International Journal of Community Medicine and Public Health
Reddy SV et al. Int J Community Med Public Health. 2026 Apr;13(4):1719-1725
http://www.ijcmph.com
pISSN 2394-6032 | eISSN 2394-6040

DOI: https://dx.doi.org/10.18203/2394-6040.ijcmph20260810

Original Research Article

Intrinsic capacity, frailty, fall risk and environmental setting among older adults in India

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Received: 01 March 2026
Accepted: 18 March 2026

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ABSTRACT

Background: Falls are a major cause of disability in India's ageing population. The World Health Organization emphasizes maintaining intrinsic capacity (IC) and preventing frailty in older adults. However, urban–rural differences in these associations remain underexplored. This study examined the relationships among IC, frailty, and fall risk in older Indian adults, including urban–rural differences.
Methods: We performed a cross-sectional analysis using Wave 1 (2017–2018) data from the Longitudinal Ageing Study in India (LASI), including 31,902 individuals aged ≥60 years. IC was measured using a composite score (0–10) across five WHO-ICOPE domains, and frailty was assessed using the Fried phenotype. Multivariable logistic regression accounts for complex survey design and covariates, estimated adjusted odds ratios (aORs) for falls, high IC, and frailty.
Results: Fall prevalence was higher in rural areas (12.5%) than in urban areas (9.5%; p<0.001). Urban residence was associated with lower odds of falling (aOR 0.73; 95% CI 0.67–0.80) and higher odds of high IC (aOR 1.91; 95% CI 1.78–2.05). High IC was associated with lower odds of falling (aOR 0.80; 95% CI 0.67–0.96), while frailty increased fall risk (aOR 1.24; 95% CI 1.10–1.40). Depression and multimorbidity, which refers to the presence of multiple chronic health conditions, were associated with lower independence in daily activities (IC) and higher frailty.
Conclusions: IC and frailty contribute to fall risk among older adults in India, with urban–rural differences suggesting an important role for environmental context.

Keywords: Aging, Frailty, Intrinsic capacity, Falls, LASI, Urban–rural disparities

INTRODUCTION

India's older population is growing rapidly. By 2050, an estimated 320 million Indians (about 20% of the population) will be aged 60 years or older.[1] This demographic transition increases the burden of geriatric syndromes, particularly falls, which are a major cause of functional decline and unintentional injury. Approximately 37 million falls each year require medical attention.[2,3] Falls often lead to injury, loss of independence, fear of falling, and a cycle of reduced mobility that can precipitate functional decline and frailty.[4]

Frailty is a common geriatric condition linked to falls and other adverse outcomes and reflects increased vulnerability due to age-related declines across multiple physiological systems.[6] In this study, frailty is conceptualized using the physical frailty phenotype proposed by Fried et al, comprising unintentional weight loss, self-reported exhaustion, low physical activity, slow gait speed, and weak grip strength.[7] Prior studies in India report that approximately 25–30% of older adults are frail, and more than half are pre-frail, with consistent risk factors including female sex, advanced age, undernutrition, and chronic illness.[5,8]

Frailty and falls frequently co-occur. Using LASI data, one cross-sectional analysis reported higher odds of falls and multiple falls among frail older adults compared with non-frail peers.[9] These findings support the value of frailty assessment for identifying older adults at elevated fall risk.

In recent years, the World Health Organization (WHO) has promoted a function-centered approach to ageing, emphasizing intrinsic capacity (IC) and functional ability.[2,11] Intrinsic capacity represents the composite of an individual's physical and mental capacities across domains, including locomotion, cognition, vitality, sensory function, and psychological health.[10] The WHO integrated care for older people (ICOPE) framework uses IC to guide community-level interventions aimed at maintaining function and delaying dependency.[10] Higher intrinsic capacity has been associated with lower risks of functional decline, disability, and mortality.[11,13] However, IC is a relatively new construct, and evidence from low- and middle-income countries remains limited.[13] India's large and diverse older population provides an important context to examine IC alongside frailty and fall outcomes.

One important aspect of aging in India is the disparity between urban and rural areas. While urban older adults typically have greater access to healthcare and education, they also bear a greater burden of lifestyle-related chronic diseases, such as obesity and inactivity.[13,14] Rural older adults may continue to be physically active through manual labor, but they face greater environmental risks and have less access to healthcare.[15] Previous research indicates that fall patterns vary across these environments, with older adults in rural areas frequently reporting higher fall rates despite lower prevalence of diagnosed diseases. This could be due to underdiagnosis and increased exposure to environmental factors.[8,15]

Although they are related, frailty and intrinsic capacity are not the same thing. Whereas intrinsic capacity represents retained functional potential, frailty represents accumulated vulnerability. A more thorough understanding of fall risk can be obtained by combining the two constructs, especially in contexts where environmental conditions vary between urban and rural areas. However, evidence linking falls, frailty, and intrinsic capacity in the Indian population remains lacking. Closing this gap could clarify how living conditions and functional health interact to affect fall outcomes in later life.

Thus, the purpose of this study was to investigate the relationships among fall risk, frailty, and intrinsic capacity in older adults in India, with special attention to urban–rural variations.

We specifically calculated the prevalence of falls, frailty, and high intrinsic capacity; identified sociodemographic and health-related factors associated with falls and intrinsic capacity; and assessed the separate relationships between fall risk and frailty and between fall risk and intrinsic capacity.

METHODS

This research utilized cross-sectional data from Wave 1 (2017–2018) of the LASI, a nationally representative survey of individuals aged 45 years and older, executed through multistage stratified cluster sampling across Indian states and union territories (excluding Sikkim). This analysis was limited to respondents aged 60 years and older. Publicly available individual and biomarker datasets were combined for analysis. The final analytic sample included 31,902 older adults (15,340 men and 16,562 women) after excluding those without data on falls, intrinsic capacity, or frailty.

The Indian Council of Medical Research and the Institutional Review Board of the International Institute for Population Sciences in Mumbai approved the LASI protocol. Participants provided written consent. The present secondary analysis utilized de-identified data.

Study variables

IC was constructed as a composite score ranging from 0 to 10 based on five domains aligned with the WHO ICOPE framework: locomotion, cognition, vitality, sensory function, and psychological health. Each domain contributed equally (0–2 points). For regression analyses, IC was categorized as high (score ≥9) and low (<9). Frailty was assessed using the Fried physical frailty phenotype, which includes five components: unintentional weight loss, exhaustion, low physical activity, slow gait speed, and weak grip strength. Each component was coded as present or absent, and the counts were summed (range 0–5). Participants were categorized as robust (0 components), pre-frail (1–2 components), or frail (≥3 components). Falls were assessed by self-report of any fall in the preceding two years. The primary outcome was dichotomized as no fall versus at least one fall.

Sociodemographic variables included age group, sex, education, region, religion, living arrangement, place of residence (urban/rural), and monthly per capita consumption expenditure (MPCE) quintile. Health-related variables included the number of chronic conditions and depressive symptoms.

Statistical analysis

All analyses accounted for complex survey design and sampling weights to generate nationally representative estimates. Descriptive statistics are presented as frequencies and weighted percentages. Differences between urban and rural groups were assessed using chi-square tests. Multivariable logistic regression models were fitted to examine factors associated including: any fall, high intrinsic capacity, and frailty status. Adjusted odds ratios (aORs) with 95% confidence intervals (CIs) were reported. Statistical significance was set at $p<0.05$. All analyses were performed using Stata version 16 (StataCorp, College Station, TX, USA) and R version 4.0.

RESULTS

A total of 31,902 adults aged ≥60 years were included in the analysis. Of these, 66.1% resided in rural areas and 33.9% in urban areas (Table 1). The sample was 51.9% female. The mean age was 68.5 years (SD 7.4); 58.7% were aged 60–69 years, 30.1% were aged 70–79 years, and 11.2% were aged ≥80 years. Significant differences were observed between rural and urban participants across several sociodemographic variables. Educational attainment was substantially lower in rural areas, where 63.8% had no schooling compared with 34.5% in urban areas (p<0.001). Urban respondents had higher proportions with secondary and graduate-level education. Regional distribution also differed by residence. Living arrangements were similar across settings, with approximately 89% living with a spouse or children in both rural and urban areas.

Health characteristics differed significantly by place of residence (Table 2). Urban older adults reported a higher prevalence of chronic conditions and multimorbidity than rural participants (p<0.05). In contrast, depressive symptoms were more prevalent in rural areas (9.17%) than in urban areas (6.75%) (p<0.05). MPCE quintiles were similarly distributed proportionally across rural and urban groups, although absolute expenditure levels differed between settings.

Overall, 11.43% of respondents reported at least one fall in the previous two years (Table 3). Fall prevalence was higher in rural areas (12.46%) than in urban areas (9.47%) (p<0.001). High intrinsic capacity (IC≥9) was observed in 31.7% of participants. A higher proportion of urban older adults had high IC than rural older adults (36.37% versus 18.25%; p<0.001). Regarding frailty status, 14.51% were robust, 72.13% pre-frail, and 13.36% frail. Frailty prevalence was similar between rural (13.70%) and urban (12.71%) groups; however, rural participants had a higher proportion classified as robust, whereas urban participants had a higher proportion classified as pre-frail.

Cramér's V analysis showed modest associations between intrinsic capacity and frailty (V≈0.16), frailty and falls (V≈0.16), and intrinsic capacity and falls (V≈0.12) (Figure 1).

Multivariable logistic regression results are presented in Table 4. Urban residence was associated with lower odds of falling compared with rural residence (aOR 0.73; 95% CI 0.67–0.80; p<0.001). Female sex was independently associated with higher fall risk (aOR 1.33; 95% CI 1.22–1.44; p<0.001). Participants aged ≥80 years had higher odds of falling compared with those aged 60–69 years (aOR 1.18; 95% CI 1.04–1.33; p=0.008).

Table 1: Baseline sociodemographic characteristics of study participants by place of residence.

Characteristic	Category	Overall, N (%)	Rural, N (%)	Urban, N (%)
Total sample		31,902 (100.0)	21,085 (66.09)	10,817 (33.91)
Sex	Male	15,340 (48.08)	10,283 (48.74)	5,057 (46.81)
	Female	16,562 (51.92)	10,802 (51.26)	5,760 (53.19)
Age group (years)	60–69	18,043 (58.71)	11,872 (56.40)	6,171 (56.86)
	70–79	9,250 (30.10)	6,037 (28.66)	3,213 (29.65)
	≥80	3,441 (11.20)	2,387 (11.34)	1,054 (9.72)
Education	No schooling	17,190 (53.88)	13,464 (63.82)	3,726 (34.51)
	Less than primary	3,835 (12.02)	2,456 (11.65)	1,379 (12.75)
	Primary to higher secondary/diploma	9,558 (29.96)	4,851 (23.02)	4,707 (43.49)
	Graduate and above	1,319 (4.13)	318 (1.51)	1,001 (9.25)
Geographic region	North	5,812 (18.22)	3,789 (17.97)	2,023 (18.71)
	North East	4,190 (13.13)	3,171 (15.04)	1,019 (9.41)
	East	5,757 (18.05)	4,368 (20.72)	1,389 (12.84)
	Central	4,262 (13.36)	3,360 (15.93)	902 (8.35)
	West	4,303 (13.49)	2,226 (10.55)	2,077 (19.22)
	South	7,578 (23.75)	4,179 (19.80)	3,399 (31.47)
Religion	Hindu	23,292 (73.16)	15,630 (74.10)	7,662 (70.88)
	Muslim	3,731 (11.72)	1,990 (9.44)	1,741 (16.09)
	Christian	3,194 (10.03)	2,281 (10.82)	913 (8.43)
	Sikh	979 (3.08)	693 (3.29)	286 (2.63)
	Other	641 (2.01)	438 (2.08)	203 (1.88)
Living arrangement	Living alone	1,630 (5.11)	1,160 (5.50)	470 (4.35)
	With spouse/children	28,507 (89.36)	18,774 (89.06)	9,733 (89.93)
	Extended/joint family	1,765 (5.53)	1,148 (5.44)	617 (5.72)

Table 2: Health and socioeconomic characteristics by place of residence.

Characteristic	Category	Overall, N (%)	Rural, N (%)	Urban, N (%)
Chronic conditions	No disease	14,579 (45.70)	10,969 (52.03)	3,610 (33.35)
	1 disease	16,548 (51.87)	9,770 (46.36)	6,778 (62.61)
	≥2 diseases	775 (2.43)	339 (1.61)	436 (4.03)
Depression	No	29,239 (91.65)	19,136 (90.83)	10,103 (93.25)
	Yes	2,663 (8.35)	1,935 (9.17)	728 (6.75)
MPCE quintile	Q1 (poorest)	6,512 (20.45)	4,309 (20.45)	2,203 (20.98)
	Q2 (poorer)	6,547 (20.52)	4,328 (20.52)	2,219 (21.10)
	Q3 (middle)	6,554 (20.56)	4,336 (20.56)	2,218 (21.07)
	Q4 (richer)	6,293 (19.74)	4,160 (19.74)	2,133 (20.29)
	Q5 (richest)	5,976 (18.73)	3,946 (18.73)	2,030 (19.34)

Table 3: Distribution of primary outcome variables overall and by place of residence.

Outcome Variable	Category	Overall, N (%)	Rural, N (%)	Urban, N (%)
Fall occurrence (n=28,706)	No fall	25,424 (88.57)	18,450 (87.54)	6,974 (90.53)
	Any fall in the past 2 years	3,282 (11.43)	2,635 (12.46)	647 (9.47)
Intrinsic capacity (n=24,543)	Normal/Low IC	16,762 (68.30)	12,933 (81.75)	3,829 (63.63)
	High IC (≥9)	7,781 (31.70)	2,883 (18.25)	4,898 (36.37)
Frailty status (n=30,705)	Non-frail (0 components)	4,455 (14.51)	3,459 (16.41)	996 (10.78)
	Pre-frail (1–2 components)	22,147 (72.13)	14,747 (69.89)	7,400 (76.51)
	Frail (≥3 components)	4,103 (13.36)	2,890 (13.70)	1,213 (12.71)

Table 4: Risk factors for experiencing any fall in the past 2 years using multivariable logistic regression.

Variables	Category	Fall	High_IC	Frailty (0 versus 1)	Frailty (0 versus 2)
Place of residence (rural)	Urban	0.73 (0.67-0.80), <0.001	1.91 (1.78-2.05), <0.001	1.58 (1.45-1.72), <0.001	1.37 (1.20-1.56), <0.001
Region (North)	North East	0.79 (0.66-0.95), 0.013	1.01 (0.89-1.16), 0.839	0.80 (0.69-0.92), 0.001	0.65 (0.51-0.83),<0.001
Region (North)	East	2.02 (1.77-2.30), <0.001	0.86 (0.77-0.96), 0.007	1.07 (0.95-1.21), 0.293	1.64 (1.36-1.99), <0.001
Region (North)	Central	1.47 (1.27-1.70), <0.001	0.82 (0.73-0.93), 0.002	0.95 (0.83-1.08), 0.419	1.37 (1.12-1.68), 0.002
Region (North)	West	1.67 (1.45-1.92), <0.001	1.17 (1.04-1.32), 0.008	0.75 (0.66-0.85), <0.001	0.87 (0.71-1.07), 0.177
Region (North)	South	0.97 (0.85-1.12), 0.712	1.44 (1.30-1.60), <0.001	0.96 (0.86-1.08), 0.531	1.33 (1.11-1.60), 0.002
Age group (60-69)	70-79	1.05 (0.96-1.14), 0.277	0.48 (0.44-0.51), <0.001	1.95 (1.80-2.12), <0.001	5.02 (4.48-5.64), <0.001
Age group (60-69)	>= 80	1.18 (1.04-1.33), 0.008	0.21 (0.18-0.24), <0.001	4.85 (3.98-5.91), <0.001	28.78 (23.07-35.89), <0.001
N diseases (0 diseases)	1	1.21 (1.12-1.31), <0.001	1.17 (1.10-1.25), <0.001	1.55 (1.44-1.66), <0.001	2.46 (2.20-2.76), <0.001
N diseases (0 diseases)	2 or more	1.80 (1.43-2.27), <0.001	0.86 (0.70-1.06), 0.166	2.22 (1.63-3.04), <0.001	5.77 (3.91-8.52), <0.001
Depression (no)	Yes	1.74 (1.55-1.96), <0.001	0.12 (0.10-0.15), <0.001	1.29 (1.12-1.48), <0.001	2.52 (2.10-3.02), <0.001
Living (alone)	Spouse/ Children	0.96 (0.81-1.13), 0.602	1.26 (1.07-1.48), 0.005	1.12 (0.94-1.33), 0.204	0.83 (0.65-1.05), 0.127
Living (alone)	Others	1.03 (0.82-1.29), 0.812	1.02 (0.82-1.27), 0.869	1.25 (0.98-1.60), 0.069	1.21 (0.87-1.69), 0.252
Religion (Hindu)	Muslim	0.85 (0.75-0.97), 0.013	1.01 (0.91-1.11), 0.871	1.36 (1.21-1.54), <0.001	1.33 (1.11-1.58), 0.002

Continued.

Variables	Category	Fall	High_IC	Frailty (0 versus 1)	Frailty (0 versus 2)
Religion (Hindu)	Christian	0.82 (0.69-0.96), 0.016	0.84 (0.74-0.94), 0.004	0.86 (0.76-0.97), 0.018	0.68 (0.55-0.85), 0.001
Religion (Hindu)	Sikh	2.00 (1.63-2.47), <0.001	1.25 (1.04-1.51), 0.020	0.98 (0.79-1.21), 0.839	0.79 (0.56-1.12), 0.189
Religion (Hindu)	Other	0.88 (0.65-1.20), 0.423	1.17 (0.92-1.49), 0.189	1.12 (0.87-1.44), 0.375	1.02 (0.68-1.51), 0.944

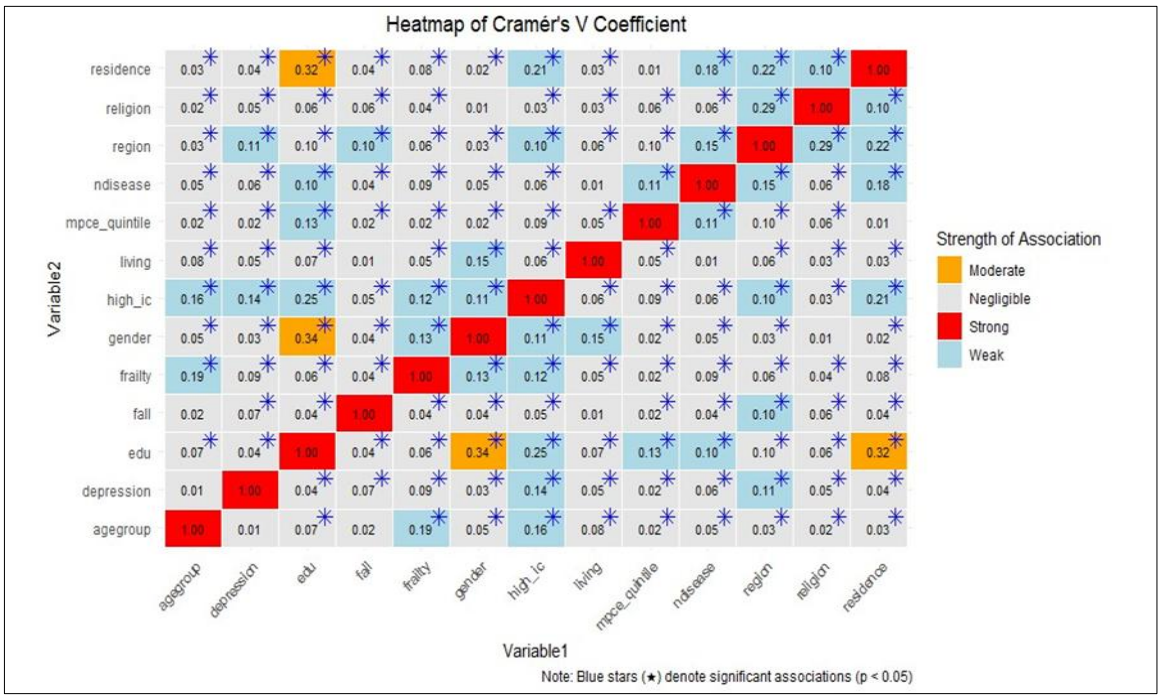

Figure 1: Heatmap of Cramér's V association coefficients among key variables.

Depressive symptoms were strongly associated with falls (aOR 1.74; 95% CI 1.55–1.96; p<0.001). Having one chronic condition was associated with slightly increased odds of falling (aOR 1.21; 95% CI 1.12–1.31; p<0.001), while multimorbidity showed a higher point estimate (aOR 1.80; 95% CI 1.43–2.27; p<0.001). In supplementary models, high intrinsic capacity was associated with lower odds of falling (aOR 0.80; 95% CI 0.67–0.96; p=0.017). Frailty was associated with increased fall risk compared with robust status (aOR 1.24; 95% CI 1.10–1.40; p<0.001).

Urban residence was strongly associated with higher odds of high intrinsic capacity (aOR 1.91; 95% CI 1.78–2.05; p<0.001). Increasing age was inversely associated with high IC. Compared with individuals aged 60–69 years, those aged 70–79 years (aOR 0.48; 95% CI 0.44–0.51; p<0.001) and ≥80 years (aOR 0.21; 95% CI 0.18–0.24; p<0.001) had significantly lower odds of high IC. Female sex was associated with lower odds of high IC (aOR 0.87; 95% CI 0.82–0.94; p<0.001). Higher education and higher MPCE quintile were positively associated with high IC. Multimorbidity and depressive symptoms were strongly inversely associated with high IC. Frailty was strongly associated with increasing age and female sex. Compared with those aged 60–69 years, individuals aged ≥80 years had substantially higher odds of frailty (aOR 28.78; 95% CI 23.07–35.89; p<0.001). Female participants had higher odds of frailty compared with males. Urban residence was associated with higher odds of pre-frailty and frailty after adjustment. Multimorbidity and depressive symptoms were significant predictors of frailty in adjusted models.

DISCUSSION

This nationally representative study examined the interrelationships among intrinsic capacity, frailty, environmental setting, and fall risk among older adults in India. Several key findings emerged from this analysis.

First, there were big differences between cities and rural areas in both intrinsic capacity and fall rates. Older people who lived in cities were more likely to exhibit high intrinsic capacity, while those who lived in the country were more likely to fall. These results indicate that environmental context may significantly influence functional health outcomes in later life. Urban areas may offer structural benefits, such as better access to healthcare, support services, and infrastructure that help people maintain their functional capacity. Conversely, rural settings may expose older adults to heightened

environmental risks and limited access to preventive services, potentially increasing fall risk.[8,15]

Second, intrinsic capacity and frailty, while interconnected, exhibited distinct correlations with fall risk. Greater intrinsic capacity was independently associated with reduced fall risk, whereas frailty was associated with an increased risk of falling. These results are consistent with previous studies that demonstrate that maintained mobility, strength, cognition, and sensory function serve as protective factors against falls. Simultaneously, frailty—defined by weakness, fatigue, and diminished physiological reserve—has been consistently associated with negative outcomes, including falls. Our findings endorse the synergistic significance of evaluating both intrinsic capacity and frailty in assessing fall risk among older adults.

Third, depressive symptoms were identified as one of the most significant correlations of both fall risk and diminished intrinsic capacity. Depression was correlated with an increased likelihood of falling and a significantly diminished likelihood of high intrinsic capacity. These results align with prior research associating depressive symptoms with compromised mobility, diminished physical activity, and functional deterioration.[8,17] The findings underscore the necessity of incorporating mental health evaluation into geriatric risk screening protocols.

Sociodemographic factors exhibited significant correlations. Being female and older were both linked to a higher risk of falling and frailty, which is in line with previous research from India and other countries. Education and socioeconomic status were both associated with a higher intrinsic capacity and a lower risk of frailty, demonstrating how social factors can affect functional health in later life. These results indicate that functional aging is influenced not only by biological mechanisms but also by enduring social and economic exposures.

Interestingly, living in a city was associated with both a higher intrinsic capacity and a higher adjusted risk of frailty. This pattern shows that intrinsic capacity and frailty are distinct. Older adults may maintain functional capacity in certain domains while concurrently fulfilling frailty criteria. This difference makes it even more important to examine positive and deficit-based measures separately rather than assuming they are the same.

The overall two-year fall prevalence of about 11% in this nationally representative sample is lower than estimates reported in hospital-based or shorter recall studies in India.[8,18] This variation may be attributed to disparities in the sampling frame, the recall period, and the measurement methodology.

Strengths and limitations

This study reveals several intriguing findings. It employs a substantial, nationally representative dataset featuring standardized assessments of intrinsic capacity and frailty. The analysis accounted for intricate survey design and various confounding variables, thereby facilitating reliable population-level estimates. Nonetheless, various limitations must be acknowledged. The cross-sectional design prevents causal inference. Falls were self-reported and susceptible to recall bias. We used available LASI variables to measure intrinsic capacity, but these may not cover all WHO ICOPE domains. Furthermore, environmental characteristics were assessed using urban–rural residence as a proxy, excluding comprehensive built-environment variables. Longitudinal analyses utilizing subsequent LASI waves are essential to elucidate the temporal relationships among intrinsic capacity, frailty, and fall risk.

Public health implications

These results underscore the need to integrate evaluations of both intrinsic capacity and frailty into geriatric screening methodologies. The difference in fall risk between urban and rural areas suggests that fall prevention efforts should account for the environmental context. Interventions designed to preserve functional capacity, mitigate frailty, and incorporate mental health support may enhance healthier aging trajectories in India.

CONCLUSION

In this nationally representative study of older adults in India, intrinsic capacity and frailty were independently linked to fall risk, revealing significant disparities between urban and rural environments. Greater intrinsic capacity was associated with reduced fall risk, whereas frailty and depressive symptoms were associated with heightened fall risk. Older adults living in rural areas had more falls, even though they had fewer diagnosed diseases. This suggests that the environment may play a role. These results highlight the importance of incorporating functional capacity and frailty assessments into geriatric care frameworks and advocate for context-sensitive fall-prevention strategies in India.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Reddy SV, Ganna AK, Shivaprasad R. Intrinsic capacity, frailty, fall risk and environmental setting among older adults in India. Int J Community Med Public Health 2026;13:1719-25.