

Risk of Frailty Prediction Among Institutionalized Older Adults

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Research article

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Abstract

Background: Frailty is a state of the decreased physiological reserve, inability to maintain homeostasis manifested by weakness, weight loss, reduced gait speed, exhaustion, and increased vulnerability to adverse health outcomes. It is commonly associated with aging and is considered as a predictor of hospitalization, morbidity, and mortality, thereby increasing the economic burden on the nation. Early identification of people who are at risk for frailty is vital in prevention and minimizing its socio-economic consequences.

Objective: To develop a prediction model for the risk of frailty among institutionalized older adults.

Methods: This study adopted a case-control design, wherein older adults categorized into frail and non-frail, using Fried's criteria were considered as cases and controls respectively. Individuals above 55 years of age, who could follow instructions; without severe motor and cognitive impairment and severe terminal illness were recruited from nine conveniently selected institutions for older adults. Socio-demographic details like age, gender, BMI, marital status and duration of institutionalization; lifestyle and behavioral factors like comorbidities, history of fall, smoking, alcohol consumption status, economic dependability, depression and cognition and; physical performance factors like physical activity, functional mobility, gait speed, and grip strength were evaluated. Binary logistic regression was performed to identify the odds ratio between the independent variables and frailty and to develop a prediction model.

Results: Hundred elderly were recruited and analyzed from nine different institutions. Among the fourteen identified independent variables female gender (OR=1.038), cognition (OR=1.477), smoking (OR=1.907), vegetarian diet (OR=0.016), presence of more than 3 co-morbidities (OR=8.840), gait speed (OR=0.000) and grip strength (OR=0.575) showed a statistically significant odds ratio ($r^2 = 0.883$) and were used for developing a prediction model for risk of frailty.

Conclusion: Risk factors for frailty among institutionalized older adults have been identified and a prediction model for risk frailty has been developed. This model could be used for the early identification of frailty during community-level screening programs.

Introduction

Frailty is "a state of age-related physiological vulnerability resulting from impaired homeostatic reserve and a reduced capacity of the individual to withstand stress" [1] and an independent predictor of deleterious health outcomes among aged. [2] Frailty is irreversible and difficult to manage because of the multisystem involvement and displays a wide array of physical, psychological & social problems leading to dependency and poor quality of life. [3] Many geriatricians have operationalized frailty in several ways as the accumulation of deficit, clinical syndrome, and clinical phenotype. [4] Fried's criterion (physical frailty phenotype) is the most widely evaluated and frequently used tool for identifying frailty among different groups of older adults. [5] Diagnostic criteria for frailty met three out of five frailty phenotypes

(FPs): unintentional weight loss, weakness, exhaustion, reduced gait speed, and reduced physical activity. [4]

The prevalence of frailty among the elderly living in the community is about 17.4% and 52.3% among institutionalized elderly. The frequency of frailty is considered to be more among females and is associated with increased age. [6] In India, its prevalence is reported to be 26% among community-dwelling older adults. [7] Frailty is more in developing countries, illiteracy, and low economic background. [8] Frailty is more prevalent among institutionalized elderly than community-dwelling elderly. Institutionalized elderly are heterogeneous populations for quality of life, disability status and have reduced functional, cognitive ability which makes them more vulnerable than community-dwelling elderly. [9, 10] Frailty is associated with the risk of developing unfavorable health events, such as increased morbidity, falls, physical and psychological dependency, hospitalization, and death. [1]

Early identification of people who are at risk for frailty is vital in prevention and minimizing its socio-economic consequences in low resource countries like India. However, risk factors for frailty among Indian institutionalized older adults have been seldom explored. Prevention or delaying frailty should be given importance to reduce the physical, financial burden for which we need to identify factors causing frailty among institutionalized older adults, so it can be delayed or reversed. [11] Hence, the objective of this study was to develop a prediction model for the risk of frailty among the institutionalized elderly.

Methodology

Permission was granted from the Institutional Research Committee, MCHP, and Institutional Ethics Committee (IEC 47/2019), Kasturba Hospital, and CTRI registration (CTRI/2019/018033) were obtained. Permission was taken from the authorities of the institutions for older adults. This study adopted a case-control study design, older adults from nine institutions from Udupi district were included. Sample size estimated was 98 (case-49 control-49) using the formula $n = 2 * PQ (Z_{1-\alpha/2} + Z_{1-\beta})^2 / (p_1 - p_2)^2$ where n= Sample size in each group, p_1 = Probability of exposure among cases (Diabetes), $p_1 = p_2 * OR \div p_2 * OR + (1 - p_2)$ ($p_1 = 0.6$, $p_2 = 0.3$, $OR = 3.5$), p_2 = Probability of exposure among controls, OR = Anticipated odds ratio, $P = p_1 + p_2 \div 2$, $Q = 1 - P$, $Z_{1-\alpha/2} = 1.96$ for 95% of confidence interval (at $\alpha = 0.05$), $Z_{1-\beta} = 0.84$ at 80% power.

Individuals aged 55 and above and residing in one of the nine conveniently selected institutions for older adults, located in Udupi district, Karnataka, India were included in this study. Those who presented with severe motor and cognitive impairment, who could not follow instructions and severe terminal illness were excluded. The procedure was explained, the participant information sheet was given and written informed consent was obtained. The included individuals were evaluated using a structured assessment proforma, developed after reviewing the literature and expert suggestions. It included socio-demographic details such as age, gender, BMI, marital status and duration of institutionalization, lifestyle and behavioral factors like comorbidities, history of fall, smoking, alcohol consumption status, economic dependability, depression, cognition, and functional mobility. The short-form version of the Geriatric Depression Scale (GDS-SF, 15 item scale) was used to quantify depression. A score of more than 5 is

considered as being depressed. [12] Cognition was assessed using the Montreal Cognitive Assessment tool. It is scored out of 30, more number indicates better cognition. English and Kannada version of MOCA was used in this study. [13] Functional mobility was assessed using the Timed Up and Go test, a standardized tool to measure balance and fall risk among the elderly, which needed a standard chair with the armrest, stopwatch, and a 3-meter walkway. Instructions were "on the word go, you will stand up, walk to the line on the floor, turn around and walk back to the chair and sit back" and time was recorded in seconds. [14]

Physical frailty assessed by Fried's frailty phenotype criteria was considered as the dependent variable. Fried's five phenotype criteria were used to categorize the elderly into frail (case) and non-frail (control). The five criteria were unintentional weight loss, weakness, exhaustion, reduced gait speed, and reduced physical activity. Unintentional weight loss was identified by a drop of ≥ 4.5 kg in the past one year; grip strength was assessed using the JAMAR hand dynamometer. Participants were made to sit erect in an armless chair, with the elbow flexed to 90 degrees. The dynamometer was held in the dominant hand and participants were asked to press and grip it to their maximum strength for about 5 seconds. Three readings were taken and the average was calculated and the score less than 18 kg for females and less than 26 kg for males were the cut off values. [1]

Gait speed was assessed with 10 Meter Walk Test participants were asked to walk on the 10-meter walkway, and time was recorded. Gait speed of less than 0.8m/s is considered as reduced gait speed according to Fried's criteria. [15] Physical activity of the participants was measured using RAPA, which is a 10 items scale and participants had to choose the statement which would categorize them into different levels of physical activity, such as sedentary, underactive, regular underactive (light activities), regular underactive, and regularly active. Individuals with a score of < 5 were considered to be less physically active. [16] Exhaustion was measured using two questions "I felt like everything I did was an effort: In the last one week I could not get going" affirmative answers to any of these questions were considered as positive exhaustion. [17] After assessing the five phenotypes of frailty, the participants who had three or more phenotypes were categorized into frail, and participants with less than three phenotypes were categorized into non-frail.

Data were analyzed using SPSS software version 16. Descriptive statistics were used to summarize the data. A statistically significant relationship between cases and controls concerning categorical and continuous variables was identified using the Chi-Square test and Independent T-test. Binary logistic regression was performed to identify the odds ratio between the independent variables and frailty and to develop a prediction model. The considered level of significance was $p \leq 0.05$.

Results

Figure 1 depicts the flow of participants in this study. One hundred and fifty-seven subjects were screened and a hundred participants were included in this study. After evaluation using Fried's frailty criteria, they were categorized into 49 controls and 51 cases.

The socio-demographic, lifestyle and physical performance characteristics among the participants in cases and control groups are given in table.1. Results showed variables like age, cognition, mobility, gait speed, grip strength, number of co-morbidities, polypharmacy, presences of more than 3 comorbidities and history of previous fall showed a statistically significant difference between case and control groups. The mean age, mobility score, and no. of co-morbidities among the participants in cases were 5.07 years, 7.79 sec, and 1.44 points more when compared to controls respectively. Whereas, mean BMI, cognition, gait speed, grip strength, and duration of institution stay were 1.1kg/m², 6.41points, 0.59m/s, 7.12kg, and 3.5 years less respectively among the participants in case group when compared to the control group.

Variables	Cases (n=51)	Controls (n=49)	p value
	Mean ± SD		
Age (years)	75.33 ± 8.84	70.26 ± 8.11	0.004
BMI (kg/m ²)	22.10 ± 4.36	23.20 ± 4.06	0.198
Duration of institutionalisation (years)	6.24 ± 5.16	9.74 ± 2.02	0.244
No. of co-morbidities	3.33 ± 1.40	1.89 ± 1.32	0.000
Cognition (MOCA)	15.54 ± 6.32	21.95 ± 5.23	0.000
Functional mobility (TUG in sec)	17.53 ± 7.13	9.74 ± 2.02	0.000
Gait speed (m/s)	0.70 ± 0.31	1.29 ± 0.28	0.000
Grip strength (kg)	12.20 ± 5.21	19.41 ± 7.19	0.000
Variables	Number (Percentage)		
Gender – Male: Female	17:34 (39%: 61%)	22:27(44.9%: 55.1%)	0.306
Educational status			
≤ 7	25 (49.01%)	14 (28.6%)	0.064
8-12	16 (31.37%)	26 (53.06%)	
>12	10 (19.60%)	9 (18.36%)	
Smoking status			
Smoker	2 (3.92%)	0 (0%)	0.361
Reformed	7 (13.72%)	8 (16.32%)	
Non-smoker	42 (82.35%)	41 (83.67%)	
Partner status			
Single	15 (29.41%)	13 (26.53%)	0.308
Separated	34 (66.66%)	30 (61.22%)	
Together	2 (3.92%)	6 (12.24%)	
Economic dependency status			
Dependent	43 (84.31%)	34 (69.38%)	0.051
Independent	8 (15.68%)	15 (30.61%)	
Alcohol intake			

	Alcoholic	7 (13.72%)	5 (10.20%)	0.511
	Reformed	1 (1.96%)	3 (6.12%)	
	Non-alcoholic	43 (84.31%)	41(83.67%)	
Diet				
	Vegetarian	10 (19.60%)	9 (18.36%)	1.000
	Mixed	41 (80.39%)	40 (81.63%)	
History of fall		28 (54.90%)	9 (18.36%)	0.000
Polypharmacy		31 (60.78%)	21 (42.85%)	0.027
≥ 3 co-morbidities		23 (45.09%)	8 (16.32%)	0.000

Table 1

Socio-demographic, lifestyle and physical performance characteristics of the participants (n=100)

Table.2 represents the unadjusted and adjusted odds ratio after the univariate analysis and multivariate analysis respectively. Variables that showed a statistically significant odds ratio in univariate analysis are age, cognition, functional mobility, polypharmacy, presence of ≥ 3 morbidities, gait speed, and grip strength. However, when multivariate analysis was carried out, female gender, vegetarian diet, smoker, cognition, presence of ≥ 3 morbidities, gait speed and grip strength turned out to have significant odd's ratio. Hence, these variables were taken for developing the model.

Variables	Univariate analysis			Multivariate analysis		
	B	p value	OR (95% CI)	B	p value	OR (95% CI)
Age	0.070	0.005	1.072 (1.021, 1.126)	-0.367	0.995	0.693 (0.000, 9.490)
Gender (Women)	0.488	0.237	1.630 (0.725, 3.663)	-3.271	0.036	1.038 (0.002, 0.803)
BMI	-0.063	0.199	0.939 (0.853, 1.034)	-5.453	0.982	0.004 (0.000, 8.987)
Education status (< 8 th standard)	0.474	0.290	0.554 (0.185, 1.655)	0.506	0.775	1.659 (0.052, 53.116)
Partner status (Single)	1.242	0.168	3.462 (0.593, 20.206)	9.542	0.998	0.000 (0.000, 0.000)
Diet (Vegetarian)	0.081	0.874	1.084 (0.399, 2.948)	-4.126	0.023	0.016 (0.000, 0.572)
Smoker	21.179	0.779	0.854 (0.284, 2.571)	5.251	0.011	1.907 (3.323, 10.945)
Alcoholic	0.289	0.644	1.335 (0.392, 4.543)	12.274	0.390	2.141 (1.914, 2395.76)
Cognition	-0.185	0.000	0.831 (0.765, 0.903)	0.390	0.016	1.477 (1.076, 2.028)
Functional mobility	0.632	0.000	1.882 (1.468, 2.412)	-0.358	0.256	0.699 (0.377, 1.296)
Polypharmacy	0.981	0.018	2.667	2.487	0.322	12.023

			(1.184, 6.005)			(0.088, 1644.06)
≥ 3 comorbidities	2.207	0.000	9.091 (3.657, 22.601)	2.179	0.045	8.840 (1.964, 8.107)
Gait speed	-7.036	0.000	0.001 (0.000, 0.013)	-18.831	0.001	0.000 (0.000, 0.000)
Grip strength	-0.201	0.000	0.818 (0.747, 0.896)	-0.553	0.001	0.575 (0.415, 0.796)

Table 2

Univariate and multivariate analysis of frailty with the socio-demographic, physical performance and comorbid factors

After performing multivariate analysis, seven variables that showed significant odds ratio with frailty among institutionalized older adults were female gender, vegetarian diet, smoker, cognition, presence of ≥ 3 morbidities, gait speed, and grip strength. All those variables except being a smoker and presence of comorbidities are negatively related to frailty. Hence, a regression model developed using those variables had a Nagelkarke R square value of 0.883.

Risk of frailty among institutionalized older adults = Exp [21.361 – 3.271 (Female) - 4.126 (vegetarian) + 5.251 (smoker) - 0.390 (cognition) + 2.179 (≥ 3 comorbidities) – 18.831 (gait speed) – 0.553 (grip strength)]

Discussion

This study was intended to identify the factors associated with frailty and thereby develop a prediction model to identify the risk of frailty among institutionalized older adults. In this study, five phenotypes criteria by Fried et al (2001) were used to categorize older adults into frail (cases) and non-frail (controls). [1] With the majority of the studies looking at frailty and its associated factors in community-dwelling aged individuals, the current study was directed at the seldom explored institutionalized elderly.

Multivariate regression analysis showed that seven out of fourteen independent factors showed a statistically significant odds ratio. Among those seven significant factors, comorbidities and smoking status had a positive relationship with frailty. In the present study, the presence of ≥ 3 comorbidities showed an increased probability of frailty. This finding has been supported by a review done by Vetrano DL et al (2019) which states that frailty and multimorbidity are two related conditions in older adults and multimorbidities are major determinants of frailty syndrome. [18] However, their findings are inconclusive regarding the causal association between the two conditions. Hanlon P et al (2018) reported that frailty is

significantly associated with multimorbidity and the prevalence rate of frailty increased with the number of multimorbidities. [19]

Modifiable factors like smoking are also significantly associated with frailty, supporting current study results. A review published by Kojima et al (2015) reported smoking as a predictor of worsening frailty status among the elderly. [9] Smoking causes increased levels of inflammatory markers leading to chronic inflammation, muscle wasting and weakness, exhaustion, slow gait speed contributing to frailty component. [6, 20] Amiri and Behnezhad (2019) had done a systematic review and meta-analysis on the relationship between smoking and frailty and reported that the risk ratio of frailty based on smoking was 1.63. The mechanism that has been stated in this regard is that smoking involves substances that increase inflammatory mediators which result in muscle loss, weight loss, and fatigue—all factors engaged in frailty. [21]

Won et al (2020), in their cohort study, have reported that women tended to exhibit a higher prevalence of frailty than men. However, the findings of the current study indicate a negative relationship between female gender and frailty. [22] The reason for this could be due to unequal gender distribution especially after 80 years of age (20 women vs 9 men). A statistically significant association has been found in this study between vegetarian diet and frailty. In this study, dietary nutrition intake was not assessed in detail; only whether the participants consumed a non-vegetarian diet was noted categorically. Huang RY et al (2016) in their multivariate nutrient density model identified associations between low muscle mass and dietary protein intake among community-dwelling older adults. They have reported that the participants in the lowest quartile of total protein density intake were at high risk of sarcopenia, a precursor of frailty. [23]

Frailty and cognition have been negatively associated with this study. Similar results have been shown in a review by [Deirdre A Robertson](#) et al (2013). This is explained by the fact that advanced age is a major risk factor for physical and cognitive impairment. [24] In addition to this, institutionalized elderly are more vulnerable and prone have age-related co-morbidities leading to exacerbated homeostatic imbalance, brain aging, and cognitive decline. [25]

Gait speed and grip strength were found to have a statistically significant negative relationship with frailty in this study. Binotto and colleagues performed a systematic analysis of gait speed and physical frailty and found that gait speed is substantially correlated with disability, frailty, cognitive impairment, dependency, mortality, sedentary lifestyle, muscle weakness, poorer health and quality of life, stress, obesity, weight and percentage of body fat and low performance in gait parameters. They had reported considering reduced gait speed as a marker of physical frailty. [26] Bohannon RW advocated the usage grip strength as an indispensable marker for older adults as it was a consistent explanator of concurrent overall strength, upper limb function, bone mineral density, fractures, falls, malnutrition, cognitive impairment, depression, sleep problems, diabetes, multimorbidity, and quality of life. Evidence was also provided for a predictive link between grip strength and all-cause and disease-specific mortality, future function, bone mineral density, fractures, cognition and depression, and problems associated with hospitalization. [27]

Diez-Ruiz et al (2016) identified factors leading to adverse health events among the elderly and aimed to propose a model to identify these elderly in the primary care setting. Age, TUG time (in seconds), and polypharmacy were positively associated with the frailty-related adverse outcome which was expressed using a single model. [28] The results of the univariate analysis in the current study had identified age, TUG, and polypharmacy as the predictors. However, when multivariate analysis was carried out those variables were not identified as the predictors of frailty. The probable reason for this could be the differences in the settings in which these two studies are carried out. Sousa JA et al (2018) have established a prediction model for the development of physical frailty among the oldest old population of primary health care. That model composed of metabolic diseases, dyslipidemias, and several hospitalizations in the last 12 months with the odds ratio of 1.99, 0.32, and 2.50 respectively. [29]

This study has a few limitations. First and foremost, the current study recruited participants from nine old age homes with different levels of assistance and of different environmental dimensions (infrastructure and domestic assistance) which would vary the results. Secondly, physical activity and exhaustion were measured subjectively; objective measures like accelerometer or activity monitors could have been used. Thirdly, socio-demographic and morbidity factors were participant reported, recall bias which is very much prevalent among the elderly would have influenced the results. The model developed can be validated in future studies, incorporating more objective frailty assessment methods like serological or inflammatory biomarkers and inclusion of homogeneous institutions to generalize the results for this population.

Significance of the study

This study identified the factors influencing frailty among institutionalized older adults which would help in decision making about the address of significant factors during the rehabilitation. The prediction model developed could be used at community level screening programs for identifying older adults with the risk of frailty at an earlier stage.

Conclusion

Female gender, cognition, smoking, vegetarian diet, presence of more than 3 co-morbidities, gait speed, and grip strength were found to have a significant association with the risk of frailty. A model has been developed to predict the risk of frailty among institutionalized older adults.

Declarations

Ethics approval and consent to participate:

Ethics approval was taken from the institutional ethics committee, Kasturba hospital, Manipal (IEC 47/2019), Kasturba Hospital, and CTRI registration (CTRI/2019/018033). Written informed consent was taken from all the participants of this study

Consent for publication:

"Not applicable"

Availability of data:

The datasets during and/or analysed during the current study available from the corresponding author on reasonable request.

Competing interests:

"The authors declare that they have no competing interests"

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Authors' contributions:

	Ms. Nisha Kulal	Dr. Vaishali K	Dr. Girish N
Conceptualisation	ü		ü
Literature review	ü		
Research gap identification		ü	ü
Designing methods		ü	ü
Seeking ethical approval	ü		
Data collection	ü		
Data analysis			ü
Journal submission			ü

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Conflicts of interest disclosure:

The researchers declare no conflict of interest.

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Figures

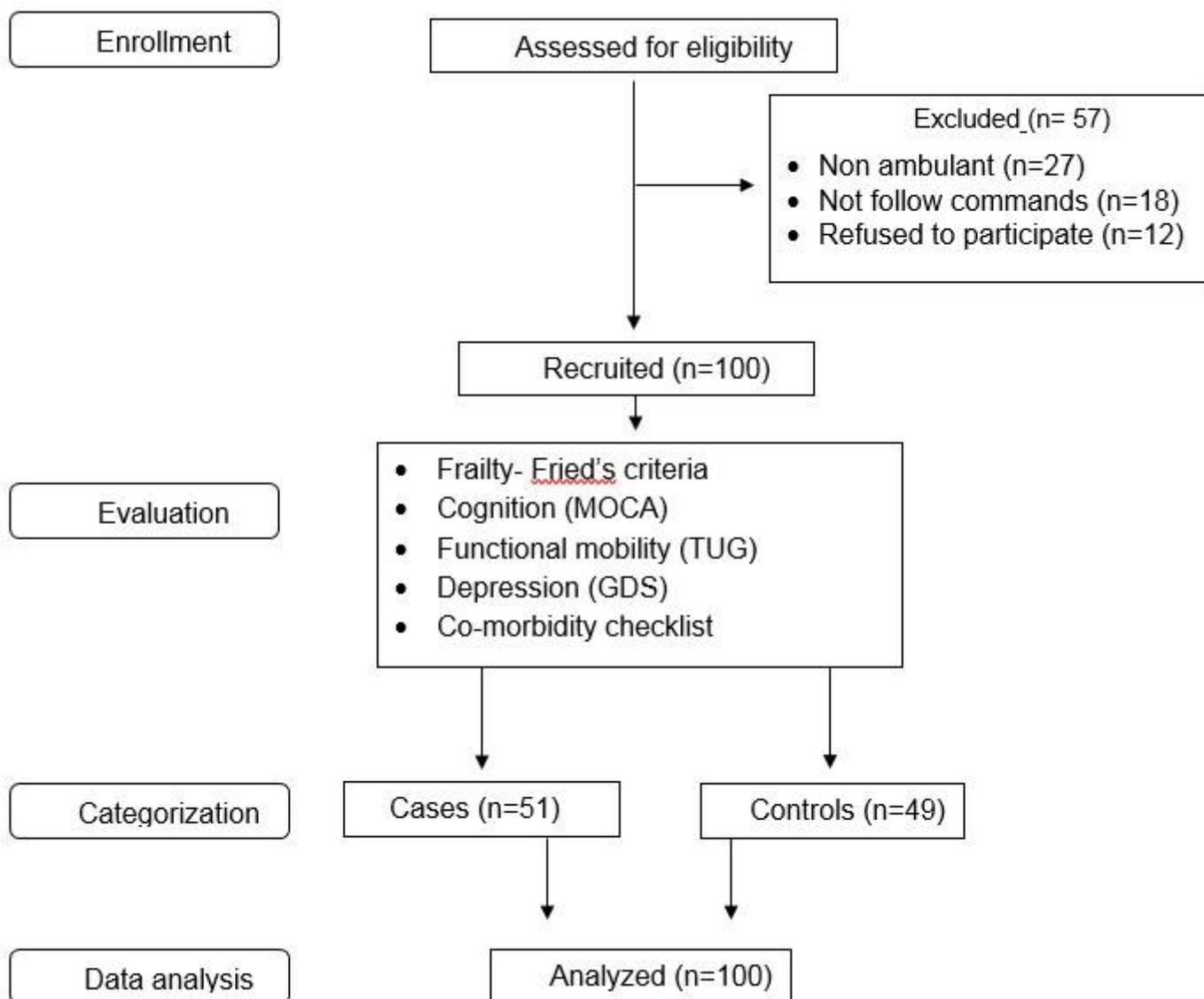


Figure 1

Flow of participants