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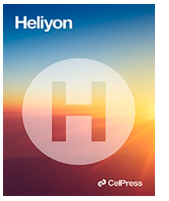

Research article

Development of cognitive frailty screening tool among community-dwelling older adults

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ABSTRACT

Purpose: To develop a brief screening tool consisting of twelve items that can be self-administered for rapid identification of older adults at risk of cognitive frailty (CF), named as Cognitive Frailty Screening Tool (CFST).
Patients and methods: A total of 1318 community-dwelling individuals aged 60 years and above were selected and assessed for cognitive frailty using a set of neuropsychology batteries and physical function tests. A binary logistic regression (BLR) was used to identify predictors of CF to be used as items in the screening tool. A suitable cut-off point was developed using receiver operating characteristic analysis.
Results: Twelve items were included in the screening tool, comprising of gender, education years, medical history, depressive symptoms and functional status as well as lifestyle activities. The area under the curve (AUC) was 0.817 (95 % CI:0.774–0.861), indicating an excellent discriminating power. The sensitivity and specificity for cut-off 7 were 80.8 % and 79.0 %, with an acceptable range of positive predictive value (PPV) (73.3 %) and negative predictive value (NPV) (85.2 %) for screening tools. Concurrent validity of CFST score with standard cognitive and frailty assessment tools shows a significant association with the total score of CFST with low to moderate correlation ($p < 0.05$ for all parameters).
Conclusion: CFST had good sensitivity and specificity and was valid for community-dwelling older adults. There is a need to evaluate further the cost-effectiveness of implementing CFST as a

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screening for the risk of CF in the community. Its usage in clinical settings needs further validation.

1. Introduction

The aging population poses great challenges globally, where age-related chronic conditions, especially dementia, extensively increase healthcare needs and affect the quality of life of older adults. Given the limited availability of therapeutic drugs for dementia, it is critically important to pinpoint its risk factors to assist the policymakers in screening and intervening in those at high risk effectively. Frailty is an age-related syndrome characterized by decreased physiological reserves and increased vulnerability to stressors [1]. Prior studies have indicated that the five components of frailty, including weight loss, tiredness, low grip strength, reduced physical activity, and slow gait speed, independently predicted the incidence of dementia [2]. The presence of physical frailty increases the prevalence of cognitive impairment, and co-existing these conditions accumulate negative effects and confer a greater risk of adverse health outcomes [3–5].

Cognitive frailty (CF) refers to a condition in which an individual experiences both physical frailty and mild cognitive impairment, as indicated by a Clinical Dementia Rating (CDR) of 0.5. This term was defined by the International Academy of Nutrition and Aging (IANA) and the International Association of Gerontology and Geriatrics (IAGG). Notably, CF is distinct from various dementias, as those conditions are excluded from this definition [6]. There are two types of CF subtypes, which are reversible CF (pre-frailty and subjective cognitive decline) and potentially reversible CF (frailty and mild cognitive impairment, CDR = 0.5) [7]. Solfrizzi et al. [8] have reported that even reversible CF is a robust predictor of dementia and mortality after adjusting for vascular risk factors and depressive symptoms, suggesting its role as a physiological precursor to degenerative nervous system diseases and adverse health outcomes. Besides CF, various subtypes of frailty have been proposed, such as psychological, social, and oral frailty, each encompassing different domains of physiological dysfunctions [9–11]. Psychological frailty signifies emotional or psychological vulnerability [10], while social frailty relates to social isolation, limited social networks, or challenges in engaging in social activities [9]. Oral frailty specifically denotes deterioration in oral health [11]. Overall, CF stands out among these sub-categories of frailty due to its specific emphasis on the complex interplay between cognitive and physical health in older adults.

The prevalence of CF among Malaysian older adults is 39.6 % [12], which is higher than the figure reported from other Asian studies that ranged from 1.0 to 6.7 % [4,13,14]. According to the subtypes, Ruan et al. [15] has reported that the prevalence of reversible CF and potentially reversible CF was 19.9 % and 6.3 %, respectively. The difference in prevalence rates could be attributed to the distinct operationalization of cognitive frailty (CF), wherein combining the groups of cognitively pre-frail and cognitively frail individuals resulted in a higher prevalence rate. Pre-frailty exhibits clear distinctions from normal aging, as evidenced by the involvement of clinical, functional, behavioral factors, and biomarkers associated with pathological aging process, suggesting the possibility of grouping pre-frailty together with frailty as a target group for potential interventions [16]. In accordance, it was reported that increased age, depression, decreased processing speed, reduced functional status and low vitamin D intake were predictors for CF in Malaysian older adults, where both pre-frailty and frailty status were grouped in a same categories [17].

Early identification of older adults at risk of CF is the first step to facilitate early management, personalised care and prescribing of multi-domain interventions [18], which may slow the onset of physical decline, dependency, and dementia and regarding the syndrome onset [6]. The biggest challenge in diagnosing CF was that most previous studies used comprehensive but time-consuming instruments to assess cognitive function, limiting its use in busy clinical settings [19]. At present, the most widely used cognitive screening tool for mild cognitive impairment (MCI) is the Montreal Cognitive Assessment (MoCA) and Mini-Mental State Examination (MMSE). However, its specificity is poor in many studies due to its variability in cut-off according to the population [20,21].

Tseng et al. [22] developed and validated a simple, evidence-based instrument known as cognitive frailty risk (CFR) to identify community-dwelling older adults at risk of CF. CFR has six items developed based on simple history-taking, including age, sex, cardiometabolic risk, memory, sarcopenia and nutrition. However, CFR required anthropometric measurements to be taken. These would require a specific tool and trained individuals to perform the measurement.

Apparently, the self-administered screening tools for detecting CF in the community or clinical settings are still very limited. Since detecting cognitive decline and frailty remains difficult, developing a simple screening tool seems desirable to identify individuals at high risk of CF as a first step prior to a more comprehensive assessment for intervention planning. Hence, this study intended to develop a simple screening tool to identify individuals at risk of CF in the population.

2. Material and methods

2.1. Study design and population samples

Study data were excerpted from a previous longitudinal study on the Neuroprotective Model for Healthy Longevity (LRGS TUA) cohort [23], where a total of 2322 older adults aged 60 years and above were recruited at baseline. It is important to note that in Malaysia, older adults are defined as individuals aged 60 years and above, in line with various policy and healthcare planning purposes, as it delineates the population segment requiring specific attention and resources to address their unique needs and challenges associated with aging [24]. The participants were selected from four states in Malaysia, namely Selangor, Perak, Kelantan and Johor, to represent Malaysia's entire older adult population through a multi-stage random sampling procedure. The selection of participants

was made in collaboration with the Department of Statistics, Malaysia. The LRGS-TUA study was conducted for five years (from 2013 to 2018), consisting of four waves of follow-up (Wave I-IV). However, the frailty data from the South and the East Coast of Malaysia was unavailable at baseline and Wave II, thus reducing the number of participants included in the study to 815 only. Therefore, this study used Wave III data as a baseline (n = 1318) for cross-sectional analysis and the Wave IV data as a follow-up after 24 months for longitudinal analysis (n = 425) (acceptance rate: 51.5 %) (Fig. 1).

Older adults with dementia, any known psychiatric problems, severe vision, speech and auditory problems, and who were non-ambulant were excluded from this study. Based on Clinical Practice Guidelines of Dementia, moderate cognitive impairment for the Malaysian population was indicated by a Mini-Mental State Examination (MMSE) score of 15 and above [25], whereas those older adults with a score of below 15 were considered to have severe cognitive impairment and may be indicative of dementia. Ethical approval was obtained from the Medical Research and Ethics Committee of the Universiti Kebangsaan Malaysia (UKM1.21.3/244/NN-2018-145). This study was conducted according to the ethical principles established by the Declaration of Helsinki. Written information was given, and informed consent was acquired from all participants before participating.

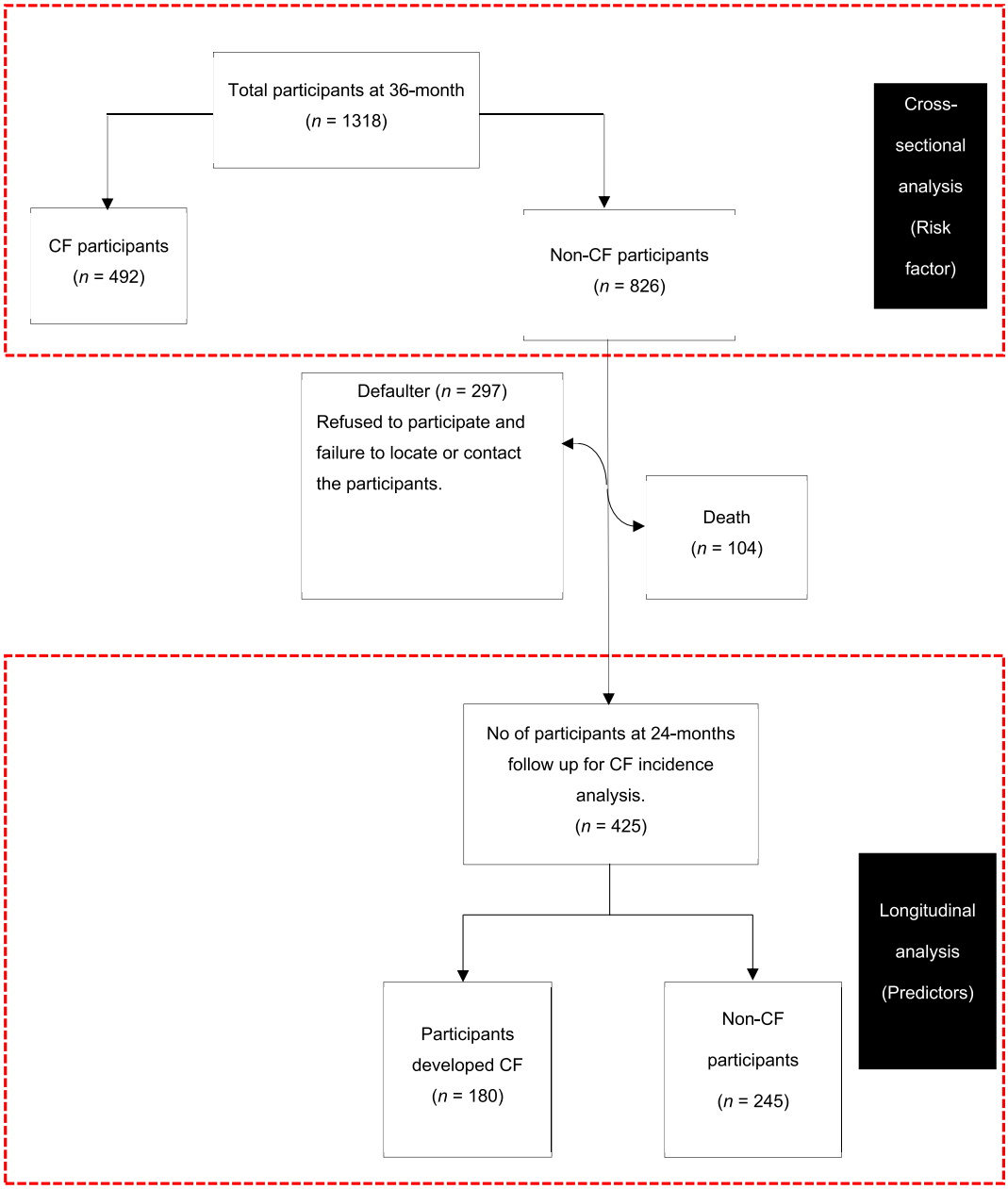

Fig. 1. Illustration of the number of participants from baseline to the 24-month follow-up for CF incidence.

2.2. Assessment of cognitive frailty status

The operationalization of cognitive frailty (CF) was based on the presence of both physical (pre-frailty/frailty) and cognitive assessments (subjective cognitive complaint; SCC/mild cognitive impairment; MCI), as reported in our previous study [12].

The frailty assessment applied in this study is based on the criteria and the cut-off points outlined in the Cardiovascular Health Study (CHS) [1]. Frailty consisted of five components, including; 1) shrinking, subjective report of unintentional weight loss of approximately 5 kg in the past few years, 2) self-reported exhaustion and poor endurance and energy, defined by the two items of the Centre of Epidemiologic Studies Depression scale (CESD), where a score of two or more was classified as exhaustion, 3) low physical activity assessed using the Malay version Physical Activity Scale for Elderly (PASE) with the lowest tertile of the score [26], 4) weakness was defined using a handgrip strength (digital hand dynamometer; Jamar® Plus+, Patternson Medical, IL, USA); and 5) slowness, measured using the 5-m gait speed test. Those participants with a score of one or two of these criteria were categorised as pre-frailty and three or more criteria as frailty.

Next, cognitive status classification was based on pretested questionnaires. Participants are classified as MCI if they meet the criteria proposed by Petersen et al. [27] and Lee et al. [28], which included no evidence of dementia with preserved global function, objective memory impairment (at least 1.5 standard deviation [SD] below the mean), subjective memory complaint by caregiver or participants (self-reported cognitive complaints by individuals who perceive a decline in their cognitive abilities compared to their previous level of functioning), no limitations experienced in basic activities of daily living (ADL), independent or extremely minimal difficulties in instrumental activities of daily living (IADL) (at least 1.5 SD below the mean norm). The MMSE score of 19 and above were chosen based on the study by Shahar et al. [23], indicating preserved global function. The determination of objective memory impairment was confirmed with a score of less or equal to 34 for the t-score Trial 5 RAVLT and less or equal to four for the scale score of Digit Span.

2.2.1. Study instruments

Sociodemographic information concerning age, sex, ethnicity, marital status, living arrangement, employment status, total monthly and household income, and period of formal education were gathered. Self-report medical comorbidities were recorded, namely, diabetes, hypertension, hyperlipidaemia, heart diseases, stroke, constipation, osteoarthritis, cancer, cataract/glaucoma, and urinary incontinence. A 20 ml was drawn by a qualified phlebotomist for biochemical analysis, including fasting blood sugar (FBS), Haemoglobin A1c (HbA1c), total cholesterol (TC), high-density lipoprotein (HDL), low-density lipoprotein (LDL) and albumin (ALB) evaluation.

Anthropometry measurement was conducted to examine the nutritional and functional status of the participants. The variables included weight, height, waist circumference, hip circumference, and calf circumference. Body mass index (BMI) was calculated and the participants were categorised as underweight ($<$18.5 kg/m^2), normal (18.5–24.9 kg/m^2), overweight (25.0–29.9 kg/m^2), and obese ($\geq$30.0 kg/m^2) [29]. Body composition was measured using the Bio-electrical Impedance Analysis InBody S10 (Biospace, Seoul, Korea).

Global cognitive function was assessed using the Malay version of the Mini-Mental State Examination (M-MMSE) [30] and the Montreal Cognitive Assessment (MoCA) [31], the Weschler Memory Scale-Revised (WMS-R) and the Digit Span Forward and Backward test were used to assessed attention and working memory; the Digit Symbol test was administered to measure the information processing speed; the Rey Auditory Verbal Learning Test (RAVLT) was used for verbal learning and memory assessment [32] and Clinical Dementia Rating (CDR) was performed to define objective cognitive impairment [33].

The potential depressive symptoms were assessed using the validated Geriatric depression scale-15 (GDS) [34]; loneliness was evaluated using a three-item loneliness scale [35]; social support status was measured by Medical Outcome Study Social Support Survey (MOSS) [36]; Instrumental Activities of Daily Living (IADL) was ask to assess functional status [37]. Several physical performance tests were performed, including a 2-min step, chair stand, chair sit and reach, back scratch, hand grip strength and timed up and go [38].

Furthermore, disability was evaluated using the WHO Disability Assessment Schedule (WHODAS) and captured six major domains: self-care, participation, cognition, mobility, getting along, and life activities [39]. The lifestyle of older adults based on their participation in physical, mental, and social activities was determined using the Victoria Longitudinal Study-Activity Lifestyle Questionnaire with Cronbach's α of 0.66 [40]. Besides that, the participants' dietary intake was also evaluated using a validated Dietary History Questionnaire [41].

2.2.2. Development of screening tool

The selection of variables for the screening tool was based on the risk factors and predictors associated with CF. The development of this screening tool considered the use of simple language, short sentences, and tools that can be self-administered easily by older adults.

2.3. Statistical analysis

Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS) IBM version 25.0 (Licensed materials – Property of SPSS Incorporation an IBM Company Copyright 1989 and 2010 SPSS Inc., Chicago, IL, United States). The details of the statistical analyses performed in this study are reported in the following sections.

2.3.1. Determination of twelve items for cognitive frailty screening tool (CFST)

A total of 1318 participants were involved in the study to identify the items for the screening tool. Items in CFST were selected via two methods; 1) risk factors from the cross-sectional study conducted among 1318 older individuals, 2) predictors identified from the longitudinal study conducted among 425 older individuals, which includes various potential factors such as sociodemographic, medical history, nutritional status, nutrients intake, functional and psychosocial status. Both findings mainly identified factors and predictors leading to CF among non-demented older adults via binary logistic regression. Notably, the missing data of five participants were handled using single imputation method, a technique where missing values are replaced with multiple sets of plausible values based on observed data patterns. This approach helps to preserve the uncertainty associated with missing data and produces more reliable estimates of model parameters.

The selection of questions related to CF was performed in two stages. The first stage was the univariate analysis between the parameters and CF status using Pearson χ^2 for categorical variables and an independent *t*-test for numerical variables. Factors with a significant p-value (less than 0.05) were entered into the multivariate model.

The second stage was the hierarchical binary logistic regression (BLR) performed between all the significant variables in the first stage, with CF status as the dependent variable. BLR was chosen because the dependent variable (CF status) had two categories. The reference variable for the BLR model was the Non-CF group, the participants without frailty and mild cognitive impairment. In this stage, we analysed all the significant variables from the univariate analysis cross-sectionally and longitudinally (data from 2016 to 2018) using BLR. Thus, any significant variables from this BLR model were risk factors and predictors of CF. BLR was employed in a stepwise manner due to the presence of numerous variables in this study. Six different BLR models were created, and the details of each model were as follows: (1) sociodemographic and medical status; (2) blood pressure, anthropometry, clinical profile, and biochemical indices; (3) social support, functional and depression status; (4) fitness and cognitive assessments; and (5) dietary intake associated with CF. Then, all significant variables ($p < 0.05$) from each model were included in the final logistic model (model 6). Table 1 shows the initial variables for the CF screening tools with their respective odds ratio (OR) and p-value.

Notably, items 10 and 11 were excluded due to their lengthy and time-consuming procedure, which is not compatible with the intention to develop a simple screening tool for CF. The items in Table 1 were further revised to establish a simple questionnaire. However, both GDS and IADL had questionnaires to identify the depressive symptoms and functional status, resulting in many items included in the CFST. Thus, the BLR analysis was performed for each item in GDS (15 items) and IADL (7 items) to determine the specific items directly associated with the CF incidence. BLR analysis was performed for each item to determine its odds ratio and significance value by controlling several confounding factors (age, gender, marital status, living arrangement, smoking status, and BMI) with CF incidence as the dependent variables (0 – Non-CF, 1 – CF).

2.3.2. Calculation of sensitivity, specificity, Youden's Index, positive predictive value (PPV) and negative predictive value (NPV) of the screening tool

The odds ratio of the selected variable was converted into a simplified coefficient for convenience in scoring. Sensitivity and

Table 1
Selection of variables for CF screening tool.

Variables	Adjusted Odd Ratio (OR)	*p*-value
Risk factors and predictors		
Socio-demography		
1. Gender (women)	1.592	<0.001***
2. Years of education (less than 6 years)	3.061	<0.001***
Health status:		
3. DM (yes)	2.077	0.012*
Depressive symptoms:		
4. GDS (had depressive symptoms)	2.993	<0.001***
Functional status:		
5. IADL (low functional status)		
Lifestyle activities:		
6. ALQ – Irregular gardening	1.466	0.008**
7. ALQ – Irregular exercise	1.395	0.015*
8. ALQ – Irregular reading	1.694	0.006**
9. ALQ – Irregular of using modern gadgets	2.921	0.016*
Physical performance tests:		
10. TUG test (lower performance)	1.099	0.020*
Dietary intake:		
11. DHQ (low vitamin C intake)	0.994	0.004**

Notes.
Abbreviations: ALQ = Activities lifestyle questionnaire; DHQ = Dietary history questionnaire; IADL = Instrumental activities of daily living; DM = Diabetes mellitus; GDS = Geriatric depression scale; TUG = Timed up and go; BLR = binary logistic regression; CF = cognitive frailty; Non-CF = Non-cognitive frailty; OR = odd-ratio. *p < 0.05, **p < 0.01, ***p < 0.001 — significant using BLR. Coding for dependent variables is 0-Non-CF, 1-CF.

Table 2
Selection of questions for CF screening tool in GDS and IADL questionnaire.

Parameters	OR (95 % CI)	*p*-value
Instrumental Activities of Daily Living (IADL)		
Item 1 - Can you use the phone?	3.870 (2.035, 7.360)	<0.001***
Item 2 - Can you go out to buy daily necessities or clothes?	1.051 (0.455, 2.426)	0.907
Item 3 - Can you do housework?	1.580 (0.513, 4.869)	0.425
Item 4 - Can you manage money?	0.883 (0.466, 1.676)	0.704
Item 5 - Can you go somewhere far (over 100 m)?	2.246 (1.051, 4.802)	0.037*
Item 6 - Can prepare own food	0.837 (0.318, 2.202)	0.719
Item 7 - Can take own medicine	1.039 (0.206, 5.241)	0.963
Geriatric Depression Scale (GDS)		
Item 1 - Are you satisfied with your life?	0.274 (0.053, 1.422)	0.123
Item 2 - Is your daily activity decreasing?	1.719 (1.105, 2.673)	0.016*
Item 3 - Do you feel your life is meaningless?	1.667 (0.528, 5.261)	0.383
Item 4 - Do you always feel tired or bored?	0.992 (0.463, 2.125)	0.983
Item 5 - Are you always in a cheerful state?	4.100 (0.741, 8.697)	0.106
Item 6 - Are you worried something terrible will happen to you?	1.076 (0.643, 1.800)	0.633
Item 7 - Do you always feel happy?	0.289 (0.045, 1.843)	0.189
Item 8 - Do you always feel helpless?	1.185 (0.640, 2.193)	0.589
Item 9 - Would you rather sit at home than go out and try something new?	1.974 (1.274, 3.057)	0.002**
Item 10 - Do you feel you have a problem with your memory compared to others?	1.567 (1.022, 2.401)	0.039*
Item 11 - Do you feel lucky in life now?	0.481 (0.081, 2.853)	0.420
Item 12 - Do you sometimes find yourself useless?	0.887 (0.282, 2.786)	0.837
Item 13 - Do you feel fully energised?	0.981 (0.517, 1.864)	0.954
Item 14 - Do you feel hopeless in the current situation?	3.007 (0.826, 9.951)	0.095
Item 15 - Do you think other people's condition is better than yours?	0.600 (0.327, 1.102)	0.100

*p < 0.05, **p < 0.01, ***p < 0.001 — significant using BLR. Coding for dependent variable are 0-Non-CF, 1-CF. Model $\chi 2$ test for IADL and GDS are significant (p < 0.05). Hosmer-Lemeshow for IADL ($\chi 2 = 1.048$, p = 0.790) and GDS ($\chi 2 = 5.753$, p = 0.675) indicated good fit for the logistic regression model to the data.

specificity were calculated for each cut-off point (Table 4) using the following formulae [42].

Sensitivity: True positive/(true positive + false negative)
Specificity: True negative/(true negative + false positive)
Youden's Index: [(sensitivity + specificity) – 100][43]
Positive predictive value (PPV) = [True positive/(true positive + false positive)] × 100.
Negative predictive value (NPV) = [True negative/(false negative + true negative)] × 100.

2.3.3. Determination of predictive accuracy of CFST tool

The area under the curve (AUC) of the receiver operating characteristic (ROC) was obtained to identify the predictive accuracy of the CFST in screening for CF among community-dwelling older adults. The greater AUC curve indicated the robustness of the screening tool in classifying cognitive decline. Each cut-off point was presented with a ninety-five per cent confidence interval (CI) (Table 2).

2.3.4. Concurrent validity

Concurrent validity was performed to determine the correlation between the score of the CFST with scores on standard cognitive and physical function tests such as MMSE, Montreal cognitive assessment (MoCA), digit span, RAVLT, digit symbol, visual reproduction test, senior fitness test and frailty phenotypes. This analysis was done using Pearson correlation for normally distributed data and Spearman's rho in case of violated assumption.

3. Results

The mean age of participants was 72.1 ± 6.2 years old, with 55.1 % being women. Table 1 shows the list of risk factors and predictors of CF obtained from the multivariate analysis, comprising the sociodemographic factors such as gender, years of education, medical history (diabetes mellitus), depressive symptoms (GDS), functional status (IADL), lifestyle activities (ALQ), physical fitness (TUG test) and nutrient intake (vitamin C). The model $\chi 2$ test revealed a significant association between the predictor variables and the outcome (p < 0.001), indicating that the model provides a better fit to the data than a model with no predictors. The goodness-of-fit of the logistic regression model was further assessed using the Hosmer-Lemeshow test, yielding a chi-square statistic of 3.389 with non-significant result (p = 0.908), suggesting the model fits the data well. The power of the study is 87.5 % probability of detecting a significant effect, given the sample size and effect size observed in this analysis. However, the two items related to TUG test and low vitamin C intake, as assessed using DHQ were excluded from the list due to its relatively tedious assessment process.

Further analysis of the IADL and GDS was conducted to pinpoint specific questionnaire items that show a significant association with an increased risk of cognitive frailty (CF) to streamline the number of items to be included in the CFST. As shown in Table 2, item 1

Table 3
Final list items for CFST and its scoring specifications.

Parameters	Answer options	Simplified coefficients (SC)
Socio-demography		
1. Gender	1. Men	0 for men
	2. Women	1 for women
2. How many years you have a formal education?	1. Never been to school	0 for more than six years
	2. Primary (1–6 years)	1 for six years and below
	3. Secondary (7–11 years)	
	4. Tertiary (≥12 years)	
Health status:		
3. Are you having DM?	1. No	0 for no
	2. Not sure	1 for yes
	3. Yes	
Depressive symptoms:		
4. Is your daily activity decreasing?	1. No	0 for no
	2. Yes	1 for yes
5. Would you rather sit at home than go out and try something new?	1. No	0 for no
	2. Yes	1 for yes
6. Do you feel you have a problem with your memory as compared to others?	1. No	0 for no
	2. Yes	1 for yes
Lifestyle activities:		
7. Do you do gardening or rearing animals?	0. Never	0 for often and very often (weekly and daily)
	1. Rarely	1 for rarely and sometimes (monthly or yearly)
	2. Sometimes	
	3. Often	2 for never
	4. Very often	
8. Do you participate in walking, cycling, tai chi, aerobic, poco-poco, dancing?	0. Never	0 for often and very often (weekly and daily)
	1. Rarely	1 for rarely and sometimes (monthly or yearly)
	2. Sometimes	
	3. Often	2 for never
	4. Very often	
9. Do you read paper, magazines, Al-Quran, holy books or any reading materials?	0. Never	0 for often and very often (weekly and daily)
	1. Rarely	1 for rarely and sometimes (monthly or yearly)
	2. Sometimes	
	3. Often	2 for never
	4. Very often	
10. Have you used modern gadgets such as iPad, laptops, or computers in the past year?	0. Never	0 for often and very often (weekly and daily)
	1. Rarely	1 for rarely and sometimes (monthly or yearly)
	2. Sometimes	
	3. Often	2 for never
	4. Very often	
Functional status:		
11. Can you use the phone?	1. No, unable to use the phone	0 for yes
	2. Yes, with the help	1 for yes but with help or no
	3. Yes	
12. Can you go somewhere far (over 100 m)?	1. No, unable to walk far	0 for yes
	2. Yes, with the help	1 for yes but with help or no
	3. Yes	
Total score		**16**

Abbreviations: DM = Diabetes mellitus; SC = Simplified coefficient.

Table 4
AUC, Sensitivity, Specificity, Youden's Index, PPV and NPV for each cut-off point.

Cut-off	Sensitivity (%)	Specificity (%)	*Youden's* Index	PPV	NPV
≥5	92.7	54.0	46.7	55.0	89.8
≥6	91.5	64.9	56.4	65.1	91.5
≥7	80.8	79.0	59.8	73.3	85.2
≥8	65.0	86.3	51.3	77.2	77.5
≥9	38.4	93.1	31.5	80.0	67.9
≥10	22.6	95.2	17.8	76.9	63.3

*Cut-off 7 was chosen for scoring of CFST because it had the highest Youden's Index. Abbreviation: CI: confidence interval; PPV: Positive predictive value; NPV: Negative predictive value.

(Can you use the phone?) and item 5 (Can you go somewhere far over 100 m?) in the IADL questionnaire were significantly associated with CF. On the other hand, three items in GDS significantly increased the risk of CF, including item 2 (Is your daily activity decreasing?), item 9 (Would you rather sit at home than go out and try something new?) and item 10 (Do you feel you have a problem

with your memory compared to others?). All the significant items in each questionnaire were included in the final list of CFST.

The final selected items for CFST, as shown in Table 3, consist of 12 questions easily administered, potentially even by older adults themselves or their caregivers. The model $\chi 2$ test showed a significant association between predictor variables and the outcome ($p < 0.001$), and Hosmer-Lemeshow test yielded a non-significant result ($p = 0.688$) with a chi-square statistic of 5.636, suggesting good fit of the logistic regression model to the data. Each item was allocated into a simplified coefficient (SC) derived from the odds ratio (ORs) for easier scoring.

The AUC, sensitivity, specificity, Youden's Index, positive predictive value (PPV), and negative predictive value (NPV) were derived. The AUC was similar for all the cut-off points; 0.817 (95 % CI: 0.774, 0.861), indicating a very good discriminating power. The minimum CFST score was zero, and the maximum 16. The cut-off of the derived model was defined as CFST >7 (Table 3), where a higher score indicates a higher risk of CF. Cut-off seven was selected because it had the highest Youden's Index (59.8), good sensitivity (80.8 %), and specificity (79.0 %) value with an acceptable range of PPV (73.3 %) and NPV (85.2 %) for screening tools. The high PPV indicated the accuracy of this screening tool in predicting the occurrence of CF among older participants.

The prevalence of an individual with a high risk of CF assessed using CFST was 46.7 %. In addition, concurrent validity assessed the correlation between CF screening tools score with standard cognitive and frailty assessment tools (Table 5) to test its validity against some outcome measures. Pearson's correlation was employed in this analysis. Generally, all cognitive and physical assessments have significant association with the total score of CFST with low to moderate correlation ($p < 0.05$ for all parameters).

4. Discussion

The CF screening tool has been successfully developed to identify older adults at a higher risk of CF incidence in our current study. Unlike other screening tools, which are time-consuming and solely focus on either physical function or cognitive assessments. CFST is a comprehensive screening tool consisting of socio-demographic information, morbidity, functional and depression assessment, as well as lifestyle activities. CFST is a senior-friendly screening tool because it consists of 12 short items and employs a simple language which could be easily understood and answered by older individuals, caregivers and the public (no scientific jargon used). This tool can also be self-administered and quickly executed.

The CFST tool would be suitable to be used in primary care or community settings due to shorter administrative time and does not require technical expertise to conduct the test. Unlike MMSE and Montreal Cognitive Assessment (MoCA) characterised by education bias [44], CFST presents with minimum educational or cultural bias, indicating that all older individuals could use this tool, irrespective of their background. Furthermore, CFST could be administered face-to-face, virtually, or by phone call as this tool does not require complex assessments and lengthy procedures. Since scores for each answer option would be stated below every question, the risk of CF could be detected via self-calculation scores. Scores of seven and above have been chosen as the most appropriate cut-off point for CFST, considering its highest Youden's Index (59.8) and sensitivity values (80.8 %). Additionally, CFST was reported to have an excellent Area Under Curve (AUC) value (0.82) that indicated its robustness in distinguishing participants at risk of CF. Hosmer and Lemeshow [45] have categorised the AUC into four categories to demonstrate the strength of the screening tool in predicting the risk of its outcome: less than 0.7 (poor), 0.71–0.80 (acceptable), 0.81–0.90 (excellent), 0.91–1.00 (outstanding discrimination).

Another important feature of the CFST tool is its good sensitivity (80.8 %), which is higher than the values reported by other cognitive frailty screening tool developed by Tseng et al. [22] known as cognitive frailty risk (CFR) with 70 % sensitivity. The CFR

Table 5
Concurrent validity between CF screening tools and standard cognitive and frailty assessment tools.

Variables	Correlation coefficient	p-value
Cognitive assessments		
Digit symbol	−0.248	<0.001***
Digit span	−0.181	<0.001***
RAVLT Trial 5	−0.198	<0.001***
RAVLT Trial 6	−0.191	<0.001***
VR I	−0.180	<0.001***
VR II	−0.163	<0.001***
CDR	0.400	<0.001***
Physical performance tests		
2-min step test	−0.165	<0.001***
Chair stand test	−0.168	<0.001***
TUG test	0.218	<0.001***
Frailty phenotypes		
1. Poor strength - Hand grip test	−0.188	<0.001***
2. Slowness - Gait speed test	−0.227	<0.001***
3. Exhaustion – CES-D score	0.161	<0.001***
4. Low physical activity – PASE score	0.231	<0.001***
5. Unintentional weight loss (0 – No; 1 – Yes)	0.146	0.042*

***$p < 0.001$ significant using Pearson correlation for continuous variable and cross-tabulation for categorical data. **Abbreviation:** CDR = Clinical dementia rating; CI = confidence interval; VR = Visual reproduction; RAVLT = Rey Auditory Verbal Learning Test; TUG = Timed up and go test.

score was developed and validated in different cohort with distinct demographic characteristics and epidemiology of CF, which could have affected the sensitivity value of the tool [22]. Since CFST was developed based on the risk factors and predictors identified among Malaysian community-dwelling older adults, thereby, the sensitivity could be different if validated in different communities.

Moreover, the sensitivity of the CFST was also higher than the cognitive assessment tools used to identify older adults with MCI. For example, the most widely used cognitive screens for MCI is MMSE and MoCA. Using the cut-off less than 27, the sensitivity and specificity of MMSE were 0.765 and 0.636 respectively, compared to MoCA with a sensitivity of 0.682 and specificity of 0.613 with the cut-off point 17/18 among Malaysian older adults [46,47]. However, these cognitive assessments have a relatively long administration time, limiting their use in the busy clinical setting. The most recent screening tool developed among Malaysian older adults was TUA-WELLNESS, which is useful to identify older adults with high risk of MCI [48]. Although this tool has good AUC (0.84 %), sensitivity (83.3 %) and specificity (73.4 %), TUA-WELLNESS is not applicable for diagnostic purpose as all the items were developed based on cross-sectional analysis. Clinical dementia rating (CDR) differs from the abovementioned ones as it is an informant-based global clinical instrument with a sensitivity of 0.93 and specificity of 0.97,[49]. which is much higher than CFST. Although the CDR had outstanding discrimination, this tool has several drawbacks, including its length of administration, reliance on professional's judgement, and availability of a reliant informant [50]. Nevertheless, other objective measures, including CDR, could be performed among those screened with CFST for further diagnosis and management plans.

The definition of frailty from Cardiovascular Health Study criteria (CHS criteria) have been used worldwide for screening frailty among older populations [1]. However, this tool has a limitation in time-consuming cases because in the CHS five criteria have to be evaluated. Besides, the Clinical Frailty Scale (CFS), simple FRAIL questionnaire, PRISMA-7 questionnaire, Time Up and Go and Gerontopole frailty screening tool (GFST) tests have a sensitivity of 56 %, 88 %, 84 %, 72 %, and 88 % with a specificity of 98.41 %, 85.71 %, 78 %, 82.54 % and 83.56 %, respectively. Almost all assessment tools have sensitivity and specificity of more than 80 %, indicating their efficacy in identifying older adults with frailty [51]. Nevertheless, these assessments were designed solely to identify older adults with frailty, and none have specifically identified CF.

In this study, the positive predictive value (PPV) (73.3 %) and negative predictive value (NPV) (85.2 %) of the CFST were high to discriminate against older adults with high and low risk of CF. The PPV of this study was the proportion of older adults correctly identified as being CF, while the NPV was the proportion of those correctly identified as not being CF. A high PPV value is essential to avoid missed screening of older adults with CF, and these values are influenced by the disease prevalence. In other words, an excellent screening test will have a poor PPV in a low-prevalence population. In contrast, with a good screening test, the NPV will be high when the incidence of the disease is low [52].

As compared to previous CF assessment tools [22], CFST was more comprehensive in investigating lifestyle predictors of CF. The items included in CFST were the significant risk factors and predictors of CF obtained from both cross-sectional and longitudinal studies described previously. Older adults who consistently obtained scores of seven and above were at risk of CF. Hence, they are required to practice lifestyle changes to reduce the likelihood of being diagnosed with CF. Engaging in gardening and avoiding a sedentary lifestyle by actively participating in exercises were the recommended lifestyle adaptations to prevent frailty and disability. Additionally, older adults should also engage in mentally stimulating activities such as reading and actively using modern gadget such as computers, laptops and others to prevent cognitive decline.

By using CFST, the prevalence of CF was 46.7 %, which is higher than the figure reported previously among the same population [12]. Unlike the conventional method, which may rely on more comprehensive assessments or diagnostic criteria, CFST may be more sensitive in detecting an individual with a risk of developing CF. The concurrent validity for the CFST indicated a significant and low to moderate correlation with other cognitive and physical assessment tools, particularly CDR. In the CFST, questions related to education years, chronic disease and depressive symptoms were strongly associated with cognitive decline and dementia among older adults [53,54]. Both CFST and CDR comprised critical components to assess cognitive impairment and dementia, thus resulting in a good agreement between the two measures. Furthermore, the items related to functional status and lifestyle activities in the CFST are essential predictors of older adults' physical function [55,56]. Thus, the comparability of CFST and other screening tools provides an alternative diagnostic instrument for CF, which are more straightforward and time-saving to be administered in both community and clinical settings. Notwithstanding, further validation of CFST among older individuals and longitudinal study is required to evaluate its ability to predict CF.

However, this study has certain limitations. First, the participants recruited in this research were community-dwelling older adults; therefore, this tool may not be generalized to other settings. Thus, it is recommended that future researchers validate this tool among older adults with illnesses who are hospitalised and residing at residential homes to assess its performance and applicability in older adults from different settings. Further research is warranted to validate the sensitivity and specificity of the CFST in diverse populations and settings. Additionally, longitudinal studies are needed to investigate the predictive validity of the CFST in identifying individuals who go on to develop clinically significant cognitive frailty over time. Second, cultural differences may limit the applicability to older adults in different socio-cultural contexts. Despite these limitations, this study benefited from including a nationally representative sample of community-dwelling older adults in Malaysia.

5. Conclusion

In this study, we have successfully developed a 12 items CF screening tool integrating of multi-domain variables, i.e. gender, education years, medical history, depressive and functional status and lifestyle activities, as generated from both cross-sectional and longitudinal studies, which represents a significant advancement to the field. Further research is required to examine and validate CFST in clinical settings to investigate its generalizability in differentiating those older adults at risk of CF, thus paving the way for

early intervention strategies and improved outcomes in this vulnerable population.

Ethics approval

Ethical approval was granted by the Medical Research and Ethics Committee of Universiti Kebangsaan Malaysia(reference number: UKM1.21.3/244/NN-2018-145) in accordance with the ethical guidelines outlined in the Declaration of Helsinki. Prior to their involvement, all participants were provided with written information and gave informed consent.

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Data availability statement

Data will be made available on request.

CRediT authorship contribution statement

Nurul Fatin Malek Rivan: Writing – original draft, Validation, Project administration, Methodology, Investigation, Formal analysis. **Suzana Shahar:** Writing – review & editing, Supervision, Project administration, Methodology, Funding acquisition, Conceptualization. **Devinder Kaur Ajit Singh:** Writing – review & editing, Supervision, Methodology, Investigation, Conceptualization. **Normah Che Din:** Writing – review & editing, Supervision, Methodology. **Hazlina Mahadzir:** Writing – review & editing, Supervision, Methodology. **Yee Xing You:** Writing – review & editing, Methodology, Formal analysis. **Mohd Zul Amin Kamaruddin:** Writing – review & editing, Project administration, Methodology.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References

[1] L.P. Fried, C.M. Tangen, J. Walston, et al., Frailty in older adults: evidence for a phenotype, The journals of gerontology Series A, Biological sciences and medical sciences 56 (3) (2001) M146–M156.
[2] F. Petermann-Rocha, D.M. Lyall, T.J. Quinn, F.K. Ho, J.P. Pell, C. Celis-Morales, Associations between physical frailty and dementia incidence: a prospective study from UK Biobank - authors' reply, Lancet Healthy Longev 2 (2) (2021) e68.
[3] N.F.M. Rivan, D.K.A. Singh, S. Shahar, et al., Cognitive frailty is a robust predictor of falls, injuries, and disability among community-dwelling older adults, BMC Geriatr. 21 (1) (2021) 593.
[4] L. Feng, M.S.Z. Nyunt, Q. Gao, et al., Physical frailty, cognitive impairment, and the risk of neurocognitive disorder in the Singapore longitudinal ageing studies, J. Gerontol.: Series A 72 (3) (2017) 369–375.
[5] H. Shimada, T. Doi, S. Lee, H. Makizako, L.K. Chen, H. Arai, Cognitive frailty predicts incident dementia among community-dwelling older people, J. Clin. Med. 7 (9) (2018).
[6] E. Kelaiditi, M. Cesari, M. Canevelli, et al., Cognitive frailty: rational and definition from an (I.A.N.A./I.A.G.G.) international consensus group, J. Nutr. Health Aging 17 (9) (2013) 726–734.
[7] Q. Ruan, Z. Yu, M. Chen, Z. Bao, J. Li, W. He, Cognitive frailty, a novel target for the prevention of elderly dependency, Ageing Res. Rev. 20 (2015 Mar) 1–10.
[8] V. Solfrizzi, E. Scafato, D. Seripa, et al., Reversible cognitive frailty, dementia, and all-cause mortality. The Italian longitudinal study on aging, J. Am. Med. Dir. Assoc. 18 (1) (2017) 89.e81–89.e88.
[9] J.E. Morley, B. Vellas, van Kan AG Frailty consensus: a call to action, J Am Med Dir 14 (6) (2013) 392–397.
[10] J. Zhao, Y.W.J. Liu, S. Tyrovolas, J. Mutz, Exploring the concept of psychological frailty in older adults: a systematic scoping review, J. Clin. Epidemiol. 159 (2023 Jul) 300–308.
[11] V. Dibello, F. Lobbezoo, M. Lozupone, R. Sardone, A. Ballini, G. Berardino, A. Mollica, H.J. Coelho-Júnior, G. De Pergola, R. Stallone, A. Dibello, A. Daniele, M. Petruzzi, F. Santarcangelo, V. Solfrizzi, D. Manfredini, F. Panza, Oral frailty indicators to target major adverse health-related outcomes in older age: a systematic review, Geroscience 45 (2) (2023 Apr) 663–706.
[12] N.F.M. Rivan, S. Shahar, N.F. Rajab, et al., Cognitive frailty among Malaysian older adults: baseline findings from the LRGS TUA cohort study, Clin. Interv. Aging 14 (2019) 1343–1352.
[13] P. Wongtrakulruang, W. Muangpaisan, B. Panpradup, A. Tawatwattananun, M. Siribamrungwong, S. Tomongkon, The prevalence of cognitive frailty and pre-frailty among older people in Bangkok metropolitan area: a multicenter study of hospital-based outpatient clinics, Journal of frailty, sarcopenia and falls 5 (3) (2020) 62–71.
[14] L. Ma, L. Zhang, Y. Zhang, Y. Li, Z. Tang, P. Chan, Cognitive frailty in China: results from China comprehensive geriatric assessment study, Front. Med. 4 (2017) 174.

[15] Q. Ruan, F. Xiao, K. Gong, W. Zhang, M. Zhang, J. Ruan, X. Zhang, Q. Chen, Z. Yu, Prevalence of cognitive frailty phenotypes and associated factors in a community-dwelling elderly population, J. Nutr. Health Aging 24 (2) (2020) 172–180.
[16] G. Abellan van Kan, Y. Rolland, H. Bergman, J.E. Morley, S.B. Kritchevsky, B. Vellas, The I.A.N.A Task Force on frailty assessment of older people in clinical practice, J. Nutr. Health Aging 12 (1) (2008) 29–37.
[17] N.F.M. Rivan, S. Shahar, N.F. Rajab, et al., Incidence and predictors of cognitive frailty among older adults: a community-based longitudinal study, Int J Environ Res Public Health 17 (5) (2020) 1547.
[18] R.R. Murukesu, D.K.A. Singh, S. Shahar, P. Subramaniam, A multi-domain intervention protocol for the potential reversal of cognitive frailty: "WE-RISE" randomized controlled trial, Front. Public Health 8 (2020).
[19] T. Sugimoto, T. Sakurai, R. Ono, et al., Epidemiological and clinical significance of cognitive frailty: a mini review, Ageing Res. Rev. 44 (2018) 1–7.
[20] J.C. Tsai, C.W. Chen, H. Chu, et al., Comparing the sensitivity, specificity, and predictive values of the Montreal cognitive assessment and mini-mental state examination when screening people for mild cognitive impairment and dementia in Chinese population, Arch. Psychiatr. Nurs. 30 (4) (2016) 486–491.
[21] A. Breton, D. Casey, N.A. Arnaoutoglou, Cognitive tests for the detection of mild cognitive impairment (MCI), the prodromal stage of dementia: meta-analysis of diagnostic accuracy studies, Int J Geriatr Psychiatry 34 (2) (2019) 233–242.
[22] S.H. Tseng, L.K. Liu, L.-N. Peng, P.N. Wang, C.H. Loh, L.-K. Chen, Development and validation of a tool to screen for cognitive frailty among community-dwelling elders, J. Nutr. Health Aging 23 (9) (2019) 904–909.
[23] S. Shahar, A. Omar, D. Vanoh, et al., Approaches in methodology for population-based longitudinal study on neuroprotective model for healthy longevity (TUA) among Malaysian Older Adults, Aging Clin. Exp. Res. 28 (6) (2016) 1089–1104.
[24] United Nations, Department of economic and social affairs, population division, World Population Ageing 2019 (2019). https://www.un.org/en/development/desa/population/publications/pdf/ageing/WorldPopulationAgeing2019-Highlights.pdf. (Accessed 3 January 2020).
[25] Clinical Practice Guidelines. Management of dementia, 2nd Edition, 2009. https://www.moh.gov.my/moh/attachments/4484.pdf (Accessed from 1 Jan 2023).
[26] D.K.A. Singh, N. Nor, B. Rajaratnam, T.C. Yi, S. Shahar, Validity and reliability of physical activity scale for elderly in Malay language (PASE-M), Malaysian Journal of Public Health Medicine 2018 (2018) 116–123.
[27] R.C. Petersen, B. Caracciolo, C. Brayne, S. Gauthier, V. Jelic, L. Fratiglioni, Mild cognitive impairment: a concept in evolution, J. Intern. Med. 275 (3) (2014) 214–228.
[28] L.K. Lee, S. Shahar, A.V. Chin, N.A. Mohd Yusoff, N. Rajab, S.A. Aziz, Prevalence of gender disparities and predictors affecting the occurrence of mild cognitive impairment (MCI), Arch. Gerontol. Geriatr. 54 (1) (2012) 185–191.
[29] World Health Organization. A healthy lifestyle - WHO recommendations, 2010. https://www.who.int/europe/news-room/fact-sheets/item/a-healthy-lifestyle—who-recommendations (Accessed 2 January 2023).
[30] N.M. Ibrahim, S. Shohaimi, H.T. Chong, et al., Validation study of the mini-mental state examination in a Malay-speaking elderly population in Malaysia, Dement. Geriatr. Cognit. Disord. 27 (3) (2009) 247–253.
[31] R. Razali, L. Jean-Li, A. Jaffar, et al., Is the Bahasa Malaysia version of the Montreal Cognitive Assessment (MoCA-BM) a better instrument than the Malay version of the Mini Mental State Examination (M-MMSE) in screening for mild cognitive impairment (MCI) in the elderly? Compr. Psychiatr. 55 (Suppl 1) (2014) S70–S75.
[32] D. Weshsler, Wechsler Adult Intelligence Scale-III. San Antonio, The Psychological Corporation, 1997.
[33] J.C. Morris, Clinical dementia rating: a reliable and valid diagnostic and staging measure for dementia of the alzheimer type, Int. Psychogeriatr. 9 (S1) (1997) 173–176.
[34] E.E. Teh, C.I. Hasanah, Validation of Malay Version of Geriatric Depression Scale Among Elderly Inpatients, 2004. http://priory.com/psych/MalayGDS.html. (Accessed 8 June 2021).
[35] M.E. Hughes, L.J. Waite, L.C. Hawkley, J.T. Cacioppo, A short scale for measuring loneliness in large surveys: results from two population-based studies, Res. Aging 26 (6) (2004) 655–672.
[36] C.D. Sherbourne, A.L. Stewart, The MOS social support survey, Soc. Sci. Med. 32 (6) (1991) 705–714.
[37] C. Graf, The Lawton instrumental activities of daily living scale, Am. J. Nurs. 108 (4) (2008) 52–62.
[38] R.E. Rikli, C.J. Jones, Senior Fitness Test Manual, second ed., Human Kinetics, USA, 2012.
[39] G. Andrews, A. Kemp, M. Sunderland, M. Von Korff, T.B. Ustun, Normative data for the 12 item WHO disability assessment Schedule 2.0, PLoS One 4 (12) (2009) e8343.
[40] D.F. Hultsch, C. Hertzog, B.J. Small, R.A. Dixon, Use it or lose it: engaged lifestyle as a buffer of cognitive decline in aging? Psychol. Aging 14 (2) (1999) 245–263.
[41] S. Shahar, J. Earland, S. Abdulrahman, Validation of a dietary history questionnaire against a 7-D weighed record for estimating nutrient intake among rural elderly malays, Malaysian journal of nutrition 6 (1) (2000) 33–44.
[42] R. Trevethan, Sensitivity, specificity, and predictive values: foundations, pliabilities, and pitfalls in research and practice, Front. Public Health 5 (2017) 307.
[43] W.J. Youden, Index for rating diagnostic tests, Cancer 3 (1) (1950) 32–35.
[44] C.B. Cordell, S. Borson, M. Boustani, et al., Alzheimer's Association recommendations for operationalizing the detection of cognitive impairment during the Medicare Annual Wellness Visit in a primary care setting, Alzheimer's Dementia : the journal of the Alzheimer's Association 9 (2) (2013) 141–150.
[45] D.W.J. Hosmer, S. Lemeshow, R.X. Sturdivant, Applied Logistic Regression, third ed. ed., John Wiley & Sons, Inc., New York, 2013.
[46] W.-K. Cheah, Validation of Malay version of Montreal cognitive assessment in patients with cognitive impairment, Clin. Med. Res. 3 (2014) 56.
[47] C.D. Normah, S. Shahar, B.H. Zulkifli, R. Razali, A. Chin, A. Omar, Validation and optimal cut-off scores of the bahasa Malaysia version of the Montreal cognitive assessment (MoCA-BM) for mild cognitive impairment among community dwelling older adults in Malaysia, Keesahan dan Skor Titik Potong Optimum Versi Bahasa Malaysia Penilaian Kognitif Montreal (MoCA-BM) untuk Kecelaan Kognitif Ringan dalam Kalangan Komuniti Rumah Warga Tua di Malaysia) 45 (2016) 1337–1343.
[48] D. Vanoh, S. Shahar, R. Rosdinom, N.C. Din, H.M. Yahya, A. Omar, Development of TUA-WELLNESS screening tool for screening risk of mild cognitive impairment among community-dwelling older adults, Clin. Interv. Aging 11 (2016) 579–587.
[49] H.C. Huang, Y.M. Tseng, Y.C. Chen, P.Y. Chen, H.Y. Chiu, Diagnostic accuracy of the Clinical Dementia Rating Scale for detecting mild cognitive impairment and dementia: a bivariate meta-analysis, Int J Geriatr Psychiatry 36 (2) (2021) 239–251.
[50] W.S. Lim, M.S. Chong, S. Sahadevan, Utility of the clinical dementia rating in Asian populations, Clin. Med. Res. 5 (1) (2007) 61–70.
[51] N. Sukkriang, C. Punsawad, Comparison of geriatric assessment tools for frailty among community elderly, Heliyon 6 (9) (2020) e04797.
[52] M.A. Lutgendorf, K.A. Stoll, Why 99% may not be as good as you think it is: limitations of screening for rare diseases. The journal of maternal-fetal & neonatal medicine : the official journal of the European Association of Perinatal Medicine, the Federation of Asia and Oceania Perinatal Societies, the International Society of Perinatal Obstet 29 (7) (2016) 1187–1189.
[53] E.B. dos Santos, S. Tudesco Ide, L.O. Caboclo, E.M. Yacubian, Low educational level effects on the performance of healthy adults on a Neuropsychological Protocol suggested by the Commission on Neuropsychology of the Liga Brasileira de Epilepsia, Arq Neuropsiquiatr 69 (5) (2011) 778–784.
[54] A. Cobo, L.A. Vázquez, J. Reviriego, L. Rodríguez-Mañas, Impact of frailty in older patients with diabetes mellitus: an overview, Endocrinol. Nutr. : organo de la Sociedad Espanola de Endocrinologia y Nutricion 63 (6) (2016) 291–303.
[55] G. Kojima, Frailty as a predictor of disabilities among community-dwelling older people: a systematic review and meta-analysis, Disabil. Rehabil. 39 (19) (2017) 1897–1908.
[56] V.D. da Silva, S. Tribess, J. Meneguci, et al., Association between frailty and the combination of physical activity level and sedentary behavior in older adults, BMC Publ. Health 19 (1) (2019) 709.