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Development of a proposed scale for assessing fall risk in older adults in primary care

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Abstract

Introduction
Population aging has been accompanied by an increase in falls among older adults, constituting an important public health problem, particularly in primary care; however, fall risk assessment continues to rely on instruments developed for hospital settings that are poorly sensitive to the specific features of community settings.

Objective
To develop an easy-to-use scale for assessing fall risk in older adults in primary care, based on the identification of clinical, sociodemographic, and psychosocial factors associated with previous falls.

Methods
An observational, analytical, cross-sectional, quantitative study was initially conducted with a convenience sample of 322 older adults to identify factors associated with falls. Based on these results, a methodological study was conducted, enabling the construction of a fall risk assessment scale using coefficients from a logistic regression model.

Results
Inferential analysis identified significant associations between falls and sociodemographic, clinical, and functional variables that, after multicollinearity analysis, were used to define and fit a logistic regression model. The final model included four predictors - history of falls, age, fear of falling, and living arrangement—whose coefficients were converted into point values to construct a proposed fall risk assessment scale.

Conclusion
Fall risk in older adults is multifactorial, and the lack of instruments specifically designed for primary care hinders its early identification. This study enabled the development of a fall risk assessment scale with potential for use in identifying fall risk in older adults; however, evaluation in the development sample limits the generalizability of the findings, and future external validation is needed.

Keywords
Aged, Accidental Falls, Risk Assessment, Primary Health Care, Frail Elderly.

Introduction

Population aging is one of the major demographic and public health challenges of the 21st century. In Portugal, the aging index increased from 121.6 in 2010 to 182.7 in 2023, reflecting a growing proportion of older adults in the population.[1] This phenomenon is associated with a higher prevalence of chronic

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diseases, functional dependence, and vulnerability, making older adults particularly susceptible to adverse events such as falls.

Falls are among the leading causes of morbidity, loss of independence, and institutionalization in older adults.[2] An estimated 28% to 35% of individuals older than 65 years fall at least once a year, a proportion that may reach 42% after age 75.[3,4] In Portugal, data from the EVITA system show that, in 2023, more than 70% of accidents involving older adults were falls, with 63.9% occurring at home.[5] International studies support these findings, particularly among individuals older than 75 years.[6]

Falls among older adults are multifactorial events with clinical, social, and economic implications. In addition to physical injuries such as fractures, falls may trigger fear of falling, social isolation, depression, functional decline, and increased health care costs.[7] Fall prevention should therefore be a priority in health care, especially in primary care, where monitoring and early intervention are essential. The clinical complexity of the older adult population reinforces the need for a fall risk assessment instrument specifically tailored to the primary care setting.[8]

Despite the high prevalence of falls, fall risk assessment in primary care continues to rely on instruments developed for hospital settings, such as the Morse Fall Scale. This highlights a gap in clinical practice, since risk factors in community settings span social, environmental, and behavioral dimensions that are not captured by hospital-based scales.[9,10]

The Morse Fall Scale was developed by Janice Morse in 1985 and, in Portugal, was adapted and validated for the adult population by Costa-Dias in 2014 and is recommended by the Directorate-General of Health for fall risk assessment in hospital settings.[11] It is, however, the scale used in primary care, despite not being specific to this setting. Other scales have been developed to assess fall risk, but few have been validated for use in primary care. The systematic review by Meekes, published in *BMJ Open*, analyzed six tools applicable in primary care—including the Timed Up and Go Test (TUGT), Gait Speed, Berg Balance Scale, POMA, and history of falls—and concluded that none showed robust predictive performance, with most studies reporting AUC values between 0.5 and 0.74. Other scales, such as STRATIFY and FRAT, have been tested in Portugal but have not demonstrated sufficient validity for systematic use in primary care.[9,12,13] In Savić's study, the Tinetti Scale indicated that most older adults over 75 years of age were at high fall risk[6], highlighting the greater vulnerability of this population and reinforcing the need for more sensitive tools adapted to community settings.

The lack of a validated scale tailored to primary care justifies the development of a new instrument based on data from noninstitutionalized older adults. This instrument incorporates risk factors identified in the literature, including age over 65 years; sex; number of falls in the past 3 months; polypharmacy[14,15]; visual or hearing impairment[14]; balance problems and other physical limitations[15]; and psychological factors such as fear of falling.[16] The availability of a simple, easy-to-use scale in primary care could help promote active monitoring and the early implementation of preventive strategies.

The objective of this study is to develop an easy-to-use scale for assessing fall risk in older adults in primary care, based on the identification of clinical, sociodemographic, and psychosocial factors associated with previous falls.

Methods

A methodological study was conducted in two complementary stages. In the first stage, a cross-sectional observational analysis of the data was performed following the STROBE recommendations to identify factors associated with falls among older adults, a necessary step to support the development of the instrument. In the second stage, the coefficients obtained from the logistic regression model were used to develop a proposed fall risk assessment scale by assigning weights to the significant variables. The discriminatory ability of the scale was subsequently evaluated in the same sample using a receiver operating characteristic (ROC) curve.

Data were collected in 2019 at a Family Health Unit (FHU) in the Almada region. The study population included all individuals aged 65 years or older registered with the FHU, and the sample was selected by convenience using nonprobability sampling. All older adults who voluntarily agreed to participate during the study period, either during an in-person consultation or a home visit, were included. Inability to sign the informed consent form was considered an exclusion criterion.

A total of 322 valid questionnaires were collected from participants who met the inclusion criteria and agreed to participate in data collection. This sample size was considered adequate for the statistical analysis performed.[17,18]

The following variables were considered: a) sociodemographic variables (sex, age, educational attainment, housing type, household composition, and marital status); b) clinical and functional variables (history of falls,

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comorbidities, polypharmacy, fear of falling, balance, mobility, and Barthel Index); and fall risk (assessed using the Morse Fall Scale).[9,19]

The self-administered questionnaire comprised four sections: 1) sociodemographic characteristics; 2) clinical and functional variables; 3) Barthel Index; and 4) Morse Fall Scale. For participants who had difficulty reading or writing, the questionnaire was administered with the assistance of a family member or a health care professional, who read the questions and recorded the responses provided by the older adult.

Based on the factors identified and their clinical relevance, a fall risk assessment scale was constructed, with a score assigned to each variable according to its relative weight in relation to the outcome.

For model construction, the variables were recorded as dichotomous. Age was recorded as <80 vs ≥80 years, a cutoff supported by the literature indicating a significantly increased risk of falls among older adults aged 80 years or older. At this stage, it is important to distinguish the dependent variable ("falls in the past 3 months") from the predictor variable "history of falls." The outcome was recoded as 0 = up to one fall and 1 = two or more falls, whereas "history of falls" referred to previous falls and was entered into the model as an independent predictor.

Data was analyzed using IBM SPSS Statistics® 13.0. Descriptive statistics were initially used to characterize the sample, and inferential statistics were used to identify factors associated with fall risk using binary logistic regression and corresponding 95% confidence intervals.

The study was approved by the Ethics Committee of the Regional Health Administration of Lisbon and Tagus Valley (ARSLVT) (Opinion No. 074/CES/INV/2019). All participants were informed about the objectives, risks, and benefits of participation and signed the informed consent form. Anonymity and confidentiality were ensured, and participants could withdraw at any time without affecting the care they received. The scales used had previously been validated for the Portuguese population, and permission to use them was requested from the respective authors.

Results

The sample consisted of 322 older adults with a mean age of 78.25 years (minimum 65, maximum 99). The remaining sociodemographic characteristics are shown in Table 1.

Table 1. Sociodemographic characteristics of the sample.

Variable	Category	n	%
Sex	Female	213	66.1%
	Male	109	33.9%
Marital status	Married	207	64.3%
	Single	11	3.4%
	Widowed	104	32.3%
Living arrangement	Alone	50	15.5%
	Spouse	203	63%
	More than 2 people	69	21.4%
Educational attainment	Illiterate	47	14.6%
	Primary education	210	65.2%
	Preparatory education	40	12.4%
	Secondary education	15	4.7%
	Higher education	10	3.1%
Housing type	Apartment with stairs/level changes	115	35.7%
	Apartment without stairs/level changes	76	23.6%
	Single-story house with stairs/level changes	63	19.6%
	Single-story house without stairs/level changes	68	21.1%
Falls in the past 3 months	Yes	84	26.1%
	No	238	73.9%
Polypharmacy (+4 medications/day)	Yes	264	82%
	No	58	18%
Physical activity	Yes	17	5.3%
	No	305	94.7%
Ability to climb a flight of stairs	Yes	253	78.6%
	No	69	21.4%
Ability to descend a flight of stairs	Yes	232	72%
	No	90	28%
Ability to walk 100 m	Yes	207	64.3%
	No	115	35.7%
Fear of falling	Yes	259	80.4%
	No	63	19.6%
Feeling unsteady	Yes	191	59.3%

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No	131	40.7%

Before the inferential analysis, a normality analysis was performed. The Shapiro-Wilk test indicated a non-normal distribution for age ($p < 0.001$), weight ($p < 0.001$), height ($p = 0,002$), and number of falls ($p < 0.001$). The association between falls and several categorical variables was assessed using the nonparametric chi-square test. Falls were more frequent among women ($p = 0.011$), individuals who were illiterate or had only primary education ($p = 0.005$), widowed individuals ($p < 0.001$), those with polypharmacy ($p = 0.007$), those who consumed alcohol ($p = 0.024$), those living alone or with more than 2 people ($p < 0.001$), and those with fear of falling ($p < 0.001$).

Falls occurred more frequently in the morning and at night ($p < 0.001$) and among older adults living in homes with stairs or level changes ($p = 0.030$). Individuals who had difficulty climbing stairs ($p = 0.002$) or descending stairs ($p = 0.007$) experienced more falls, as did those who reported feeling unsteady ($p < 0.001$). Gait limitation, measured by difficulty walking 100 m, was also associated with higher fall risk ($p = 0.001$).

In contrast, no statistically significant association was found between physical activity ($p = 0.167$) and falls.

Spearman correlation indicated a very high positive correlation between "Ability to climb a flight of stairs" and "Ability to descend a flight of stairs" ($p = 0.788$, $p < 0.001$), as well as a strong correlation between "Ability to climb a flight of stairs" and "Ability to walk 100 m" ($p = 0.622$, $p < 0.001$). These variables were initially included because they represented different dimensions of functional mobility, which is recognized as a determinant of fall risk among older adults[14]; however, after collinearity analysis, only difficulty walking 100 m was retained because it reflects a broader aspect of functional mobility.

"Fear of falling" and "feeling unsteady" showed moderate correlations ($p = 0.400$ and $p = 0.356$, respectively), according to the classification proposed by Mukaka[20], but were retained because they represent distinct constructs (psychological and physical). Finally, the "living arrangement" variable showed a moderate negative correlation with "marital status" (p=-0,151, p=0,007); the former was therefore selected because it was considered to better reflect living arrangements. The remaining variables showed weak correlations ($p < 0.40$) and were retained for multivariable analysis.

A binary logistic regression model was used, and the variables were recorded as dichotomous variables to identify factors associated with fall risk. Variables showing a statistically significant association ($p < 0.05$) with the fall outcome were included in the model, and two approaches were considered. In the first (Enter method), all variables were entered simultaneously. In the second (Forward method), only statistically significant variables were entered sequentially.

In an attempt to avoid collinearity, the binary fall variable was recorded as (0) up to 1 fall in the past 3 months and (1) two or more falls.

Table 2. Comparison of binary logistic regression models

Criterion	Enter	Forward Stepwise
Teste Omnibus	$\chi^2 = 369.633$; $p < 0.001$	$\chi^2 = 101.057$; $p < 0.001$
Hosmer-Lemeshowtest	$p = 1.000$ (perfect fit)	$p = 0.930$ (Excellent fit)
Correct classification (%)	100% (overfitting)	79.8%
Sensitivity	100%	22.6%
Specificity	100%	100%
Nagelkerke R^2	1.000 (overfitting)	0.395
No. Of significant variables	11 (with colinearity)	4 (Without critical collinearity)
Statistical stability	No (perfect fit/collapse)	Yes (estimable model)

Both models showed overall statistical significance; however, the second showed better fit, greater predictive ability, and a more efficient structure.

Based on the final coefficients, the following variables were included in the final model: "two or more falls" (B = 23.024) was the strongest predictor and was associated with higher fall risk, whereas "younger age" (B = –1.436), "no fear of falling" (B = –2.193), and "living with one other person" (B = –0.713) were associated with lower fall risk.

Table 3 presents the B coefficients, odds ratios (Exp(B)), 95% confidence intervals, and *p* values for the variables included in the final model.

Table 3. Final binary logistic regression model

Variable	Category	Coefficient (B)	Exp(B)	95% CI	pvalue
History of falls	One or more falls	23.024	1E+010	0	.998
Age	≥ 80 years	-1.436	0.238	0.110 – 0.514	0.000
Fear of falling	Yes	-2.193	0.112	0.026 – 0.478	0.003
Living with one other person	Yes	-0.713	0.490	0.269 – 0.893	0.020

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The predictor "two or more falls" had a very high coefficient, reflecting a strong association with the outcome, whereas the remaining variables showed protective effects, with ORs below 1. In constructing the scale, the predictor "two or more falls" was operationalized as "history of falls (Yes/No)," maintaining the direction and relative weight observed in the model while simplifying the category to facilitate clinical use.

To transform the logistic regression coefficients, the coefficient with the smallest absolute magnitude (living with one other person = -0,713) was used in an attempt to preserve the relationship among the different explanatory factors. This value indicates that living with one other person is a protective factor and may reduce fall risk. A constant factor was used to normalize the weights of the variables in the model, thereby avoiding decimal values and subsequently facilitating practical application and scoring of the scale.

Normalization of the items by dividing them by the coefficient with the smallest absolute magnitude is an approach recommended by authors such as Hosmer, Lemeshow, and Sturdivant.[21] The final scale score was adjusted based on the clinical relevance of the identified predictors, following an approach similar to that used by Morse[19]; for this reason, the variable "one or more falls" was retained despite having a substantially higher score, given its recognized clinical relevance.[19]

Table 4. Normalization of coefficients for each variable

Variable	Coefficient (B)	B / Bmin (0,713)	Final score
Living with one other person	-0.713	1	1
Age	-1.436	2.01	2
Fear of falling	-2.193	3.08	3
One or more falls	23.024	32.29	32

To begin constructing the scale, the logistic regression coefficients (B) were normalized by dividing each coefficient by the coefficient with the smallest absolute magnitude ($|\beta| = 0.713$). The resulting values were then rounded to the nearest integer.

Next, to adapt the scale scoring and obtain a simple, easy-to-use instrument for clinical practice, the values were adjusted to facilitate clinical use of the scale while preserving the relative importance of the predictors identified in the model.

Table 5. Normalization of coefficients for each variable

Variable	Category	Final score
History of falls	Yes	6
	No	0
Age	≥ 80 years	2
	< 80 years	1
Fear of falling	Yes	3
	No	0
Living arrangement	Alone or with +2 people	1
	With 1 person	0

Because the "history of falls" variable had a larger coefficient than the other variables, the coefficients were normalized to facilitate clinical application and assessment of the scale. Point assignment was intended to preserve the order of importance of the predictors identified by the model while preventing a single factor from disproportionately determining the overall risk classification.

The 6-point score assigned to history of falls was not mathematically derived (statistical score) but reflected a clinical decision (clinical score). The intention was to reflect the clinical relevance of this factor as one of the main predictors of subsequent falls without making the scale dichotomous or allowing this variable to nullify the contribution of the remaining predictors. A weight of 32 points would mean that the presence of a history of falls would, by itself, determine nearly the entire risk classification, substantially reducing the contribution of the remaining variables to discrimination.

Thus, this variable was retained as the factor with the greatest weight in the scale, reflecting its recognized clinical relevance, while a weighting scheme was adopted to incorporate all predictors in a balanced manner. This adaptation therefore represents a decision based on clinical criteria and should be reevaluated in future validation studies.

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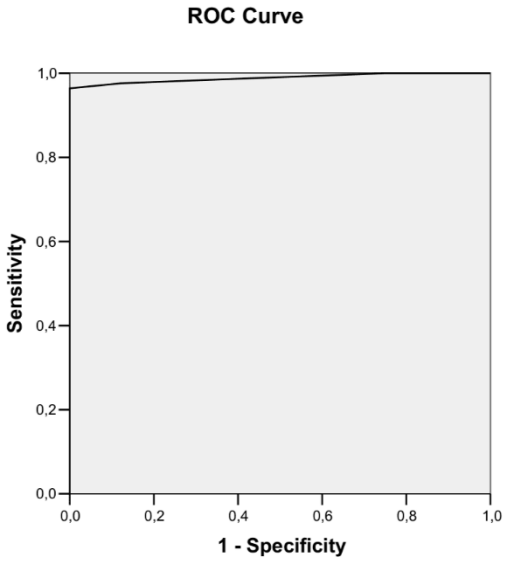


Figure 1. ROC curve for the final model

The logistic regression model had an area under the ROC curve (AUC) of 0.989 and showed high discrimination in the study sample, suggesting that it may distinguish individuals at risk of falls from those not at risk.
Based on the predictors identified by the model, a proposed scale was constructed for future clinical application and validation.

Discussion

Fall risk is a multifactorial phenomenon influenced by clinical, functional, psychological, and social characteristics[13]. The lack of a specific instrument for identifying older adults at higher fall risk poses a relevant challenge in health care, since existing instruments are not adapted to the primary care setting.[12,13]
In the sample of 322 older adults, 26.1% had experienced at least one fall in the previous 3 months, a finding consistent with the annual prevalence of falls reported in community-based studies, which ranges from 26% to 35%[6,22]. Falls were significantly associated with sociodemographic and clinical variables. Despite the multifactorial nature of falls, these findings enabled the identification of a set of variables independently associated with higher fall risk, particularly comorbidities and functional and psychological factors.[6,8]
The need for a multifactorial scale has also been suggested by other authors[4, 12, 13], who refer to the use of "physical tests" within an approach that combines fall history with other domains.
The proposed scale includes "history of falls," the variable with the greatest weight, a finding consistent with evidence that a previous fall is one of the strongest individual predictors of future falls[6, 8, 23]; "age," a robust predictor after age 65, with risk increasing further after age 80[2, 6, 8, 24]; "fear of falling," recognized as a determinant of fall risk[16, 25, 26] and selected to combine physical and psychological factors[16, 27]; and "living arrangement," a key environmental variable in primary care.[12, 13] Here, the "history of falls" item corresponds to the predictor identified in the model ("two or more falls") and was simplified to "Yes/No" to facilitate clinical use.
After the independent predictors were identified, the proposed scale was constructed. The scoring was adapted to facilitate clinical use of the scale while preserving the hierarchy of the predictors identified by the model. The reduction in the weight assigned to history of falls reflected a clinical decision intended to prevent a single predictor from dominating the overall risk classification. Risk categories should subsequently be established and validated in future studies.
In the present sample, the logistic regression model showed high discrimination (AUC = 0,989), a value higher than those usually reported, as moderate AUC values are more common.[4, 12, 13] However, this value should be interpreted with caution because it may reflect overfitting to the dataset, as the model was

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developed and tested in the same sample. In addition, the presence of a predictor with a very high weight in the final scale score (history of falls) may influence the outcome, contributing to such an optimistic AUC value, particularly because the scale was tested in the same sample in which it was developed; subsequent external validation is therefore needed. Similar studies generally report lower values.[4,12]

The study has limitations that should be considered: convenience sampling and data collection at a single health care unit, which may limit the generalizability of the findings because the sample may not be representative of the older adult population in primary care; lack of longitudinal follow-up; and low internal consistency, consistent with the multidimensional nature of falls. Given the sequence of procedures used and because the proposed scale was evaluated in the same sample used to construct it, the results reflect only internal validity and possible overfitting, rather than future predictive ability. Furthermore, the high weight of history of falls may have influenced the observed discriminatory ability, an aspect that should be reevaluated in future studies.

The study findings support the proposed scale as a potential instrument for assessing fall risk among older adults in primary care; however, external validation is still needed. Its use in future studies conducted in primary care is recommended to assess its predictive ability at 3, 6, and 12 months.

Conclusion

In this study, several factors associated with falls among older adults were identified, enabling the development of a proposed fall risk assessment scale designed for primary care: history of falls, age, fear of falling, and living arrangement.

The use of a limited set of variables significantly associated with fall risk allows the scale to be completed and administered quickly, which may encourage its use by health care professionals and make it a useful tool in primary care. Although promising, the scale was evaluated in the same sample used to develop it, limiting the generalizability of the findings.

Nevertheless, the study makes relevant contributions. For research, it represents a first step toward developing a multifactorial scale specifically designed for primary care, which should be further tested. For clinical practice, the proposed scale may support the early identification of older adults at risk and guide more targeted preventive interventions. In the area of education, the findings reinforce the need to train health care professionals to assess fall risk systematically and comprehensively, taking physical, psychological, and social dimensions into account and promoting a broader preventive approach.

Authorship and Contributions

AS: Study conception and design, Data collection, Data analysis and interpretation, Drafting of the manuscript, Critical review of the manuscript, Approval of the final version of the manuscript and assumption of responsibility for it.

ES: Conception and design of the study, drafting of the manuscript, critical review of the manuscript, approval of the final version of the manuscript and assumption of responsibility for it.

Conflicts of interest and Funding

No conflict of interest has been declared by the authors.

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Data availability statement

The dataset supporting the findings of this study is available from the authors upon reasonable request. Access may be provided for academic or research purposes, subject to appropriate ethical and confidentiality considerations.

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