17); percent mediated: 54.83%). Among elderly people with DM, those having food insecurity had higher odds of having physical frailty (aOR = 1.31, 95% CI: 1.10, 1.56) than those were food secure. However, the association was not significantly mediated by BMI. Further, among elderly people with DM, females had higher odds of having physical frailty (aOR = 1.41, 95% CI: 1.19, 1.68) than males with additional comorbidities being the mediator (indirect effect, aOR = 1.04, 95% CI: 1.01, 1.06) with 10.61% of the effect being mediated.

Figure 1A shows the weighted prevalence of frailty among the elderly population ($N = 31,902$) across various states and union territories (UTs) of India. The highest prevalence of frailty was reported from Delhi (40.69%), followed by West Bengal (35.90%) and Kerala (31.68%). Similarly, Fig. 1B shows the weighted prevalence of frailty among elderly population with DM ($N = 4934$) with the highest prevalence observed in Delhi (47.23%), West Bengal (43.08%), and Arunachal Pradesh (38.16%).

Discussion

The present study explored the intersection of food insecurity, DM, and frailty in the geriatric population in India. The findings revealed that a substantial proportion (45.25%) of elderly individuals with DM in India experienced food insecurity. Furthermore, nearly one in four patients (24%) with DM were observed having frailty, comparatively higher than the estimates from previous literature [7, 21, 22]. The combination of food insecurity and DM is a significant concern since it has detrimental effects on the management of long-term health outcomes in this vulnerable population [23].

The overall prevalence of frailty was 22.37% in men and 28.05% in women, in line with previous evidence that females are more prone to frailty [24]. Further, weak grip strength and low physical activity were identified as the most prevalent components of frailty among males and females, respectively. These components are consistent with the Fried frailty phenotype scale and are indicative of reduced physical capacity and mobility.

In this study, age emerged as a significant predictor of frailty, with those aged 75 years and above having significantly higher odds of frailty. This finding is consistent with the well-established association between advancing age and frailty [25]. Furthermore, those having additional comorbidities were found to have higher odds of frailty, consistent with the evidence from previous studies [26, 27]. Higher education levels and current employment were associated with lower odds of frailty, highlighting the potential protective effects of education and remaining active in later life [28, 29].

The present study findings from the mediation analysis suggested the presence of DM was associated with an increased risk of frailty, with this association being partially mediated by food insecurity and additional comorbidities, underscoring the complex interplay between chronic

Table 3 Distribution of frailty status and its determinants among participants with DM ($N=4910$)

Variables	Absent ($N=3632$) n (weighted %)	Present ($N=1278$) n (weighted %)	Crude OR [95% CI]	Adjusted OR [95% CI]
Age (years)				
60–74	3079 (79.83)	894 (20.17)	Ref	Ref
75 and above	553 (60.59)	384 (39.41)	2.57 [1.89, 3.50] **	1.85 [1.18, 2.91] *
Sex				
Male	1942 (79.32)	536 (20.68)	Ref	Ref
Female	1690 (73.43)	742 (26.57)	1.38 [1.03, 1.86] *	1.10 [0.69, 1.76]
Education				
No education or less than primary	419 (68.35)	199 (31.65)	Ref	Ref
Primary complete	567 (81.37)	174 (18.63)	0.49 [0.31, 0.76] *	0.50 [0.29, 0.87]
Secondary	915 (85.91)	224 (14.09)	0.35 [0.20, 0.60] **	0.41 [0.26, 0.65] **
Higher	275 (78.68)	70 (21.32)	0.58 [0.33, 1.02]	0.63 [0.34, 1.17]
Graduate and above	329 (83.66)	72 (16.34)	0.42 [0.25, 0.69] *	0.35 [0.19, 0.64] *
Marital status				
Never married	26 (81.53)	6 (18.47)	Ref	-
Currently married	2573 (79.36)	736 (20.64)	1.14 [0.30, 4.30]	
Widowed/Divorced/Separated/Deserted	1033 (70.72)	536 (29.28)	1.82 [0.46, 7.13]	
Work Status				
Not working	1683 (71.03)	688 (28.97)	Ref	Ref
Currently Working	776 (91.09)	100 (8.90)	0.24 [0.17, 0.34] **	0.21 [0.12, 0.35] **
Place of Residence				
Rural	1561 (73.03)	587 (26.97)	Ref	Ref
Urban	2071 (79.13)	691 (20.87)	0.71 [0.53, 0.94] *	1.11 [0.75, 1.64]
MPCE Quintile				
Poorest	490 (71.52)	200 (28.48)	Ref	Ref
Poorer	600 (72.59)	220 (27.41)	0.94 [0.65, 1.36]	1.25 [0.68, 2.28]
Middle	709 (74.03)	255 (25.97)	0.88 [0.61, 1.25]	1.25 [0.68, 2.30]
Richer	836 (79.16)	286 (20.84)	0.66 [0.42, 1.03]	0.91 [0.50, 1.66]
Richest	997 (80.10)	317 (19.90)	0.62 [0.40, 0.95] *	0.90 [0.47, 1.74]
BMI (kg/m^2)				
Underweight	171 (50.85)	140 (49.15)	Ref	Ref
Normal	1523 (72.23)	575 (27.77)	0.39 [0.27, 0.57] **	0.38 [0.22, 0.68] *
Overweight	1066 (79.47)	364 (20.53)	0.26 [0.16, 0.42] **	0.34 [0.18, 0.63] *
Obese	332 (78.23)	194 (21.77)	0.28 [0.13, 0.59] *	0.40 [0.19, 0.86] *
Tobacco consumption				
No	2630 (77.52)	919 (22.48)	Ref	-
Yes	992 (73.00)	356 (27.00)	1.27, [0.97, 1.66]	
Alcohol use				
No	3079 (75.91)	1130 (24.09)	Ref	-
Yes	545 (78.75)	148 (21.25)	0.85 [0.61, 1.17]	
Additional Comorbidities				
None	840 (82.28)	198 (17.72)	Ref	Ref
1 or more	2792 (74.76)	1080 (25.24)	1.56 [1.16, 2.10] *	1.59 [1.03, 2.45] *
Food insecurity				
Food secure	2026 (77.69)	640 (22.31)	Ref	-
Food insecure	1606 (74.59)	638 (25.41)	1.18 [0.88, 1.59]	

Hosmer–Lemeshow test for goodness-of-fit, $P=0.6149$

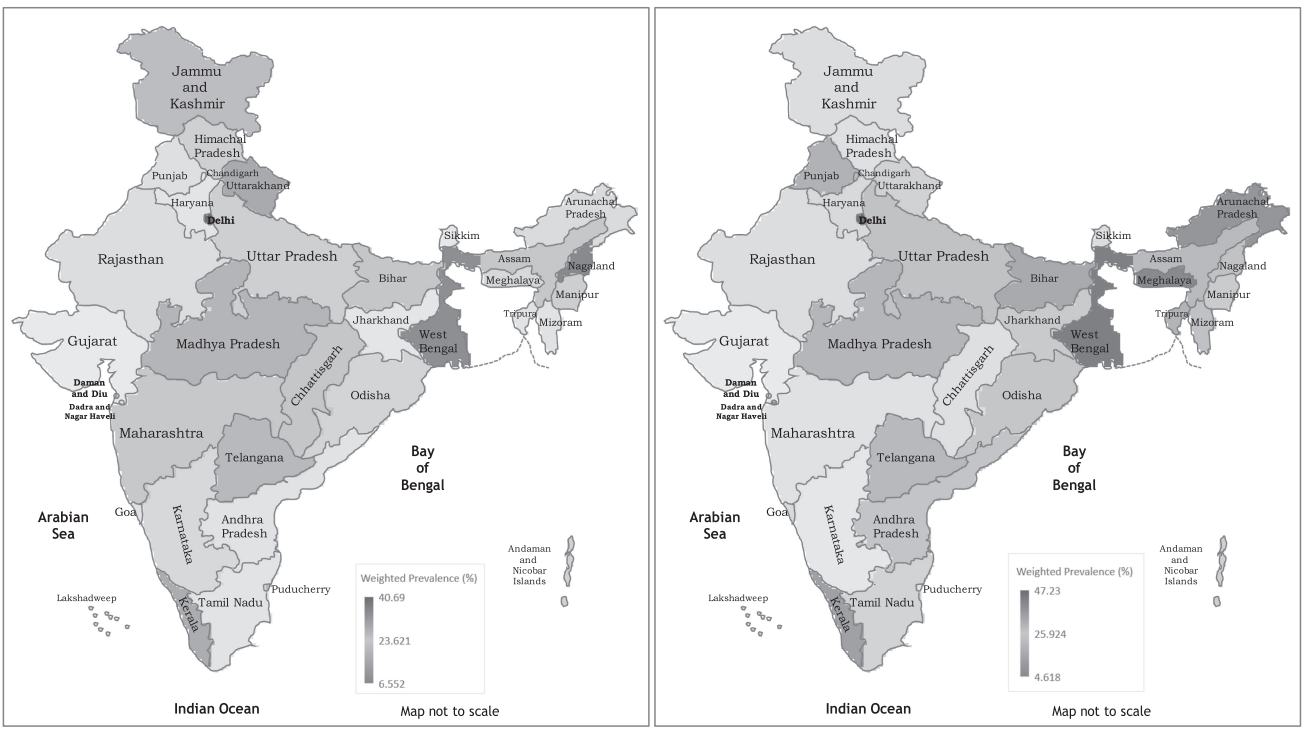
*$p<0.05$, **$p<0.001$

Table 4 Mediated multivariable regression estimates of physical frailty

Key exposure	Physical frailty Adjusted OR[a] [95% CI]	% of effect mediated
Diabetes		
Total effect	1.26 [1.14, 1.39] **	3.60
Direct effect	1.25 [1.13, 1.38] **	
Indirect effect of ***food insecurity (mediator)***	1.01 [1.01, 1.02] *	
Diabetes		
Total effect	1.27 [1.15, 1.40] **	54.83
Direct effect	1.11 [1.01, 1.23] *	
Indirect effect of ***additional comorbidities (mediator)***	1.14 [1.11, 1.17] **	
Food insecurity		
Total effect	1.31 [1.10, 1.56] **	NA
Direct effect	1.31 [1.10, 1.56] **	
Indirect effect of ***BMI (mediator)***	1.00 [0.998, 1.001]	
Sex		
Total effect	1.41 [1.19, 1.68] **	10.61
Direct effect	1.36 [1.14, 1.62] **	
Indirect effect of ***additional comorbidities (mediator)***	1.04 [1.01, 1.06] *	

[a]Adjusted for sociodemographic and lifestyle factors

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



A) Weighted prevalence of frailty among older adults

B) Weighted prevalence of frailty among older adults with DM

Fig. 1 Heat-map with frailty prevalence among older adults across Indian states and UTs. **A** Weighted prevalence of frailty among older adults. **B** Weighted prevalence of frailty among older adults with DM

conditions and frailty in older adults [30]. Furthermore, additional comorbidities among female patients with DM was acting as a mediator accentuating their risk of frailty.

The study's findings have important implications for healthcare policy and practice in India. Efforts to address food insecurity among elderly individuals with DM is crucial, as food insecurity was identified as a mediator of frailty. Furthermore, the high prevalence of food insecurity underscores the need for targeted interventions to ensure adequate access to nutritious food for this vulnerable population. Additionally, interventions targeting the management of comorbidities and the promotion of physical activity are essential in reducing frailty risk among this population and also improve glycemic control and promote overall health and well-being.

Our study possesses distinct strengths inclusive of the use of a nationally representative large sample data of older adults. We also utilized the well-established Fried frailty phenotype criteria, which enhances both the practical applicability of the study findings and their potential policy implications. The present study has certain limitations especially the reliance on a physical frailty phenotype scale in this study, which restricted our capacity to grasp the broader biopsychosocial perspective on frailty. Second, the causal relationships could be established due to the cross-sectional design of this study. Third, we employed various self-reported measures as potential predictor variables that are subject to the social desirability bias.

Conclusion

Approximately 25% of individuals diagnosed with DM in India exhibit frailty, which is characterized by diminished grip strength and reduced engagement in physical activities linked with reduced physical capacity and mobility in a social environment of widespread food insecurity. A multifaceted approach that considers sociodemographic, health-related, and environmental determinants in addressing frailty warrants urgent prioritization to ensure sustainable and improved health outcomes and quality of life for older individuals living with DM in India.

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Authors' contributions Conceptualization: Saurav Basu and Rutul Gokalani; Methodology: Saurav Basu and Vansh Maheshwari; Formal analysis: Vansh Maheshwari and Puja Samanta; Writing - original draft preparation: Vansh Maheshwari and Puja Samanta; Writing - review and editing: Saurav Basu and Rutul Gokalani. All authors read and approved the final manuscript.

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Data availability LASI Wave-1 datasets are available for use upon approval from IIPS (https://www.iipsindia.ac.in/lasi).

Declarations

Ethics approval The ethical approval for LASI survey was obtained from the Indian Council of Medical Research (ICMR), with written and informed consent being obtained from each respondent before participating in the survey. No separate ethical approval is required for this secondary data analysis, since the LASI Wave 1 dataset is an anonymous publicly available dataset including no identifiable information about the participants.

Conflict of interest The authors declare no conflict of interests.

References

1. Ageing and health n.d. https://www.who.int/news-room/fact-sheets/detail/ageing-and-health (Accessed 10 Jul 2023).
2. Ebrahimi Z, Wilhelmson K, Eklund K, Moore CD, Jakobsson A. Health despite frailty: Exploring influences on frail older adults' experiences of health. Geriatr Nur (Lond). 2013;34:289–94. https://doi.org/10.1016/j.gerinurse.2013.04.008.
3. García-Esquinas E, Graciani A, Guallar-Castillón P, López-García E, Rodríguez-Mañas L, Rodríguez-Artalejo F. Diabetes and risk of frailty and its potential mechanisms: a prospective cohort study of older adults. J Am Med Dir Assoc. 2015;16:748–54. https://doi.org/10.1016/j.jamda.2015.04.008.
4. Abd Ghafar MZA, O'Donovan M, Sezgin D, Moloney E, Rodríguez-Laso Á, Liew A, et al. Frailty and diabetes in older adults: Overview of current controversies and challenges in clinical practice. Front Clin Diabetes Healthc. 2022;3:895313. https://doi.org/10.3389/fcdhc.2022.895313.
5. Morley JE. Diabetes, Sarcopenia, and Frailty. Clin Geriatr Med. 2008;24:455–69. https://doi.org/10.1016/j.cger.2008.03.004.
6. Magliano DJ, Boyko EJ, IDF Diabetes Atlas 10th edition scientific committee. IDF DIABETES ATLAS. 10th ed. Brussels: International Diabetes Federation; 2021.
7. Kong L-N, Lyu Q, Yao H-Y, Yang L, Chen S-Z. The prevalence of frailty among community-dwelling older adults with diabetes: A meta-analysis. Int J Nurs Stud. 2021;119:103952. https://doi.org/10.1016/j.ijnurstu.2021.103952.
8. Bawadi HA, Ammari F, Abu-Jamous D, Khader YS, Bataineh S, Tayyem RF. Food insecurity is related to glycemic control deterioration in patients with type 2 diabetes. Clin Nutr. 2012;31:250–4. https://doi.org/10.1016/j.clnu.2011.09.014.
9. Wu T-Y, Bessire R, Ford O, Rainville AJ, Man Chong C, Caboral-Stevens M. Food Insecurity and Diabetes: An Investigation of Underserved Asian Americans in Michigan. Health Promot Pract. 2022;23:67S-75S. https://doi.org/10.1177/15248399221116088.
10. Chaudhary M. Association of food insecurity with frailty among older adults in India. J Public Health. 2018;26:321–30. https://doi.org/10.1007/s10389-017-0866-4.
11. Muhammad T, Saravanakumar P, Sharma A, Srivastava S, Irshad CV. Association of food insecurity with physical frailty among older adults: study based on LASI, 2017–18. Arch Gerontol Geriatr. 2022;103:104762. https://doi.org/10.1016/j.archger.2022.104762.
12. Pérez-Zepeda MU, Castrejón-Pérez RC, Wynne-Bannister E, García-Peña C. Frailty and food insecurity in older adults. Public

Health Nutr. 2016;19:2844–9. https://doi.org/10.1017/S1368980016000987.
13. Chen H, Huang X, Dong M, Wen S, Zhou L, Yuan X. The Association Between Sarcopenia and Diabetes: From Pathophysiology Mechanism to Therapeutic Strategy. Diabetes Metab Syndr Obes. 2023;16:1541–54. https://doi.org/10.2147/DMSO.S410834.
14. Ruan H, Hu J, Zhao J, Tao H, Chi J, Niu X, et al. Menopause and frailty: a scoping review. Menopause. 2020;27:1185. https://doi.org/10.1097/GME.0000000000001612.
15. Thillainadesan J, Scott IA, Le Couteur DG. Frailty, a multisystem ageing syndrome. Age Ageing. 2020;49:758–63. https://doi.org/10.1093/ageing/afaa112.
16. Longitudinal Ageing Study in India- LASI Wave-1 Report along with India & States/UTs Fact Sheets | Ministry of Health and Family Welfare | GOI n.d. https://main.mohfw.gov.in/newshighlights-33 (Accessed 30 Jul 2023).
17. Fried LP, Tangen CM, Walston J, Newman AB, Hirsch C, Gottdiener J, et al. Frailty in older adults: evidence for a phenotype. J Gerontol A Biol Sci Med Sci. 2001;56:M146-156. https://doi.org/10.1093/gerona/56.3.m146.
18. A healthy lifestyle - WHO recommendations n.d. https://www.who.int/europe/news-room/fact-sheets/item/a-healthy-lifestyle---who-recommendations (Accessed 10 May 2023).
19. Karlson KB, Holm A. Decomposing primary and secondary effects: A new decomposition method. Res Soc Stratif Mobil. 2011;29:221–37. https://doi.org/10.1016/j.rssm.2010.12.005.
20. Kohler U, Karlson K, Holm A. Comparing Coefficients of Nested Nonlinear Probability Models. Stata J 2011;11. https://doi.org/10.1177/1536867X1101100306.
21. Zeng X, Jia N, Meng L, Shi J, Li Y, Hu X, et al. A study on the prevalence and related factors of frailty and pre-frailty in the older population with diabetes in China: A national cross-sectional study. Front Public Health. 2022;10:996190. https://doi.org/10.3389/fpubh.2022.996190.
22. Kang S, Oh TJ, Cho BL, Park YS, Roh E, Kim HJ, et al. Sex differences in sarcopenia and frailty among community-dwelling Korean older adults with diabetes: The Korean Frailty and Aging Cohort Study. J Diabetes Investig. 2021;12:155–64. https://doi.org/10.1111/jdi.13348.
23. Gundersen C, Ziliak JP. Food Insecurity And Health Outcomes. Health Aff (Millwood). 2015;34:1830–9. https://doi.org/10.1377/hlthaff.2015.0645.
24. Kane AE, Howlett SE. Sex differences in frailty: Comparisons between humans and preclinical models. Mech Ageing Dev. 2021;198:111546. https://doi.org/10.1016/j.mad.2021.111546.
25. Frailty in Older People. Lancet. 2013;381:752–62. https://doi.org/10.1016/S0140-6736(12)62167-9.
26. Sinclair AJ, Abdelhafiz AH. Multimorbidity, Frailty and Diabetes in Older People-Identifying Interrelationships and Outcomes. J Pers Med. 2022;12:1911. https://doi.org/10.3390/jpm12111911.
27. Wang Y, Li R, Yuan L, Yang X, Lv J, Ye Z, et al. Association between diabetes complicated with comorbidities and frailty in older adults: A cross-sectional study. J Clin Nurs. 2023;32:894–900. https://doi.org/10.1111/jocn.16442.
28. Hoogendijk EO, van Hout HPJ, Heymans MW, van der Horst HE, Frijters DHM, Broese van Groenou MI, et al. Explaining the association between educational level and frailty in older adults: results from a 13-year longitudinal study in the Netherlands. Ann Epidemiol. 2014;24:538-544e2. https://doi.org/10.1016/j.annepidem.2014.05.002.
29. Sobhani A, Sharifi F, Fadayevatan R, Kamrani AAA, Moodi M, Khorashadizadeh M, et al. Low physical activity is the strongest factor associated with frailty phenotype and frailty index: data from baseline phase of Birjand Longitudinal Aging Study (BLAS). BMC Geriatr. 2022;22:498. https://doi.org/10.1186/s12877-022-03135-y.
30. Mangin D, Lawson J, Risdon C, Siu HYH, Packer T, Wong ST, et al. Association between frailty, chronic conditions and socioeconomic status in community-dwelling older adults attending primary care: a cross-sectional study using practice-based research network data. BMJ Open. 2023;13:e066269. https://doi.org/10.1136/bmjopen-2022-066269.