ORIGINAL ARTICLE

Primary Prevention of Fragility Hip Fracture in High-Risk Elderly by Village Health Volunteers in Nan Province, Thailand

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Objective: To evaluate the effectiveness of village health volunteers (VHVs) in providing home visits to high-risk elderly individuals in Nan Province, Thailand, to monitor and prevent new fragility hip fractures. The increasing incidence of hip fractures among the elderly in this region highlights the need for effective preventive measures.

Materials and Methods: The present study was a prospective cohort study conducted in Nan Province, Thailand, between January 1, 2020, and December 31, 2023. The study population consisted of elderly Thai individuals aged 65 years and above with a FRAX hip score greater than 3% and no prior history of hip fragility fractures. The intervention involved home visits by VHVs at least once every six months for two years.

Results: Of the 12,302 eligible participants, 9,215 (74.9%) received home visits, with an average of 2.4 visits per person. Four hundred seven participants (3.3%) experienced new hip fractures, with 198 (2.1%) in the home visit group and 209 (6.8%) in the non-home visit group. The key factors associated with new hip fractures included the history of non-hip fragility fractures, dementia, and non-home visits. Home visits by VHVs were associated with a 3.34 times lower risk of hip fractures compared to those not receiving home visits.

Conclusion: The utilization of VHVs for home visits, particularly for at-risk individuals identified using the FRAX tool, is a significantly effective method for reducing the incidence of fragility hip fractures.

Keywords: Primary prevention; Fall; Older adults; Fragility hip fracture; Village health volunteers; Home visit; Thailand

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Fragility hip fractures (HF) are low-energy fractures of the proximal femur that occur due to minimal trauma, typically from a fall from a standing height or less, in individuals with compromised bone strength, primarily due to osteoporosis. These fractures commonly affect the femoral neck and intertrochanteric or subtrochanteric regions. Fragility HF are a common problem among the elderly and lead to high rates of mortality and disability[1,2]. The mortality rate is particularly high in the first year after a fall, especially among elderly patients with HF, owing to complications such as infections, blood clots, and prolonged immobility[3]. This not only impacts on an individual's health but also places a significant emotional and financial burden on their families, who often become primary caregivers. The stress of managing care, particularly in rural areas with limited healthcare resources, can greatly affect the well-being of both the elderly and their family members[4]. Currently, this issue has become a significant public health problem in the Asian region owing to the aging society, resulting in substantial economic costs[5,6]. Epidemiological data from Nan Province reported an increasing incidence of HF, with rates of 211.6, 214.9, and 238.5 per 100,000 population in 2015, 2016, and 2017, respectively[7]. The incidence of fragility HF in the elderly in Nan Province has been increasing annually and is quite severe, posing a serious public health problem that needs to be addressed.

The Fracture Risk Assessment Tool (FRAX) is a reliable and widely accepted risk assessment tool for predicting fractures due to osteoporosis[8,9]. The World Health Organization developed the FRAX tool to estimate the 10-year probability of HF and major

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osteoporotic fractures (MOF), including vertebral, hip, and proximal humeral fractures. Each step is based on individual patient analysis, considering risk factors such as age, gender, body mass index (BMI), history of fractures, family history of HF, smoking, long-term corticosteroid use, rheumatoid arthritis, secondary osteoporosis causes, and high alcohol intake, along with bone mineral density (BMD) or BMI[10,11]. The National Osteoporosis Foundation (NOF) of the United States and Osteoporosis Canada recommend treatment when the FRAX HF score for both men and women exceeds 3%, considering them at high risk for HF[12]. In clinical practice, FRAX without BMD is used to screen individuals at risk of osteoporotic fractures, and studies have shown that it can accurately screen for HF risk[13,14]. Studies have demonstrated that the primary prevention and screening of HF are cost-effective[15-18]. Screening for HF risk in the community based on the FRAX HF probability significantly reduced the number of HF in elderly women.

Village health volunteers (VHVs) are health personnel who receive continuous training in primary health care knowledge and skills. They are crucial for strengthening and sustaining Thailand's community health system by working closely with public health agencies and the community. Their roles include 1) providing health education and promotion, 2) conducting disease surveillance and prevention, 3) offering patient care in the community, 4) serving as intermediaries between the community and public health agencies, and 5) supporting public health activities (https://prgroup.hss.moph.go.th/article/1000).

Surveillance and monitoring of the elderly to prevent falls and fractures cannot cover all elderly individuals in the community because of the large number of elderly people, which exceeds the workload of public health officials. Therefore, screening high-risk groups as targets for intervention is necessary. The present study selected the FRAX tool for screening the risk of HF owing to its ease of use, convenience, speed, accuracy, reliability, and ability to screen a large population online simultaneously. However, the number of high-risk elderly individuals identified through screening remains high. To reach these high-risk elderly individuals, the present study utilized VHVs, which are already part of the primary health care system in the community, to monitor and follow up with them for HF within the community.

The present study is the first to evaluate the effectiveness of surveillance and prevention of new HF in at-risk elderly individuals using the FRAX screening tool in Thailand. VHVs in the Nan Province conduct home visits to provide education and guidance on fall prevention to prevent new HF.

Materials and Methods

The present study was a prospective cohort study conducted in Nan Province, Thailand, between January 1, 2020, and December 31, 2023. The study population comprised all older adults aged 65 years and above, both male and female resided in Nan Province, Thailand, totaling 60,901 individuals. Data was obtained from the 2020 annual elderly health screening program recorded in the database of the provincial public health office, which compiled information from all healthcare facilities in Nan Province. The collected data included age, gender, weight, height, and BMI. FRAX HF was calculated using the Thai version of the FRAX tool without BMD and clinical risk factor assessment. Older adults with FRAX HF greater than 3% and no history of HF due to osteoporosis were included in the present study. Those with terminal illnesses, bedridden or unable to perform daily activities independently were excluded. Twelve thousand three hundred two older adults were classified as being at risk of HF.

At-risk older adults with HF received home visits from VHVs who were extensively trained by nurses from local healthcare facilities. These nurses formed the core network of the elderly fall prevention program in Nan Province, ensuring a structured and standardized approach to home-visit interventions. VHVs were assigned to at-risk individuals based on their designated service areas, enabling consistent monitoring and individualized support. To enhance effectiveness, VHVs underwent comprehensive training led by healthcare professionals, covering key topics, such as fall risk assessment, osteoporosis management, medication adherence, nutrition for older adults, and environmental modifications to minimize home hazards. The training combined theoretical instruction with hands-on simulations, equipping VHVs with skills to conduct standardized assessments using validated tools and checklists. In addition, they were trained to educate older adults on proper nutrition, physical activity, and lifestyle adjustments to promote bone health and prevent falls. Regular refresher courses and ongoing supervision by healthcare teams reinforce adherence to protocols and ensure continuous skill development. This structured approach enhanced the consistency of home-visit procedures, minimized variability in assessments, and

maximized the effectiveness of VHVs in reducing HF risk among high-risk elderly individuals.

VHVs conducted home visits at least once every six months for a duration of two years. During each visit, activities included promoting high-calcium and vitamin D diets, especially encouraging the daily consumption of plain milk after breakfast, recommending weight-bearing exercises such as at least 30 minutes of walking daily and thigh muscle-strengthening exercises, assessing the home environment for fall risks, and implementing necessary modifications.

Home visits were voluntary, non-randomized, and without financial incentives. VHVs recorded their home-visit data in an online electronic form. Older adults who received at least one home visit were categorized as the home-visited group, totaling 9,215 individuals (74.9%), while those who did not receive any home visits were classified as the non-home-visited group, totaling 3,087 individuals (25.1%).

The study of at-risk older adults, which included 12,302 participants, collected general patient information, including age, gender, weight, height, BMI, caregiver presence, gait and mobility, history of non-hip fragility fractures, alcohol consumption, smoking history, corticosteroid use, anti-osteoporotic drug use, parental history of HF, and comorbidities such as diabetes mellitus (DM), hypertension (HT), chronic obstructive pulmonary disease (COPD), heart disease, chronic kidney disease (CKD), cerebrovascular accidents (CVA), dementia, and Parkinson's disease.

HF data was obtained from the Nan Provincial Health Office database between January 1, 2021, and December 31, 2023. The mortality data for the at-risk elderly population were tracked using the Nan Model program. HFs were identified from the hospital records as cases diagnosed with fractures due to low-energy trauma. HFs were defined using the International Classification of Diseases, 10th revision (ICD-10) with the following codes: S72.0 as fracture of the femoral neck, S72.1 as fracture of the trochanteric region, and S72.2 as fracture of the subtrochanteric region.

Clinical characteristics were summarized using descriptive statistics, including frequencies, percentages, means, and standard deviations. To evaluate the association between independent variables and the risk of HF, both univariate and multivariate regression analyses were conducted. Univariate regression analysis was performed to identify potential risk factors for HF, assessing each variable separately. The results were presented as odds ratios (OR) with 95% confidence intervals (CI). Variables with a p-value less than 0.10 in the univariate analysis were considered for inclusion in the multivariate regression analysis. A multivariable logistic regression model was used to determine independent predictors of HF risk. To account for confounding factors, such as age and gender, these variables were adjusted in the multivariate analysis. Additionally, clinically relevant variables identified from previous literature and expert consensus were incorporated to ensure a comprehensive assessment. The final model retained only statistically significant variables, with results reported as adjusted odds ratios (AOR) and 95% CI.

All statistical analyses were performed using IBM SPSS Statistics, version 26.0 (IBM Corp., Armonk, NY, USA), with statistical significance set at p-value less than 0.05. The present study was approved by the Research Ethics Committee of Nan Hospital (Nan Hos. REC No. 074/2024).

Results

The study population consisted of 13,264 elderly individuals at risk with a FRAX hip score greater than 3%. Among them, 12,302, including 894 males (7.3%) and 11,408 females (92.7%), had no prior history of HF (Figure 1). The average age was 79.7±6.3 years. The age distribution was 163 individuals (1.3%) aged 65 to 69 years, 2,224 or (18.1%) aged 70 to 74 years, 3,893 (31.6%) aged 75 to 79 years, 3,042 (24.7%) aged 80 to 84 years, 2,159 (17.5%) aged 85 to 89 years, and 821 (6.7%) aged 90 years and above. There were 1,462 individuals (11.9%) without a primary caregiver, 2,709 (22.0%) ambulated with a gait aid, and 573 (4.7%) with a history of non-hip fragility fractures, including 152 (26.5%) vertebral compression fractures, 68 (11.9%) proximal humerus fractures, and 353 (61.6%) distal forearm fractures. The comorbidities included diabetes in 1,450 individuals (11.8%), HT in 5,317 (43.2%), COPD in 485 (3.9%), heart disease in 466 (3.8%), CKD in 197 (1.6%), CVA in 89 (0.7%), dementia in 108 (0.9%), and Parkinson's disease in 27 (0.2%). A comparison of clinical parameters between those who received home visits and those who did not, showed any significant differences, except for gender, age, and HT (Table 1).

Between January 1, 2021, and December 31, 2022, 22,479 home visits were conducted. Among the at-risk elderly, 9,215 (74.9%) received home visits, with an average of 2.4 visits per person, while the

Table 1. Comparison of clinical parameters and FRAX hip score among high-risk elderly with home visit and non-home visit

	Number of non-home visit (n=3,087)	Number of home visit (n=9,215)	p-value*
Female; n (%)	2,836 (91.9)	8,572 (93.0)	0.033
No caregiver; n (%)	349 (11.3)	1,113 (12.1)	0.261
History of non-hip fragility fracture; n (%)	148 (4.8)	425 (4.6)	0.695
DM; n (%)	360 (11.7)	1,090 (11.8)	0.082
HT; n (%)	1,101 (35.7)	4,216 (45.8)	<0.001
COPD; n (%)	137 (4.4)	348 (3.8)	0.108
Heart; n (%)	108 (3.5)	358 (3.9)	0.354
CKD; n (%)	53 (1.7)	144 (1.6)	0.566
CVA; n (%)	16 (0.5)	73 (0.8)	0.144
Dementia; n (%)	32 (1.0)	76 (0.8)	0.267
Parkinson's disease; n (%)	5 (0.2)	22 (0.2)	0.512
Ambulate with gait aid; n (%)	715 (23.2)	1,994 (21.6)	0.079
Age (years); mean±SD	79.9±6.5	79.7±6.2	0.087
Weight (kg); mean±SD	43.6±8.2	43.8±8.0	0.190
Height (cm); mean±SD	150.7±7.1	150.9±6.9	0.155
BMI (kg/m^2); mean±SD	19.2±3.2	19.3±3.2	0.756
FRAX hip score (%); mean±SD	4.8±1.5	4.9±1.5	0.649

DM=diabetes mellitus; HT=hypertension; COPD=chronic obstructive pulmonary disease; CKD=chronic kidney disease; CVA=cerebrovascular accidents; BMI=body mass index; SD=standard deviation

* p<0.05, considered statistically significant

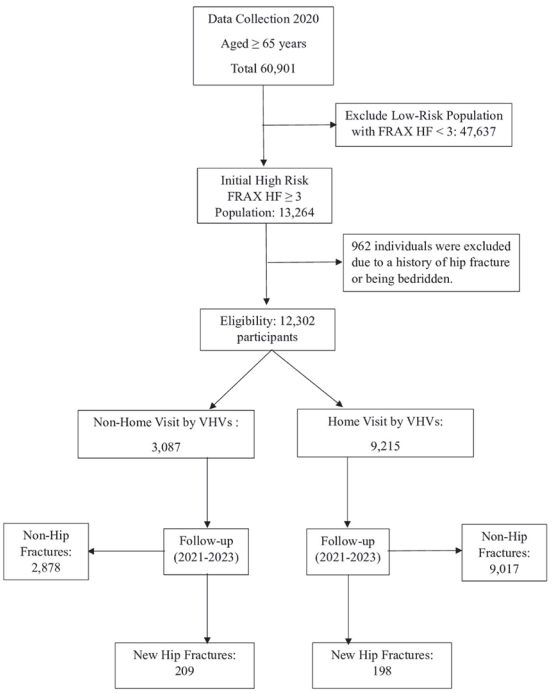

Figure 1. Flow chart of the number of participants eligible for analysis.

remaining 3,087 (25.1%) did not receive home visits. Follow-up on HF incidence through December 31, 2023, revealed 407 (3.3%) new HF among the at-risk elderly, with 198 (2.1%) in the home-visit group and 209 (6.8%) in the non-home visit group (Table 2).

Table 2. The number of new hip fractures in high-risk elderly who received home visit and non-home visit

	Non-hip fracture n (%)	New hip fracture n (%)
Non-home visit (n=3,087)	2,878 (93.2)	209 (6.8)
Home visit group (n=9,215)	9,017 (97.9)	198 (2.1)

In the univariate regression analysis (Table 3), several factors were found to be associated with an increased risk of new fragility HF in high-risk elderly individuals. Age was a significant predictor, with individuals aged 85 to 89 years (OR 4.28, 95% CI 1.047 to 17.492, p=0.043) and those aged 90 years and older (OR 5.11, 95% CI 1.230 to 21.225, p=0.025) showing a significantly higher risk compared to the reference group, which were aged 65 to 69 years. Other significant risk factors included a history of non-hip fragility fractures (OR 1.86, 95% CI 1.286 to 2.676, p=0.001), dementia (OR 2.69, 95% CI 1.352 to 5.370, p=0.005), ambulation with a gait aid (OR 3.31, 95% CI 2.711 to 4.035, p<0.001), and non-home visits (OR 3.30, 95% CI 2.711 to 4.035, p<0.001).

In the multivariate regression analysis (Table 4), after adjusting for potential confounders, several factors remained significant independent predictors of new fragility HF. A history of non-hip fragility fractures (AOR 1.82, 95% CI 1.254 to 2.648,

Table 3. Univariate regression analyses of factors for new fragility hip fracture in high-risk elderly

Risk factors	Number of hip fracture; n (%)	Odds ratio	95% confidence interval	p-value*
Age (year)				
65 to 69	2 (1.2)	Reference		
70 to 74	24 (1.1)	0.88	0.206 to 3.749	0.861
75 to 79	96 (2.5)	2.04	0.497 to 8.329	0.323
80 to 84	127 (4.2)	3.51	0.860 to 14.305	0.080
85 to 89	109 (5.0)	4.28	1.047 to 17.492	0.043
90 or more	49 (6.0)	5.11	1.230 to 21.225	0.025
BMI <20 kg/m^2	242 (3.2)	1.10	0.898 to 1.344	0.359
Female	380 (3.3)	1.11	0.744 to 1.645	0.617
No caregiver	42 (2.9)	0.849	0.614 to 1.174	0.322
History of non-hip fragility fracture	33 (5.8)	1.86	1.286 to 2.676	0.001
DM	55 (3.8)	1.18	0.880 to 1.571	0.272
HT	194 (3.6)	1.20	0.988 to 1.467	0.066
COPD	21 (4.3)	1.34	0.856 to 2.100	0.201
Heart	17 (3.6)	1.11	0.678 to 1.822	0.676
CKD	6 (3.0)	0.92	0.404 to 2.079	0.835
CVA	3 (3.4)	1.02	0.321 to 3.238	0.974
Dementia	9 (8.3)	2.69	1.352 to 5.370	0.005
Parkinson's disease	1 (3.7)	1.12	0.152 to 8.306	0.909
Ambulate with gait aid	135 (5.0)	3.31	2.711 to 4.035	<0.001
Non-home visit	209 (6.8)	3.30	2.711 to 4.035	<0.001

BMI=body mass index; DM=diabetes mellitus; HT=hypertension; COPD=chronic obstructive pulmonary disease; CKD=chronic kidney disease; CVA=cerebrovascular accidents

* p<0.05, considered statistically significant

Table 4. Multivariate regression analyses of factors for new fragility hip fracture in high-risk elderly

Risk factors	Number of hip fracture; n (%)	Adjusted odds ratio	95% confidence interval	p-value*
Age (year)				
65 to 69	2 (1.2)	Reference		
70 to 74	24 (1.1)	0.85	0.199 to 3.652	0.829
75 to 79	96 (2.5)	1.97	0.478 to 8.098	0.348
80 to 84	127 (4.2)	3.20	0.778 to 13.126	0.107
85 to 89	109 (5.0)	3.73	0.906 to 15.363	0.068
90 or more	49 (6.0)	4.16	0.991 to 17.444	0.052
History of non-hip fragility fracture	33 (5.8)	1.82	1.254 to 2.648	0.002
HT	194 (3.6)	1.21	0.989 to 1.486	0.063
Dementia	9 (8.3)	2.06	1.010 to 4.180	0.047
Ambulate with gait aid	135 (5.0)	1.25	0.997 to 1.565	0.053
Non-home visit	209 (6.8)	3.34	2.730 to 4.086	<0.001

HT=hypertension

* p<0.05, considered statistically significant

p=0.002) and dementia (AOR 2.06, 95% CI 1.010 to 4.180, p=0.047) were identified as significant risk factors. Non-home visits (AOR 3.34, 95% CI 2.730 to 4.086, p<0.001) remained the strongest predictor of HF in this population.

Other factors, such as older age, continued to show a trend toward increased risk, with individuals aged 90 years and older (AOR 4.16, 95% CI 0.991 to 17.444, p=0.052). Additionally, HT (AOR 1.21, 95% CI 0.989 to 1.486, p=0.063) and ambulation with a gait aid (AOR 1.25, 95% CI 0.997 to 1.565, p=0.053) exhibited a potential association with HF. However, these factors did not reach the predefined threshold for statistical significance (p<0.05). These

findings highlight the significant impact of prior fracture history, dementia, and non-home visits as key predictors of HF risk in high-risk elderly individuals, reinforcing the necessity for targeted preventive strategies in this population.

Discussion

The present study identified prior fracture history, dementia, and non-home visits as significant predictors of HF risk in high-risk elderly individuals, consistent with previous research. Recognizing these risk factors is essential for developing effective prevention strategies.

Prior fractures indicate underlying bone fragility and increased fall risk, emphasizing the need for secondary prevention strategies[19,20], including pharmacologic treatment and lifestyle modifications[21]. Non-hip fragility fractures, such as vertebral, wrist, or humeral fractures, are strong indicators of osteoporosis and recurrent falls, making future HF more likely[22-24].

Dementia also significantly increases fracture risk, likely due to impaired balance, cognitive decline, and reduced adherence to fall prevention strategies. These findings align with previous studies demonstrating a higher fracture risk among individuals with cognitive impairment[25-27].

The present study highlights the significant role of continuous surveillance and home visits by VHVs in reducing the HF risk among high-risk older adults. Home visits provide fall prevention strategies, environmental modifications, nutritional guidance, medication monitoring, and social support, as protective factors that may be lacking in those who do not receive visits, leading to a higher fracture incidence. By enabling systematic screening and risk management, home visits can help mitigate unaddressed risks over time. Additionally, they enhance their mental well-being by reducing isolation and promoting self-care support. Home visits significantly decreased fall incidence, with the non-home-visited group experiencing more falls and the visited group showing a reduction, even after adjusting for demographic and health variables. Multiple studies further support the impact of home visits in reducing fall and HF risks[28,29], likely because of improved awareness and preventive measures among elderly individuals and their families[30]. Thus, home visits are a vital mechanism for safeguarding older adults from falls and fractures.

Given these findings, a multifaceted approach to HF prevention is necessary. Strategies should include osteoporosis management, fall prevention programs, cognitive health assessments, and transitional care interventions. Early identification of high-risk individuals and proactive implementation of these measures can significantly reduce the incidence of HF and improve overall health outcomes in the elderly population[31].

The FRAX tool has been widely utilized to assess fracture risk, often in combination with BMD testing to guide treatment decisions. However, in Thailand, BMD testing has accessibility and cost constraints. Therefore, an intervention following FRAX HF screening could reduce complexity and costs. The present study demonstrates the effectiveness of continuous home visits by VHVs for elderly individuals at risk of HF due to falls:

1. Raise awareness about the importance of preventing HF from falling within the community and encourage community involvement in preventing such incidents, with VHVs being close and familiar with community members.

2. Increased awareness among high-risk individuals regarding their susceptibility to HF from falls promotes vigilance and caution.

3. Thailand's existing primary healthcare infrastructure should be optimized by integrating HF prevention strategies into routine community health services, maximizing efficiency, and ensuring sustainability.

By implementing these strategies, primary healthcare providers can play a pivotal role in reducing the incidence of HF and improving the quality of life of Thailand's aging population.

A key limitation of the present study is the non-randomized allocation of participants to home visit and non-home visit groups, which may have introduced selection bias. VHVs conducted visits voluntarily, and certain participant characteristics may have influenced their likelihood of receiving home visits, potentially leading to an overestimation or underestimation of the intervention's impact. Variability in social support, healthcare access, and willingness to participate further complicates the generalizability of the findings. Several co-interventions, such as medication use like anti-osteoporotic drugs, vitamin D, and corticosteroids, lifestyle factors such as diet, exercise, smoking, and alcohol consumption, and healthcare access, could also influence HF risk and should be considered in the analysis. Participants who received home visits may have adhered better to osteoporosis treatments and received improved guidance on nutrition and physical

activity, which could have influenced fracture outcomes. Detailed baseline and follow-up data are essential for controlling these factors. Propensity score matching or multivariate adjustments may help mitigate confounders, but long-term monitoring and adherence challenges, such as inconsistent home visit practices and data completeness issues, must also be addressed. Participant retention is another challenge, as individuals may relocate, withdraw, or pass away during the study. To improve accuracy and reliability, statistical techniques such as inverse probability weighting and propensity score adjustments should be used to control selection bias. Monitoring of co-interventions, including medication adherence and lifestyle changes, should be integrated into follow-up visits. Standardizing home-visit procedures and training for VHVs will reduce variability, and future studies should incorporate randomized elements for stronger causal conclusions while maintaining feasibility in community settings.

Conclusion

The use of VHVs for home visits, particularly for at-risk individuals identified using the FRAX tool, is a significantly effective method for reducing the incidence of fragility HF. Individuals with a prior history of fractures, along with those suffering from dementia, should be closely monitored due to their heightened risk of HF resulting from falls.

What is already known about this topic?

Fragility HF is a major public health concern. FRAX aids healthcare providers in identifying individuals at a high risk of fractures and informing decisions on pharmacological and non-pharmacological interventions. Primary prevention of HF in the elderly has demonstrated potential in reducing the incidence of fragility fractures. Community-based health initiatives are underutilized. VHVs have proven effective in delivering health education and preventive care in low-resource settings, however, their role in the primary prevention of fragility HF has not been thoroughly explored. Home visits by healthcare professionals or community health workers effectively address the unique health needs of the elderly, particularly those with mobility limitations or chronic illnesses. Regular home visits have increased access to preventive care, improved medication adherence, and facilitated early detection of health problems in older adults. Studies have suggested that home visits can improve the overall quality of life of the elderly.

What does this study add?

The present study provides evidence that trained VHVs can effectively deliver primary prevention interventions to reduce the risk of fragility HF in high-risk elderly individuals. By utilizing local resources and community engagement, this novel community-based approach offers a cost-effective and sustainable model for fracture prevention in low-resource settings. This study highlights how VHVs' personalized home visits and health education improve elderly individuals' awareness of fall prevention strategies and adherence to bone health recommendations. Furthermore, the findings suggest that this community-based model can be adapted and scaled to other regions with similar demographic and healthcare challenges.

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Conflicts of interest

The authors declare no conflict of interest.

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