

Proposal for Modifications to the Bangkok Urban Health System that would Improve the Quality of Health, Independent Living, and Maintenance of Older Adults with Fall-related Trauma (Bangkok Falls Study)

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Research Article

Keywords: Bangkok urban health system, quality of health, independent living, trauma

Posted Date: August 26th, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-428302/v1>

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Abstract

Background

The Bangkok falls study aimed to identify fall-associated factors, including home healthcare hazards, nutritional status, hydration status, sarcopenia, frailty, locomotive syndrome, and health status of urban older adults in a middle-income country.

Methods

This was a population-based cohort study that enrolled adults who lived in Bangkok, Thailand. Our study recruited older adults aged ≥ 60 years old, able to walk, and expected to live in the community for at least 2 years. The study had three phases included; phase 1: subject identification and terminology clarification. Phase 2: we collected data at community sites on baseline characteristic and fall risk identification. Examinations and laboratory investigations were scheduled for one month later. Phase 3: telephone follow up for falls rate, functional status and death at 3, 6, 12 months.

Results

A total 1,001 (51.84%) people were enrolled for our study. The average age of our study was 69.9 years old (SD, 6.8), and two-thirds were female. Using “Stopping Elderly Accidents, Death and Injuries” (STEADI) screening fall risk, our study found that 37.7% had scores ≥ 4 , which means that there is a risk of fall. In addition, the risk of falls increased among older adults aged 75–84 years (49.5%) and older adults aged ≥ 85 years (67.7%) (P -value < 0.001).

Conclusion

This study demonstrated the feasibility of conducting a population-based cohort study among urban older adults in a middle-income country using the local community healthcare system. Our study have a tendency to provide data source for fall risk factors and disability in older adults.

Introduction

Falls and fall-related injuries are a leading cause of death among older adults and thus have become a growing public health concern worldwide [1, 2]. Injuries from falls often cause a decline in the activities of daily living and can lead to post-fall syndrome, such as immobilization, hip fracture, head injury, and death [3–5]. Falls can happen anywhere, at any time; therefore, fall prevention measures should be taken. A fall risk assessment considers factors such as environmental conditions, functional status, and underlying diseases [6–11]. Fall risk factors have been studied for many decades; however, the causes of falls are so varied that a fall risk assessment will not account for many unknown variables that can arise [6–11]. In addition, the fall risk assessment tools that are commonly used by older adults provide moderate predictive ability for differentiating between high risk and low-risk falls [6, 12, 13]. Because falls are a main cause of disability in older adults and factors that contribute to falls are risk factors for

numerous adverse events, a fall prevention plan may reduce the risk of disability in older adults. The “MOBILIZE Boston study” evaluated the impacts of pain [14–18], cerebral perfusion, and foot disorder on fall risks among US community older adults. Because certain risk factors for falls, including sarcopenia [19–22], locomotive syndrome (LS) [23, 24] hydration status [25, 26], and nutrition status [27, 28], are not well understood among Southeast Asian populations, large observational studies are required. An assessment for sarcopenia is usually not included among fall risk screening tools, although it is an important predictor for falls and fractures [19–22].

Identifying health conditions associated with falls is imperative for establishing prevention measures. Hypertonic dehydration is associated with falls [25, 26], as dehydration causes decreased brain perfusion and orthostatic hypotension. Malnutrition is associated with in-hospital falls [27]. A three-year longitudinal study showed an increased risk among aging Taiwanese adults with malnutrition [29], whereas a study in Australia contrarily found no association between falls and malnutrition over a one-year period in community-dwelling older adults [28].

The Bangkok falls study is a population-based cohort study that is part of the Geriatric Emergency Department Research Unit, Rehabilitation, Home Health Care Unit and Vajira Research Facilitation Division, Navamindradhiraj University program project, in collaboration with the Thai Health Promotion Foundation. Each of the studies within the Bangkok falls study aimed to identify fall-associated factors, including home healthcare hazards, nutritional status, hydration status, sarcopenia, frailty, LS, and health status of urban older adults in a middle-income country.

Methods

A large population of urban older adults were recruited and assessed for individual characteristics, which were stored in a database for cross-study research on the correlation between sarcopenia, LS, and biomarkers and the risk for falls and immobility in older populations. The project was funded by Thai Health Promotion and approved by the Vajira Institutional Review Board.

Study design

This was a population-based cohort study that enrolled adults age 60 years or older who lived in one of five subdistricts of the Dusit District, Bangkok, Thailand, between October 1, 2019, and September 30, 2021.

The present study had three phases of data collection:

Phase 1: This phase included subject identification and terminology clarification. Experts from Thai Health Promotion, Navamindradhiraj University, Thai College of Emergency Physician, Medical Service Department of Bangkok (20 participants), and the Head and Member of Community Health Promotion Volunteers for each subdistrict (46 participants) met to clarify the association between falls and health

status. Research assistants (RAs) obtained data on older adults aged ≥ 60 years who resided in the area and were willing to participate. In Bangkok, health promotion volunteers are employed by the Bangkok Metropolitan Council to work on health promotion at the subdistrict level. They conduct surveys on health status and family members and report data to the Bangkok Department of Health. RAs coordinated the schedule.

Phase 2: At each community site, the principal investigator (PI) and RAs collected data on baseline characteristic and distributed fall calendar postcards and fall risk identification cards reporting the “Stopping Elderly Accidents, Death and Injuries” (STEADI) [30]. Examinations and laboratory investigations were scheduled for one month later.

Phase 3: RAs performed telephone follow-up at 3, 6, and 12 months, which is the gold standard protocol for falls. Respondents answered questionnaires about the activities of daily living, history of falls, rating of the emergency department, hospitalization, and mortality. The results were submitted to the Head of Community and the Department of Health to generate a screening tool and health system for reducing fall occurrence. The subgroups of the cohort were invited to address questions related to the mechanism and prevention of falls, including the correlation between falls and muscle mass and sarcopenia based on ultrasound muscle. A second project determined the prevalence of dehydration and developed a new protocol for older adults.

Recruitment process

The Head of Community Health Promotion Volunteer announced the project to each subdistrict and recruited older adults who were interested in participating and met the following criteria: aged ≥ 60 years old, able to walk, and expected to live in the community for at least 2 years. When there were at least 30 participants in a subdistrict, RAs conducted a screening at the community meeting place to determine eligibility. The inclusion criteria were adults ≥ 60 years old who lived in Dusit District, could walk at least 6 meters, and were expected to live in the community for at least 2 years. The exclusion criteria were older adults who were unable to speak Thai, had severe cognitive impairment of >12 points on the six-item cognitive screening test [31], or were blind or deaf.

Data collection (Table 1 and Figure 1)

Data on baseline characteristics, underlying diseases, medications, Charlson comorbidity index [32], Barthel activities of daily living index [33], Mini Nutritional Assessment (MNA) [34], cognitive function, World Health Organization Quality of Life (WHOQOL-BREF-THAI) [35], frailty phenotype [36], mobility, fall history, and end of life decision were collected for each participant. RAs obtained written informed consent from each participant. Participants received \$8 USD for each community visits and \$15 USD for the hospital appointment. Transportation was provided based upon request. Details of data collection methods are shown in Table 1 and Figure 1.

Table 1**Data collection**

Domain	Community site interview
Demographics	Sociodemographic information
Falls	History of falls, fracture, and injuries STEADI checklist Fall risk medications Home environment
Frailty	Frailty phenotype [36]
Footwear	Footwear/shoe wear
Nutrition	MNA
Medications	Medication inventory (prescription, over-the-counter drug, herbal, or supplemental)
Comorbidity	Charlson comorbidity index [32]
Cognition	Six-item cognitive screening test [31]
Quality of life	WHOQOL-BREF-THAI [35]
Behaviors	Alcohol use, smoking, water or other drink
Pain	Pain location and characteristics
Disability	Barthel activities of daily living index, LS checklist [37]

Community site interview

Five trained RAs performed extensive interviews at the community sites and evaluated health status based on Charlson comorbidity index (self-reported physician diagnosis and confirmation by hospital medical records), sociodemographic information (age, gender, marital status, profession, monthly income, caregiver, family member, level of education, and electronic device for communication), disability (Barthel activities of daily living index), cognitive test (six-item cognitive screening test), and quality of life (WHOQOL-BREF-THAI).

Nutritional assessment [34]

Nutritional assessment was based on weight, height, body mass index, mid-arm circumference, and the MNA. The MNA score in the elderly can determine adequate nutritional status (MNA, ≥ 24), malnutrition

risk (MNA, 17–23.5), and protein–calorie malnutrition (MNA, < 17). The MNA had high sensitivity (96%) and specificity (98%) for identifying patients who were at risk for malnutrition (MNA, 17–23.5).

Frailty [36]

Frailty was evaluated using the “frailty phenotype,” [36] which has a set of five criteria: involuntary weight loss of 4.5 kg over the past year, self-reported exhaustion, slow gait speed, poor handgrip strength, and low physical activity. The results were classified as follows: not frail, no criteria present; pre-frail, one or two criteria present; and frail, three or more criteria present.

Medications

A medication review was performed at a community visit. RAs examined all containers for prescription, over-the-counter, and herbal medicines used in the previous month, and the name, daily dose, and strength were recorded. Upon hospital examination, PI confirmed the RAs’ record of medication used with the hospital electronic medical record system.

Fall assessment

Fall evaluations were determined based on the STEADI guideline and geriatric emergency department guideline. The home environment was assessed based on a checklist to assess for fall hazards such as imbalanced stair, improper lighting in the hallway, hand drill in the bathroom, and slippery floor.

Quality of life [35]

WHOQOL-BREF-THAI was used to evaluate the individual’s perception of participants in the main concept of their goal, expectations, and value of life. It has 26 items assessed on a scale of 0–5. Therefore, the final score can range from 0 to 130. Four domains are evaluated: physical health, psychological well-being, social relationships, and the environment. Our study modified the score for each domain to 0–100, following the WHO recommendations. A higher score indicates better perception of quality of life.

Clinical examination

Evaluation for clinical examination was performed by three emergency physicians who had experienced taking care of older adults for at least 5 years, three RAs who had a bachelor’s degree in health science, and experienced nurse practitioners. Before the examination started, one physiatrist trained all physicians and RAs to evaluate their physical performance. The examiner was carefully evaluated and gave participants 5–10 minutes of rest before each step of evaluation to avoid overexhaustion.

Mobility performance, muscle strength, and musculoskeletal examination

The purpose of examination was to assess muscle strength and muscle power, especially of the proximal muscle. The mobility performance assessment during hospital visit included time taken to get up and go and the 4-meter test. LS was established and defined by the Japanese Orthopedic Association in 2007 as a state of degraded mobility due to impaired locomotive organs, which increases the risk of disability.

Decreased motor function and musculoskeletal pathologies include degenerative spondylosis and spinal stenosis. LS in this study was defined using a geriatric locomotive function scale of 25 questions (GLFS-25) [37]. A score of ≥ 16 indicates LS. The study showed that GLFS-25 is associated with decreased gait speed and a risk of falls [13,14].

Fall evaluations

During hospital visits, RAs recorded orthostatic vital signs, the time taken to get up and go [39-41], physical performance [38,42-45], somatosensory function, and ultrasound muscle mass.

Each participant received a telephone follow-up at 3, 6, and 12 months.

Physical performance [42-45]

The lower extremity mobility performance was evaluated using the Short Physical Performance Battery (SPPB) [38]. The SPPB measures the total time taken to perform the sit to stand test five times, 4-meter walking speed [41], and balance while standing. The full range was based on a scale from 0 to 12.

Berg balance scale

The Berg Balance Scale consists of 14 balance tasks. The scale has been validated as a fall risk assessment tool for community-dwelling older adults.

Somatosensory function test

Light touch was evaluated using Semmes–Weinstein monofilament test (size, 5.07; weight, 10 g). We tested the greater toe and the head of the first, third, and fifth metatarsal areas. The test results were categorized as sensory deficit and no deficit.

Sarcopenia [46]

Sarcopenia was defined as an age-related loss of skeletal muscle, decreased muscle strength, and low physical performance. For identifying patients at risk for sarcopenia, we followed the Asian Working Group for Sarcopenia 2019 criteria for diagnosis.

Criteria for sarcopenia diagnosis

Grip strength was evaluated using the grip dynamometer model TK-1201 (TAKEI KIKI KOGYO, Japan) (male, < 28 kg; female, < 18 kg). *Physical performance* was evaluated based on a 6-meter walk (< 1.0 m/s) or 5-time chair stand test (≥ 12 seconds). *Appendicular skeletal muscle mass (ASM)* was evaluated using BIA (male, < 7.0 kg/m²; female, < 5.7 kg/m²). Sarcopenia was defined as having low ASM plus low muscle strength or low physical performance. Severe sarcopenia were defined as having low ASM plus low muscle strength and low physical performance.

Dehydration [25]

We performed a blood test to test the hydration status. Hypertonic dehydration was defined by serum osmolality: current dehydration (>300 mOsm/kg), impending dehydration (295–300 mOsm/kg), and normal hydration (275 to <295 mOsm/kg).

Statistical analysis

Statistical analysis was performed using STATA version 15.0. A descriptive statistic was used for the baseline demographic data. We implemented a survival analysis as part of a prospective analysis to assess the risk of falls associated with the risk of sarcopenia and dehydration (not presented in this paper). It is beyond the scope of this study to present all plan analyses performed for the Bangkok falls study; therefore, we have described a standard methodology that will be used as part of our research. The incident of falls will be identified using a new case of a fall with a recurrent fall, which has been presented as a cumulative rate. We analyzed the time to first fall using a survival analysis. Multivariate analysis was used to estimate the relative risk of falls. We used a general linear model to depict repeatedly ordinal outcomes with correlated responses, such as Poisson regression. Other analyses included structural equation modeling to determine whether there are latent variables, as defined by shared covariate potential fall risk factors.

Recruitment

The recruitment and enrollment process is depicted in Figure 2. Our study identified 1,931 (11.2%) older adults aged ≥ 60 from the total population ($N = 17,228$) from Dusit District.

A total of 1,107 people were screened, of which 824 (42.76%) refused to participate in the study. After the screening process, the following information were obtained: 91 (4.7%) people were bedridden, 10 (0.52%)

people scored more than 12 on the six-item cognitive screening, and 5 (0.26%) people were blind or deaf. Finally, 1,001 (51.84%) people were eligible for our study.

Baseline characteristics

The average age of our study was 69.9 years old (SD, 6.8), and two-thirds were female. Of the study cohort, 100% were Asian, and 98.40% were Buddhist. The study cohort had a high prevalence for education less than high school (57.44%) and unemployment (51.65%). The rate of unemployment increased among older adults aged ≥ 85 years old. Most of the participants had a caregiver (78.4%). The average age of the caregiver increased among older adults aged ≥ 85 years old (mean, 58.6 ± 15.4 years). Hypertension was the most common underlying disease, and the rate increased with age. Data are shown in table 2.

Table 2

Baseline characteristics

Functional status, fall history, and quality of life (Table 3)

Almost half of the older adults in our cohort had mild to moderate cognitive impairment. One-third had a frailty phenotype score of ≥ 3 . Our study revealed that 16.4% were obese, and one-fifth (18.6%) were at high risk for malnutrition based on the MNA. Overall, 25% had experienced falls within 1 year, and the rate increased among older adults aged ≥ 85 years old.

Using STEADI screening fall risk, our study found that 37.7% had scores ≥ 4 , which means that there is a risk of fall. In addition, the risk of falls increased among older adults aged 75–84 years (49.5%) and older adults aged ≥ 85 years (67.7%) (P -value < 0.001) (Table 3).

Table 3

Functional status, fall history, and quality of life

Characteristic	Total N=1,001(%)	Age (year)			P- value
		60-74 N=764(%)	75-84 N=206(%)	85 N=31(%)	
Gender					
Female	690 (68.9)	529(69.2)	141(68.5)	20(64.5)	0.844
Age (year), mean (SD)	69.9 (6.82)	66.8(2.7)	78.6(2.7)	86.9(2.0)	
Age (year), median(IQR)	69(64,74)	67(63,70)	78(76,80)	87(85,88)	
Religion					0.446
Buddhism	985(98.4)	752(98.4)	203(98.5)	30(96.8)	
Christianity	5(0.5)	3(0.4)	1(0.5)	1(3.2)	
Islam	10(1.0)	8(1.1)	2(1.0)	0	
Sikhism	1(0.1)	1(0.1)	0	0	
Education level					0.001
Uneducated	77(7.7)	48(6.3)	22(10.7)	7(22.6)	
Less than high school	575(57.4)	437(57.2)	121(58.7)	17(54.8)	
High school	302(30.3)	239(31.3)	59(28.6)	4(12.9)	
College or higher	47(4.6)	40(5.2)	4(1.9)	3(9.7)	
Profession					0.006
Unemployee	517(51.7)	370(48.4)	125(60.7)	22(71.0)	
General trading career	182(18.2)	144(18.9)	36(17.5)	2(6.5)	
Employment	155(15.5)	136(17.8)	16(7.8)	3(9.7)	
Others	95(9.5)	73(9.6)	20(9.7)	2(6.5)	
Retired government employee	52(5.2)	41(5.4)	9(4.4)	2(6.5)	
Has care giver	785(78.4)	591(77.4)	171(83.0)	23(74.2)	0.173
Age of care giver (year), mean (SD)	52.5 (17.92)	50.9(16.9)	57.0(18.1)	58.6(15.4)	<0.001
Caregiver					0.147
Secondary-degree relative	140(14.0)	103(17.4)	33(19.2)	4(17.4)	
First-degree relative	346(34.6)	251(42.5)	80(46.5)	15(65.2)	
Spouse	273(21.5)	218(36.9)	52(30.2)	3(13.0)	

Others	27(2.7)	19(3.2)	7(4.1)	1(4.4)	
Charlson co-morbidity score, mean (SD)	3.24(1.3)	2.9(1.1)	4.3(1.2)	4.7(0.7)	<0.001
Hypertension	585(58.4)	425(55.6)	138(67.0)	22(71.0)	0.005
Dyslipidemia	428(42.8)	318(41.6)	95(46.1)	15(48.4)	0.416
Alcohol	86(8.6)	78(10.2)	6(2.9)	2(6.5)	0.001
Smoking	85(8.5)	78(10.2)	7(3.4)	0	0.001

Characteristic	Total N=1,001(%)	Age (year)			P value
		60-74	75-84	85	
BMI (kg/m ²), mean (SD)	25.8(4.7)	26.2(4.9)	24.7(3.7)	24.5(4.9)	<0.001
< 18.5	49(4.7)	39(5.1)	7(3.4)	3(9.7)	
18.5-29.9	788(78.7)	582(76.2)	185(89.8)	21(67.7)	
≥ 30	164(16.4)	143(18.7)	14(8.8)	7(22.6)	
6-CIT score					<0.001
0-7	539(53.9)	442(57.9)	85(41.3)	12(38.7)	
8-9	324(32.4)	238(31.2)	79(38.4)	7(22.6)	
10-12.	138(13.8)	84(11.0)	42(20.4)	12(38.7)	
Use of walking aid	91(9.1)	44(5.8)	36(17.5)	11(35.5)	<0.001
Frailty score (3)	307(30.7)	215(28.1)	80(38.8)	12(38.7)	0.008
History of fall in 1 year	252(25.2)	190(24.9)	52(25.2)	10(32.3)	0.626
Indoor falls	124(49.2)	92(48.4)	25(48.1)	7(70.0)	0.457
Outdoor falls	128(50.8)	98(51.6)	27(51.9)	3(30.0)	
STEADI score (4)	377(37.7)	254(33.3)	102(49.5)	21(67.7)	<0.001
Eye examination within 1 year	498(49.8)	362(47.4)	115(55.8)	21(67.7)	0.012
Mini Nutrition Assessment Score					0.001
24 – 30 : Normal nutritional status	804(80.3)	633(82.9)	152(73.8)	19(61.3)	
17 – 23.5 : High risk for malnutrition	186(18.6)	125(16.4)	50(24.3)	11(35.5)	
< 17 : Malnourished	11(1.1)	6(0.8)	4(1.9)	1(3.2)	
WHO QOL-BREF-THAI					
Domains					
1. Physical health	48.9(9.8)	49.0(11.1)	48.8(11.7)	46.2(9.8)	0.361
2. Psychological	57.5(12.4)	57.5(12.4)	57.4(12.5)	58(10.9)	0.968
3. Social relationships	60.5(17.8)	60.7(17.4)	60.2(18.9)	58.7(19.4)	0.789
4. Environment	70.3(14.1)	70.1(14.0)	70.7(14.6)	70.8(14.2)	0.837

Data collection

From a total of 13 community visits, the median number of participants was 86 (IQR, 52–94). The estimate average length of the interview was 20 minutes per person. One month after the community visits, we scheduled each participant for clinical examination at the hospital. Of the participants, five had died, four refused to visit the hospital, and 90 could not be contacted because of the COVID-19 lockdown policy implemented in Bangkok, which forced the relocation of some older adults to rural areas; they were no longer part of the community population.

A total of 902 (90.1%) participants completed the hospital follow-up visits. The median length of clinical examination was 2.2 hours (IQR, 1.5–3.0) per person. Of the 902 participants, 898 (99.5%) performed the timed up and go, 4-meter walk test, and SPPB test. All participants had ultrasound muscle mass and inferior vena cava vein. There were four participants for which the blood test results could not be interpreted. No participants reported adverse events associated with the research. At the 12-month follow-up visit, 832 participants were retained in the study. Six participants died (data not presented).

Discussion

This study demonstrated the feasibility of a population-based study of community-dwelling older adults aged ≥ 60 years residing in a middle-income country to identify fall risk factors with the aim of developing a community health system that can reduce the number of events of falls. The results showed excellent information obtained from community visits, as there was no missing data. For the hospital visit, the data obtained from participants was good; however, the COVID-19 outbreak and the lockdown policy prevented contact with some of the participants (90/1001 (9%)). However, 99% participants who visited the hospital completed leg examination, ultrasound for the evaluation of muscle mass, and blood tests for the hydration status. The rate of completed leg examination was higher than the MBS [15] study because we included older adults aged ≥ 60 years, which was younger than the ages of participants included in the MBS study (adults aged > 70 years). The older the age range of participants, the higher the percentage of reported frailty and use of walking aids.

Participants reported a positive experience from their participation in the study, as the rate of retention was $\sim 90\%$. Our research team took precautions regarding the comfort and safety of the participants. At the community visits, we provided breaks with the option for snack or lunch and rest periods to reduce fatigue and exhaustion. We had a Line group connection with participants who were willing to receive information or health recommendations about falls from our research team (Line is a freeware app for instant communication via electronic devices such as smartphones, tablets, or computers) [47].

Our study evaluated fall risk based on a combination of environmental causes, cognitive and physical function, balance and physical performance, hydration and nutritional status, and sarcopenia. Several studies have described reasons for falls, including gait and balance limitations, that have not been well defined, such as weakness or loss of stability [1, 6, 7]. The roles of sarcopenia, hydration status, and

nutritional status have not yet been explored in other fall studies. Furthermore, studies on the use of rapid screening tools, such as ultrasound screening for sarcopenia, and their efficacy in evaluating fall risk in older adults have been limited. The Bangkok falls study provides a resource for future research, especially in Asian countries where cultural and environmental influences have been reported as factors in fall risk.

Using a population-based study allowed us to generalize our results in comparison with other populations of older adults. Our study cohort represented Asian older adults without significant severe cognitive impairment who live in an urban community setting and are able to walk around their home. Thus, ~ 42% refused to participate in our study for the primary reason that they did not have time to participate in the community site visits on the weekend for various reasons such as having a trade or job commitment on the weekend. In Bangkok, people generally work on weekends, especially when they are a trader.

Because of the limitations of the baseline population-based study, we set the study aims for five projects. The fall risks were central and may not have been specific to each project. We selected only a few factors to use as adjustment variables for performing the multivariate analyses rather than a measurement of primary exposure. For example, we determined the peripheral neuropathy of the foot rather than specific deformities, such as narrow toe boxes, absent fixation, or excessively flexible heel counter or soles.

Conclusion

This study demonstrated the feasibility of conducting a population-based cohort study among urban older adults in a middle-income country using the local community healthcare system. Our results explored fall risk factors and disability in older adults. The study revealed that older adults in urban areas feel energetic interest in performing an activity and a desire to participate in this type of research. The Bangkok falls study supplies a data resource for fall risk factors in urban older adults.

Abbreviations

LS: locomotive syndrome, RAs: Research assistants, STEADI: Stopping Elderly Accidents, Death and Injuries, MNA: Mini Nutritional Assessment, WHOQOL-BREF-THAI: World Health Organization Quality of Life, ASM: Appendicular skeletal muscle mass, SD: Standard deviation, SPPB: the Short Physical Performance Battery, IQR : Interquartile range

Declarations

Ethics approval and consent to participate

Our study was approved by Vajira institutional review board which adheres to the Declaration of Helsinki, the Belmont Report, CIOMS Guideline, ICH-GCP. (Ref: COA 107/2562). The informed consent was obtained from all subjects involved in the study and legally authorized representatives of dead patients.

Consent for publication

Not applicable

Availability of data and materials

All data generated and/or analysed during the current study available from corresponding author on reasonable request.

Competing interests

The authors have no potential conflicts of interest to disclose.

Funding

Thai Health Promotion Foundation

Authors' contributions

JS, TK, TP, YF, RRu conceived and design a study. JS, TP, KR, AV, RRo and RRu acquisition of the data. JS, TK and TP analyses and interpretation of the data. JS and TP drafted of the manuscript. JS, RRu, RRa, YF critical revision of the manuscript for important intellectual content and statistical expertise. All authors approved the final version of the manuscript to be published

Acknowledgments

The authors would like to thank Thai Health Promotion Foundation for funding this study and Vajira Hospital for allowing this study to commence.

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Figures



Mobility performance: Short Physical Performance Battery (SPPB) [38], time up and go [40,41],
4-meter normal walking speed [41], test for LS

Balance: Standing balance +/- divided task, Berg balance test [42-44]



Muscle strength: Leg muscle strength and muscle power, five times sit to stand test [45]



Sarcopenia test [46]: Ultrasound muscle mass and inferior vena cava size, dynamometer,
bioelectrical impedance analysis (BIA)



Modified Semmes–Weinstein neuropathy assessment (monofilaments)



Blood test: Non-fasting blood test, serum osmolarity, electrolyte, blood urea nitrogen, and
creatinine

Figure 1

Clinical Examination

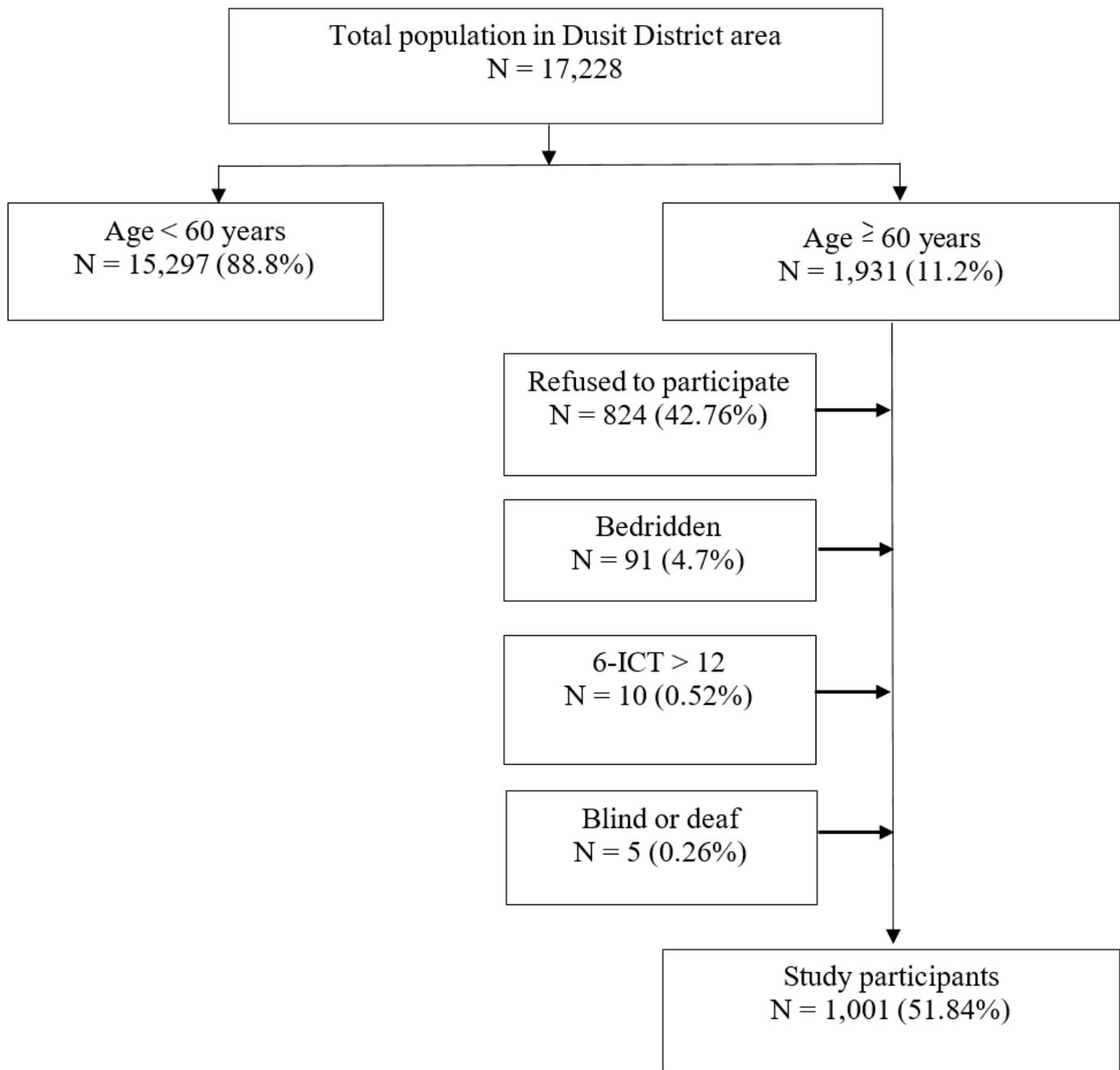


Figure 2

Recruitment and enrollment of participants for the Bangkok fall study