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ORIGINAL RESEARCH

Frailty as a Predictor of Falls in Older Adults with Type 2 Diabetes: Evidence from Vietnam

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Background: Frailty and falls significantly impact the health and quality of life of older adults with type 2 diabetes (T2D), increasing morbidity and dependency. However, their association in Vietnamese populations remains understudied. This study aimed to examine the association between frailty and fall risk and identify additional fall-related factors among older Vietnamese outpatients with T2D.

Methods: A cross-sectional study was conducted among 740 outpatients with T2D aged ≥60 years at a geriatric hospital in Hanoi, Vietnam, from March 2024 to December 2024. Fall risk was assessed using the 21-item Fall Risk Index (21-FRI), and frailty was determined by the Clinical Frailty Scale (CFS). Four multivariable logistic regression models evaluated frailty's association with falls, adjusting for demographics, diabetes-related factors, and geriatric syndromes.

Results: Among 740 older participants with T2D, 17.8% were frail, and 16.8% reported at least one fall in the past year. Frailty was strongly associated with a higher fall rate ($p<0.001$). In the fully adjusted logistic regression model, frailty emerged as a powerful and independent predictor of falls, increasing the odds by over four-fold (AOR 4.47, 95% CI 2.00–5.29). Other significant risk factors included advanced age, poor glycemic control, diabetic complications, and co-existing geriatric syndromes (depression, urinary incontinence, cognitive impairment, and sarcopenia).

Conclusion: Routine frailty screening should be integrated into T2D care to identify high-risk older adults and implement tailored fall prevention strategies.

Keywords: frailty, falls, fall risk, type 2 diabetes, older adults, Vietnam, geriatric syndromes

Introduction

Vietnam is experiencing one of the fastest rates of population aging globally, with individuals aged 60 and older comprising 11.9% of the population in 2023, projected to reach 17.9% by 2030.[1] This demographic shift has amplified the burden of chronic diseases, particularly type 2 diabetes (T2D), which affects approximately 7.3% of Vietnamese adults, with higher prevalence among older individuals.[2] The convergence of aging and T2D poses significant challenges to public health, increasing the risk of complications and reducing quality of life.

Falls are a leading cause of morbidity and mortality among older adults, with approximately 28% of individuals aged 65 and older experiencing at least one fall annually.[3] Older adults with T2D face a 59% higher risk of falls compared to their non-diabetic peers, driven by complications such as peripheral neuropathy, diabetic retinopathy, and autonomic dysfunction.[4] Peripheral neuropathy impairs sensory feedback and balance, while retinopathy diminishes visual acuity, increasing the likelihood of missteps.[5] Additionally, cardiovascular autonomic neuropathy can cause orthostatic hypotension, leading to dizziness and falls.[6] Furthermore, T2DM-associated cardiovascular pathologies can accelerate cognitive

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decline, which in turn impairs hazard perception and judgment, further increasing fall risk.[7] These diabetes-related impairments, combined with age-related declines, create a complex interplay that heightens fall risk.

Frailty, characterized by reduced physiological reserve and multisystem deterioration, further exacerbates fall risk in older adults with T2D.[8] Frailty compromises muscle strength, balance, and resilience, amplifying the impact of diabetic complications. Despite its significance, the relationship between frailty and falls in T2D patients remains understudied, particularly in low- and middle-income countries (LMIC) like Vietnam, where healthcare systems face unique challenges in managing aging populations.[9] The challenges are compounded by constrained geriatric capacity, as Vietnam has a single national geriatric hospital and geriatric departments in 49 out of 62 provinces, totaling 106 departments nationwide.[10] Furthermore, consistently elevated out-of-pocket health expenditures (approximately 41% of total health expenditure in 2016) may restrict access to multifactorial fall-prevention and rehabilitation services.[11] Prior studies have primarily focused on Western populations, leaving a critical gap in understanding frailty and falls in Asian contexts with distinct genetic, lifestyle, and healthcare access factors.[12]

Despite growing evidence linking frailty and falls in older adults with T2D globally, data in the Vietnamese population remain scarce. Moreover, a recent study among older Vietnamese rural community-dwellers revealed insufficient knowledge and only moderate attitudes and actions regarding fall prevention among older adults, highlighting substantial gaps in fall prevention.[13]

This study aimed to examine the association between frailty and risk of falls and identify fall-related factors among older Vietnamese patients with T2D. These findings could guide the development of tailored fall prevention strategies in Vietnam's rapidly aging population.

Methods

Study Design and Participants

This cross-sectional study was conducted among patients aged ≥60 with T2D, defined by American Diabetes Association (ADA) 2024, who visited the outpatient department at a Geriatric Hospital, Hanoi, Vietnam, from March 2024 to December 2024[14] Participants were excluded if they: (1) were unable to understand and/or answer the questions, (2) suffered from acute or severe illness, or (3) did not consent to participate in the study (Figure 1).

Sample Size Calculation

The sample size was calculated using the single population proportion formula: $n = Z^2_{1-a/2} * [p * (1-p)]/d^2$, where $Z_{1-a/2} = 1.96$ (95% confidence interval), $p = 0.237$ (fall prevalence from a 2021 study[15]), and $d = 0.035$ (precision). This yielded a minimum sample size of 631 participants to achieve 3.5% precision.

Data Collection

Geriatric specialists with clinical and research experience conducted standardized in-person interviews. Prior to data collection, they underwent training on the study protocol, objectives, eligibility criteria, and questionnaire administration.

Measurements

Falls

Participants reported falls in the previous 12 months (≥1 fall). For those with falls, additional details were collected on frequency, location (eg, bedroom, bathroom, stairs, hallway, outdoors, other), contributing factors (eg, postural dizziness, slippery surfaces, loss of balance, other), and fall-related consequences (eg, any injury, fracture, laceration/bruise, hospitalization).

The risk of falling was assessed using a 21-item fall risk index (FRI-21).[16] FRI-21 is a self-report, yes/no questionnaire that screens community-dwelling older adults for multifactorial fall risk. It comprises 21 items spanning intrinsic factors (prior falls, reduced gait speed, balance problems, kyphosis, dizziness on standing, visual/hearing problems), treatment factors (polypharmacy, assistive device use), and environmental hazards (barriers, slippery/uneven surfaces, stairs/slopes). The total score of 21 items (0–21) was defined as higher risk of fall if having a score ≥9 points.[17]

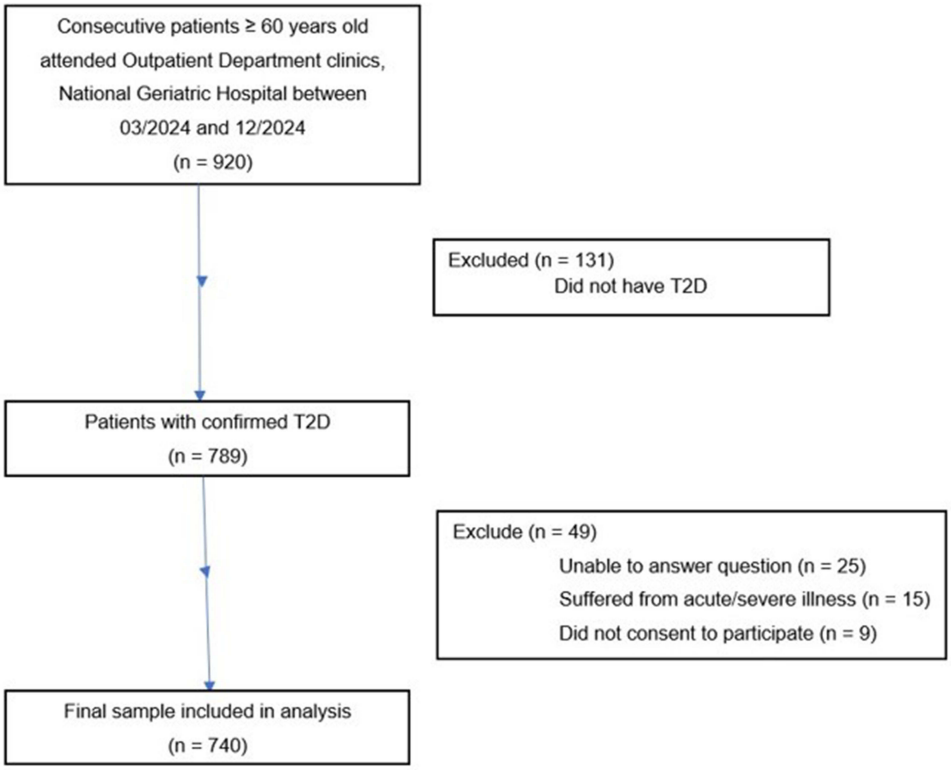

Figure 1 Flowchart of the participant recruitment process.

Frailty Assessment

Frailty was assessed using the Clinical Frailty Scale (CFS).[18,19] The score evaluates specific domains including comorbidity and loss of physical and cognitive function. The score ranges from very fit (CFS = 1) to very severely frail (CFS = 8) and terminally ill (CFS = 9). Frailty is defined as CFS ≥ 5.[20]

Independent Variables

Sociodemographic data included age (categorized as 60–69, 70–79, ≥80 years), gender (male/female), and living arrangement (with family/caregiver or alone). Diabetes-related variables, validated against medical records, included disease duration (<10 vs ≥10 years), HbA1c (<7.5% vs ≥7.5%), insulin use (yes/no), and chronic complications (yes/no, assessed via physical examination, including diabetic neuropathy, retinopathy, diabetic foot).

Geriatric Syndromes

Cognitive Function

Assessed using the Mini-cog test, including the three-word test and the clock test, with scores <3 indicating cognitive impairment.[21]

Comorbidities

Measured using the Charlson Comorbidity Index, with higher scores indicating greater morbidity.[22]

Depression

Evaluated with the 15-item Geriatric Depression Scale (GDS-15), with scores >5 indicating depression.[23]

Urinary incontinence

Assessed using the 3 Incontinence Questions (3IQ), with dichotomous responses (yes/no).[24]

Sarcopenia

Defined using the Asian Working Group for Sarcopenia (AWGS) criteria,[25] including: (1) low muscle mass (appendicular skeletal muscle mass/height^2 <7.0 kg/m^2 for men, <5.7 kg/m^2 for women, measured by bioelectrical impedance analysis [BIA 770, Korea]), (2) low muscle strength (handgrip strength <28 kg for men, <18 kg for women, measured by Jamar™ Hydraulic Hand Dynamometer), and/or (3) low gait speed (<0.8 m/s, assessed via a 4-meter walking test).

Statical Analysis

Data were analyzed using Stata version 18.0. Categorical variables were presented as frequencies and percentages, and continuous variables as medians with interquartile ranges (IQRs) due to non-normal distributions. All data collected for the variables used in this analysis were complete; therefore, no imputation or special handling for missing data was required. Differences between frail (CFS ≥ 5) and non-frail groups were assessed using Chi-squared or Fisher's exact tests for categorical variables and Wilcoxon rank-sum tests for continuous variables. Four multivariable logistic regression models evaluated the association between frailty and falls: Model 1 (frailty only), Model 2 (adjusted for age, gender, living status), Model 3 (Model 2 plus diabetes duration, HbA1c, complications, insulin use), and Model 4 (Model 3 plus depression, urinary incontinence, cognitive impairment, sarcopenia, and Charlson Comorbidity Index). Odds ratios (ORs) with 95% confidence intervals (CIs) were reported. All tests were two-tailed, with $p < 0.05$ considered statistically significant.

Results

Participant Characteristics

Among 740 older adults with type 2 diabetes (T2D) (mean age 74.6 ± 7.3 years, 63.9% female), 132 (17.8%) were frail. Frail participants were significantly older (47.0% aged ≥80 years vs 22.0% non-frail, $p < 0.001$) and had a higher prevalence of geriatric syndromes, including depression (42.4% vs 10.4%, $p < 0.001$), urinary incontinence (33.3% vs 14.1%, $p < 0.001$), cognitive impairment (68.9% vs 36.2%, $p < 0.001$), and sarcopenia (95% vs 75%, $p < 0.001$). They also had higher Charlson Comorbidity Index scores (median 6 [IQR 5–6] vs 4 [IQR 4–5], $p < 0.001$). No significant differences were observed in gender, living status, diabetes duration, or insulin use (Table 1).

Table 1 Patients Socio-Demographic and Clinical Characteristics, Older Patients with Type 2 Diabetes (N = 740)

Characteristics		Non-Frailty (n,%)	Frailty (n,%)	Total (n,%)	p-value
Age group	60-69	187 (30.8%)	22 (16.7%)	209 (28.2%)	<0.001
	70-79	287 (47.2%)	48 (36.4%)	335 (45.3%)	
	≥ 80	134 (22.0%)	62 (47.0%)	196 (26.5%)	
Gender	Male	223 (36.7%)	44 (33.3%)	267 (36.1%)	0.532
	Female	385 (63.3%)	88 (66.7%)	473 (63.9%)	
Currently living with	Family/Caregiver	580 (95.4%)	126 (95.5%)	706 (95.4%)	1.0
	Alone	28 (4.6%)	6 (4.5%)	34 (4.6%)	
Duration of diabetes	< 10 years	243 (40.0%)	56 (42.4%)	299 (40.4%)	0.672
	≥ 10 years	365 (60.0%)	76 (57.6%)	441 (59.6%)	
HbA1C	<7.5%	415 (68.3%)	78 (59.1%)	493 (66.6%)	0.055
	≥ 7.5	193 (31.7%)	54 (40.9%)	247 (33.4%)	

(*Continued*)

Table 1 (Continued).

Characteristics		Non-Frailty (n,%)	Frailty (n,%)	Total (n,%)	p-value
Using insulin	No	435 (71.5%)	84 (63.6%)	519 (70.1%)	0.09
	Yes	173 (28.5%)	48 (36.4%)	221 (29.9%)	
Having chronic diabetes complication	No	190 (31.3%)	29 (22.0%)	219 (29.6%)	0.665
	Yes	418 (68.8%)	103 (78.0%)	521 (70.4%)	
Depression (GDS-15)	Normal (≤ 5 points)	545 (89.6%)	76 (57.6%)	621 (83.9%)	<0.001
	Depression (>5 points)	63 (10.4%)	56 (42.4%)	119 (16.1%)	
Urinary Incontinence (3IQ)	No	522 (85.9%)	88 (66.7%)	610 (82.4%)	<0.001
	Yes	86 (14.1%)	44 (33.3%)	130 (17.6%)	
Cognitive impairment (Mini-cog)	No (≥3 points)	338 (63.8%)	41 (31.1%)	429 (58.0%)	<0.001
	Yes (< 3 points)	220 (36.2%)	91 (68.9%)	125 (42.0%)	
Sarcopenia (AWGS-2019)	No	152 (25%)	4 (3.0%)	156 (21.1%)	<0.001
	Yes	456 (75%)	128 (97%)	584 (78.9%)	
Charlson comorbidity index Median [IQR]		4.0 [4.0, 5.0]	6.0 [5.0, 6.0]	5.0 [4.0, 6.0]	<0.001

Fall Prevalence and Characteristics

Overall, 124 participants (16.8%) reported at least one fall in the past year, and 44 (5.9%) experienced recurrent falls (≥2 falls). Frail participants had a significantly higher single fall rate (28.0% vs 14.3%, $p < 0.001$) but not recurrent falls (7.6% vs 5.6%, $p = 0.503$) compared to non-frail participants. Falls commonly occurred in bedrooms (6.8%) and bathrooms (2.6%), with frail participants reporting higher rates in these locations ($p = 0.001$ and $p = 0.011$, respectively). Slippery floors (49.6%) and loss of balance (24.8%) were the primary fall triggers, with no significant differences between groups. Injuries included bruises (36.9%) and fractures (9.0%), with hospitalizations reported in 2.5% of cases (Table 2).

Table 2 Characteristics of Falls in Older Patients with/Without Frailty (N = 740)

Characteristic		Non-Frailty (n,%)	Frailty (n,%)	Total (n,%)	P-value
Number of falls in the previous years					
Single fall		87 (14.3%)	37 (28.0%)	124 (16.8%)	<0.001
Recurrent falls		34 (5.6%)	10 (7.6%)	44 (5.9%)	0.503
Locations of falls					
Inside home	Bedroom	32 (5.3%)	18 (13.6%)	50 (6.8%)	0.001
	Bathroom	11 (1.8%)	8 (6.1%)	19 (2.6%)	0.011
	On stairs	17 (2.8%)	4 (3.0%)	21 (2.8%)	0.778
	Hallway	7 (1.2%)	3 (2.3%)	10 (1.4%)	0.396

(*Continued*)

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Table 2 (Continued).

Characteristic	Non-Frailty (n,%)	Frailty (n,%)	Total (n,%)	P-value
Outside home	28 (4.6%)	4 (3.0%)	32 (4.3%)	0.568
Other/ do not remember	5 (0.8%)	1 (0.8%)	6 (0.8%)	1.00
Fall situation				
Dizziness when standing up	4 (4.7%)	3 (8.3%)	7 (5.8%)	0.175
Slippery floor	45 (52.9%)	15 (41.7%)	60 (49.6%)	
Loss of balance	17 (20.0%)	13 (36.1%)	30 (24.8%)	
Other	19 (22.4%)	5 (13.9%)	24 (19.8%)	
Any physical injuries				
Bruise/grazes	32 (37.6%)	13 (35.1%)	45 (36.9%)	0.718
Fracture	8 (9.4%)	3 (8.1%)	11 (9.0%)	
Hospitalized after falls	2 (2.4%)	1 (2.7%)	3 (2.5%)	
Others	0 (0.0%)	1 (2.7%)	1 (0.8%)	

Factors Associated with Falls

Logistic regression analyses showed a strong association between frailty and risk of falls. In the unadjusted model (Model 1), frailty was associated with an odds ratio (OR) of 7.35 (95% CI 4.64–11.64). This association remained significant after adjustments: Model 2 (adjusted for demographics: AOR 6.82, 95% CI 4.25–10.94), Model 3 (Model 2 plus diabetes-related factors: AOR 6.66, 95% CI 4.12–10.77), and Model 4 (fully adjusted: AOR 4.47, 95% CI 2.00–5.29). In Model 4, other significant risk factors included age 70–79 years (AOR 2.64, 95% CI 1.17–2.95), HbA1c ≥7.5% (AOR 2.37, 95% CI 1.08–2.37), diabetic complications (AOR 2.81, 95% CI 1.20–2.85), depression (AOR 5.20, 95% CI 2.51–7.70), urinary incontinence (AOR 6.46, 95% CI 3.34–9.59), cognitive impairment (AOR 2.97, 95% CI 1.20–2.49), and sarcopenia (AOR 2.16, 95% CI 1.03–2.21) (Table 3).

Table 3 Factors Associated with Increased Risk of Falls From the Univariate and Multivariable Models Regarding Relationship Between Frailty and Risk of Falls, Older Patients with T2D (N=740)

Variables	Model 1 (Univariate) OR (95% CI)	Model 2 (Multivariable) AOR (95% CI)	Model 3 (Multivariable) AOR (95% CI)	Model 4 (Multivariable) AOR (95% CI)
Frailty CFS: Yes ≥ 5 points (No)	7.35 (4.64–11.64)	6.82 (4.25–10.94)	6.66 (4.12–10.77)	4.47 (2.00–5.92)
Age group: 60-69		1.00	1.00	1.00
70-79		2.21 (1.50–3.27)	2.21 (1.48–3.29)	2.64 (1.17–2.95)
≥80		2.44 (1.56–3.80)	2.39 (1.52–3.76)	1.17 (0.77–2.75)
Gender (Female)		1.37 (0.98–1.91)	1.44 (1.03–2.03)	1.76 (0.96–2.04)
Living alone: Yes (No)		1.26 (0.61–2.64)	0.92 (0.65–1.30)	0.77 (0.30–1.68)
Duration of diabetes: ≥10 years (< 10 years)			0.82 (0.53–1.27)	0.59 (0.61–1.30)

(*Continued*)

Table 3 (Continued).

Variables	Model 1 (Univariate) OR (95% CI)	Model 2 (Multivariable) AOR (95% CI)	Model 3 (Multivariable) AOR (95% CI)	Model 4 (Multivariable) AOR (95% CI)
Hba1c: ≥7.5 (<7.5)			1.44 (1.01–2.07)	2.37 (1.08–2.37)
Have complications of diabetes: Yes (No)			2.23 (1.53–3.25)	2.81 (1.20–2.85)
Using insulin: Yes (No)			0.8 (0.55–1.18)	1.28 (0.49–1.15)
Depression GDS-15: Yes > 5 points (No)				5.20 (2.52–7.70)
Urinary incontinence 3IQ: Yes (No)				6.46 (3.34–9.59)
Cognitive impairment Mini-cog: Yes < 3 points (No)				2.97 (1.20–2.49)
Sarcopenia (AWGS-2019): Yes (No)				2.16 (1.03–2.21)
Charlson comorbidity index				1.41 (0.95–1.32)

Notes: Model 1 (basic model): Only frailty is included in the model for analysis. Model 2 (demographic adjusted model): Model 1 + age, gender, living alone. Model 3 (demographic + diabetes characteristic adjusted model): Model 2 + duration of diabetes, HbA1c, have complications of diabetes, using insulinModel 4 (fully adjusted model): Model 3 + Geriatric characteristics (depression, urinary incontinence, cognitive impairment, sarcopenia, Charlson comorbidities index).

Discussion

This study provides novel insights into the association between frailty and falls among older Vietnamese adults with type 2 diabetes (T2D), identifying frailty as a predominant risk factor. With 17.8% of participants classified as frail, our findings align with global estimates of frailty prevalence in T2D patients, which range from 15% to 30%.[26] However, our frailty prevalence is lower than reported in Western cohorts (eg, 25% in the U.S[27]), possibly due to differences in lifestyle, diet, or healthcare access in Vietnam. Especially, Vietnamese multigenerational living arrangements may enhance nutritional status and social support for older adults, possibly mitigating frailty severity.[28] Frail participants exhibited a significantly higher fall rate (28.0% vs 14.3% in non-frail, $p < 0.001$), particularly in domestic settings like bedrooms and bathrooms, underscoring the need for home-based fall prevention strategies.

Frailty's robust association with falls persisted across all regression models, consistent with prior studies linking frailty to impaired neuromuscular function and balance.[12] Frailty integrates multiple deficits, including sarcopenia, cognitive decline, and polypharmacy, which compromise postural stability and resilience, hence amplifying fall risk in T2D patients.[8] For instance, sarcopenia reduces lower-limb strength, impairing gait stability, while cognitive impairment hinders hazard recognition, increasing trip likelihood. The study demonstrated that depression exacerbates risk via psychomotor retardation and gait instability, consistent with a longitudinal meta-analysis indicating that elevated depressive symptoms increased the odds of subsequent falls by 34%.[29] Similarly, UI also increases falls risk plausibly due to the interaction of urgent voiding needs with impaired mobility and balance, particularly during rapid transitions.[30,31] Reflecting this pathway, our cohort showed a significant increase in falls occurring in the bathroom, emphasizing the crucial role of systematic home-safety assessments. These geriatric syndromes, prevalent in our cohort, interact synergistically with T2D complications like peripheral neuropathy and retinopathy, which impair sensory feedback and visual acuity.[5] This interaction creates a "vicious cycle" where, for example, frailty and cardiovascular disease, or diabetes and depression, mutually reinforce one another, further compounding a patient's overall vulnerability and fall risk.[32,33]

Poor glycemic control (HbA1c ≥ 7.5%) and diabetic complications independently increased fall risk, aligning with studies showing that hyperglycemia induces microvascular damage and neuropathy, reducing proprioception and balance.[6] Concordantly, a recent study among older T2D outpatients showed that longer diabetes duration (≥5 years) and diabetes complications were associated with poor glycaemic control, reinforcing cumulative neurovascular and visual

pathways to falls.[34] Unlike some studies reporting higher insulin-related fall risks,[4] insulin use was not significant in our cohort, possibly due to lower insulin prevalence (29.9%) or better glycemic management.

This study's strengths include its large sample size (n = 740), use of validated tools (eg, CFS, 21-FRI), and comprehensive multivariable modeling. As one of the first studies on frailty and falls in Vietnamese T2D patients, it addresses a critical gap in low- and middle-income countries, where aging and diabetes burdens are rising. However, limitations include the cross-sectional design, which precludes causality inference. Second, reliance on participant self-report for fall history over 12 months may introduce recall bias and underreport minor incidents. Integrating objective monitoring methods such as fall diaries with regular follow-up, and verification via medical records, can enhance data accuracy in future research. Third, we did not collect detailed data on polypharmacy or specific fall-risk-increasing drugs (eg, psychotropics, antihypertensives), apart from insulin. This is a known confounder, and future studies should include a comprehensive medication review. Lastly, the single-center urban setting may limit generalizability to rural populations with differing healthcare access.

Our findings advocate for routine frailty screening (eg, using CFS) and comprehensive geriatric assessments in T2D outpatient care to identify high-risk patients. Targeted interventions, such as strength training, home safety modifications, and cognitive therapy, could reduce falls.[35–37] Future longitudinal studies with objective fall monitoring and multicenter designs are needed to confirm causality and explore rural–urban differences. In Vietnam's rapidly aging population, these strategies are critical to reducing fall-related morbidity and enhancing quality of life. Furthermore, these results offer baseline, Vietnam-specific evidence that could benefit in the development of the first official Vietnamese national fall-prevention guidelines. Considering the similar constraints present in LMICs, a framework that includes CFS triage, and a cost-effective multifactorial bundle is readily transferable and could facilitate the advancement of guidelines in LMIC settings.

Conclusion

Considering the projected rise of the Vietnamese older population, mitigating falls in adults with T2D requires systemic intervention. Our findings indicate that frailty significantly stratifies fall risk independent of inadequate glycemic control, diabetes complications, and the existence of coexisting geriatric syndromes. These results support integrating frailty screening and comprehensive geriatric assessment into daily diabetes care to facilitate early detection of high-risk individuals and guide tailored fall prevention interventions.

Data Sharing Statement

The datasets of this study are available from the corresponding author on reasonable request.

Ethics Statement

The study was approved by Hanoi Medical University Ethics Committee in Vietnam *(Ref: No 113526th December 2023)*, conducted in accordance with the Declaration of Helsinki.

Informed Consent Statement

All participants or their representatives/guardians were asked to give their written informed consent and they could withdraw anytime. Their information was kept confidential and used only for research purposes.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors declare that there is no conflict of interest in this work.

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