

## Construction and Validation of a Prediction Model for Fall-Related Hospitalization Risk in Patients with Alzheimer' s Disease: A Postprint Study

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### Abstract

Background: Falls are common clinical events in patients with Alzheimer' s disease (AD), which not only increase the risk of severe trauma, infection, disability, and death but also frequently lead to unplanned hospitalizations, imposing a heavy burden on families and society. Objective: To construct and validate a risk prediction model for fall-related hospitalization in AD patients and analyze the risk factors for fall-related hospitalization in AD patients, so as to assist physicians in accurately identifying high-risk individuals and implementing interventions. Methods: A total of 987 AD patients recorded in the Dementia Database of Hubei Provincial Hospital of Traditional Chinese Medicine from January 2020 to October 2025 were included and randomly divided into a training set (n=690) and a validation set (n=297) at a ratio of 7:3. General data, assessment scales, laboratory test indicators, and medication-related data of the subjects were extracted. The occurrence of fall-related hospitalization events in AD patients was used as the outcome variable. LASSO regression was used to screen potential predictive variables, and a nomogram prediction model was established using multivariable Logistic regression. The area under the receiver operating characteristic (ROC) curve (AUC), calibration curves, and decision curve analysis (DCA) were used to test the discrimination, calibration, and clinical utility of the model. Results: Among the 987 AD patients, 276 (27.96%) experienced fall-related hospitalizations. Multivariable Logistic regression analysis based on LASSO regression showed that disease duration (OR=2.843, 95%CI=1.862-4.342), Clinical Dementia Rating (CDR) score (OR=1.275, 95%CI=1.010-1.610), history of falls (OR=7.779, 95%CI=3.515-17.213), osteoarthritis (OR=1.757, 95%CI=1.068-2.892), osteoporosis (OR=2.481, 95%CI=1.692-3.638), high-risk behavioral and

psychological symptoms of dementia (BPSD) (OR=2.193, 95%CI=1.229-3.914), albumin (ALB) levels (OR=1.781, 95%CI=1.128-2.814), and high-risk medications (OR=1.466, 95%CI=1.191-1.805) were independent influencing factors for fall-related hospitalization in AD patients ( $P<0.05$ ). ROC results showed that the AUC for the training set and validation set were 0.753 (95%CI=0.711-0.795) and 0.794 (95%CI=0.734-0.853), respectively; calibration curve results showed that the predicted curves and ideal curves for the training and validation sets had a good fit; DCA results showed that when the nomogram predicted the probability of fall-related hospitalization risk in AD patients within the threshold range of 0.1-0.8, the net benefit rate for patients was  $>0$ . Conclusion: Disease duration, CDR score, history of falls, osteoarthritis, osteoporosis, high-risk BPSD, ALB, and high-risk medications are influencing factors for fall-related hospitalization in AD patients. The nomogram model constructed in this study can be used to predict the risk of fall-related hospitalization in AD patients.

## Full Text

## Preamble

## Chinese General Practice

### Abstract

General practice (GP) serves as the cornerstone of the primary healthcare system, playing a vital role in maintaining public health and managing chronic diseases. This paper explores the current development, challenges, and future directions of general practice in China. By analyzing the integration of machine learning and deep learning technologies into clinical decision support systems, we aim to demonstrate how digital transformation can enhance the quality of care provided by general practitioners. Furthermore, we discuss the importance of standardized residency training and the implementation of the “gatekeeper” system in the context of China’s ongoing healthcare reform.

### Introduction

The discipline of general practice in China has undergone significant evolution over the past few decades. As the population ages and the burden of chronic non-communicable diseases increases, the demand for comprehensive, continuous, and personalized medical services has reached an unprecedented level. General practitioners (GPs) are no longer merely “community doctors” but are essential coordinators of healthcare resources.

The integration of advanced computational methods has become a focal point in recent academic discourse. For instance, the application of predictive modeling in patient risk stratification allows GPs to intervene earlier in disease progression. Mathematically, the optimization of these models often involves minimizing a loss function  $\mathcal{L}(\theta)$ , where  $\theta$  represents the model parameters. In the context of population health management, we can define the risk score  $R$  for a patient as:

$$R = \sum_{i=1}^n w_i x_i + \epsilon$$

where  $x_i$  denotes various clinical indicators,  $w_i$  represents the assigned weights, and  $\epsilon$  is the error term. Such quantitative approaches are increasingly being incorporated into the daily workflow of Chinese community health centers.

### Current Status of General Practice in China

Currently, China is striving to establish a tiered medical diagnosis and treatment system. The core objective is to ensure that “first contact” occurs at the primary level, with seamless referrals to specialist hospitals when necessary. provides a comprehensive overview of the growth in the number of certified general practitioners across different provinces over the last five years.

Despite the quantitative growth, qualitative challenges remain. These include disparities in medical resources between urban and rural areas, as well as the need for more robust clinical guidelines tailored to the primary care setting. Research by [?] suggests that the effective use of electronic health records (EHR) can significantly reduce

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### Construction and Validation of a Predictive Model for Fall-Related Hospitalization Risk in Patients with Alzheimer' s Disease

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#### Abstract

**Objective:** To construct and validate a predictive model for the risk of fall-related hospitalization in patients with Alzheimer' s Disease (AD) using machine learning algorithms, providing a scientific basis for clinical prevention and intervention.

**Methods:** Clinical data from AD patients were retrospectively analyzed. Feature selection was performed using LASSO regression and recursive feature elimination. Multiple machine learning models, including Logistic Regression, Random Forest, and Extreme Gradient Boosting (XGBoost), were developed and

compared. Model performance was evaluated using the Area Under the Receiver Operating Characteristic Curve (AUC), calibration plots, and Decision Curve Analysis (DCA).

**Results:** A total of [Number] patients were included in the study. Key predictors identified included age, duration of disease, gait stability, cognitive impairment severity, and medication history. The XGBoost model demonstrated superior predictive performance with an AUC of [Value] in the validation set, showing high sensitivity and specificity. Calibration curves indicated good agreement between predicted and observed outcomes, and DCA confirmed the clinical utility of the model.

**Conclusion:** The developed machine learning model effectively predicts the risk of fall-related hospitalization in AD patients. This tool can assist healthcare providers in identifying high-risk individuals and implementing targeted preventive measures to reduce the incidence of falls and associated healthcare burdens.

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## Introduction

Alzheimer's Disease (AD) is a progressive neurodegenerative disorder characterized by cognitive decline, functional impairment, and behavioral symptoms. As the global population ages, the prevalence of AD continues to rise, posing significant challenges to public health systems. Among the various complications associated with AD

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## Abstract

### Background

Falls are common clinical events in patients with Alzheimer's disease (AD), which not only increase the risk of severe trauma, infection, disability, and mortality,

but also frequently lead to unplanned hospitalizations, imposing a heavy burden on families and society.

### Objective

To construct and validate a risk prediction model for fall-related hospitalization in patients with AD, and

to analyze the risk factors associated with fall-related hospitalization in order to assist clinicians in accurately identifying and intervening with high-risk individuals.

## Methods

A total of 987 AD patients recorded in the Dementia Database of Hubei Provincial Hospital of Traditional Chinese Medicine from January 2020 to

October 2025 were included and randomly divided into a training set ( $n = 690$ ) and a validation set ( $n = 297$ ) at a 7:3 ratio.

General demographic data, assessment scales, laboratory test indicators, and medication-related data were extracted from the subjects. Fall-related hospitalization events in AD patients were used as the outcome variable. LASSO regression was employed to screen potential predictive variables, and a nomogram prediction model was established using multivariable logistic regression. The area under the receiver operating characteristic (ROC) curve (AUC), calibration curves, and decision curve analysis (DCA) were used to test the model's discrimination, calibration, and clinical utility.

## Results

Among the 987 AD patients, 276 cases (27.96%) experienced fall-related hospitalizations. Multivariable logistic regression analysis based on LASSO regression showed that disease duration (OR=2.843, 95%CI=1.862-4.342), Clinical Dementia Rating (CDR) score (OR=1.275, 95%CI=1.010-1.610), history of falls (OR=7.779, 95%CI=3.515-17.213), osteoarthritis (OR=1.757, 95%CI=1.068-2.892), osteoporosis (OR=2.481, 95%CI=1.692-3.638), high-risk behavioral and psychological symptoms of dementia (BPSD) (OR=2.193, 95%CI=1.229-3.914), albumin (ALB) levels (OR=1.781, 95%CI=1.128-2.814), and high-risk medication use (OR=1.466, 95%CI=1.191-1.805) were independent risk factors for fall-related hospitalization in AD patients ( $P < 0.05$ ).

ROC results showed that the AUC for the training and validation sets were 0.753 (95%CI=0.711-0.795) and 0.794 (95%CI=0.734-0.853), respectively. Calibration curves indicated a good fit between the predicted and ideal curves for both sets. DCA results demonstrated that when the threshold probability for the nomogram to predict fall-related hospitalization risk in AD patients was within the range of 0.1-0.8, the net benefit rate was  $> 0$ .

## Conclusion

Disease duration, CDR score, history of falls, osteoarthritis, osteoporosis, high-risk BPSD, ALB levels, and high-risk medication use are significant factors influencing fall-related hospitalization in AD patients. The nomogram model constructed in this study can be effectively utilized to predict the risk of fall-related hospitalization in this population.

**Keywords**

Alzheimer' s disease; Falls; Hospitalization; Prediction model; Nomogram; Logistic regression

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**Development and Validation of a Risk Prediction Model for Fall-related Hospitalization in Patients with Alzheimer' s Disease**

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**Abstract**

**Background:** Alzheimer' s disease (AD) is a progressive neurodegenerative disorder characterized by cognitive decline and functional impairment. Patients with AD are at a significantly higher risk of falls compared to the general elderly population, often leading to serious injuries and hospitalization. Identifying high-risk individuals through predictive modeling is essential for implementing targeted preventive interventions.

**Objective:** This study aims to develop and validate a clinical risk prediction model to identify factors associated with fall-related hospitalization in patients diagnosed with Alzheimer' s disease.

**Methods:** A retrospective cohort study was conducted using clinical data from patients with AD. Potential predictors including demographic characteristics, comorbidities, medication use, and cognitive assessment scores were analyzed. The study population was divided into a training set for model development and a validation set for performance assessment. Logistic regression analysis was employed to identify independent risk factors and construct the prediction model. The model' s performance was evaluated based on its discrimination (Area Under the Receiver Operating Characteristic Curve, AUC), calibration, and clinical utility.

**Results:** Several key predictors were identified as significantly associated with fall-related hospitalization, including advanced age, history of previous falls, gait instability, use of psychotropic medications, and severity of cognitive impairment. The developed model demonstrated robust discriminative ability in both the training and validation cohorts. Calibration plots indicated good agreement between predicted and observed outcomes.

**Conclusion:** The established risk prediction model provides a reliable tool for clinicians to assess the risk of fall-related hospitalization in AD patients. By identifying high-risk individuals, healthcare providers can implement personalized fall prevention strategies to improve patient safety and reduce the burden on the healthcare system.

**Keywords:** Alzheimer's disease; Falls; Hospitalization; Risk prediction model; Machine learning; Clinical validation

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## Introduction

Alzheimer's disease (AD) represents one of the most significant challenges to global public health, characterized by a steady decline in cognitive function, memory, and executive capabilities. Beyond cognitive symptoms, AD patients frequently experience motor dysfunction, balance issues, and spatial disorientation, all of which contribute to an elevated risk of falls. Falls in this population are not merely physical accidents; they often result in severe complications such as fractures,

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**[Abstract]**

## Background

Falls are common in patients with Alzheimer's disease (AD) and are associated with

increased risks of severe trauma, infection, disability, and death, often leading to unplanned hospitalization and placing a heavy burden on families and society. Objective

To develop and validate a risk prediction model for fall-related hospitalization in patients with AD, and to identify the risk factors for fall-related hospitalization, thereby assisting physicians in accurately identifying high-risk individuals and implementing early interventions. Methods

A total of 987 patients with AD from the

dementia database of Hubei Provincial Hospital of Traditional Chinese Medicine between January 2020 and October 2025 were included. They were randomly divided into a training set (n=690) and a validation set (n=297) at a ratio of 7:3. Data on general characteristics, assessment scales, laboratory indicators, and medication use were extracted. Fall-related hospitalization was the outcome variable. Potential predictors were selected using LASSO regression. A nomogram prediction model was established using multivariable Logistic regression. Model discrimination, calibration, and clinical utility were evaluated using the area under the

receiver operating characteristic curve (AUC), calibration curves, and decision curve analysis (DCA), respectively. Results Among the 987 patients with AD, 276 (27.96%) experienced fall-related hospitalization. Multivariable Logistic regression based on variables selected by LASSO regression showed that disease duration (OR=2.843, 95%CI=1.862-4.342), Clinical Dementia Rating (CDR) score (OR=1.275, 95%CI=1.010-1.610), history of falls (OR=7.779, 95%CI=3.515-17.213), osteoarthritis (OR=1.757, 95%CI=1.068-2.892), osteoporosis (OR=2.481, 95%CI=1.692-3.638), high-risk behavioral and psychological symptoms of dementia (BPSD) (OR=2.193, 95%CI=1.229-3.914), albumin (ALB) level (OR=1.781, 95%CI=1.128-2.814), and high-risk medication use (OR=1.466, 95%CI=1.191-1.805) were independent risk factors for fall-related hospitalization in patients with AD (P<0.05). Receiver operating characteristic analysis showed that the AUCs of the training set and validation set were 0.753 (95%CI=0.711-0.795) and 0.794 (95%CI=0.734-0.853), respectively. Calibration curves showed good agreement between the predicted and ideal curves in both sets. Decision curve analysis showed that the nomogram provided a net benefit greater than 0 when the predicted probability of fall-related hospitalization ranged from 0.1 to 0.8. Conclusion Disease duration, CDR score, history of falls, osteoarthritis, osteoporosis, high-risk BPSD, ALB level, and high-risk medication use were identified as risk factors for fall-related hospitalization in patients with AD. The nomogram model constructed in this study can be used to predict the risk of fall-related hospitalization in this population. **【Key words】** Alzheimer's disease; Falls; Hospitalization; Prediction model; Nomogram; Logistic regression

Alzheimer's disease (AD) is a neurodegenerative disorder characterized by insidious onset and progressive aggravation, predominantly affecting the elderly population [?]. With the acceleration of global population aging, AD has become one of the most severe public health challenges. Global burden of disease studies indicate that by 2040, the age-standardized prevalence of AD worldwide is expected to reach 821.80 per 100,000, with the disease burden continuing to climb, particularly in East Asia [?]. In China, a national epidemiological survey showed that the prevalence of AD among people aged  $\geq 60$  years is approximately 3.9%, with an estimated patient population of 9.83 million [?]; recent systematic reviews also suggest a prevalence of approximately 3.48% in the elderly population [?].

Overall, the burden of AD is substantial, necessitating enhanced early diagnosis and standardized management. In this context, the various comorbidities and high-risk behaviors associated with AD patients warrant particular attention. Research has found that AD patients are a high-risk group for falls, with a risk up to three times higher than that of healthy peers of the same age. This is associated with risk factors such as progressive cognitive impairment, behavioral and psychological symptoms of dementia (BPSD), and polypharmacy [?]. Falls are a primary cause of increased risk for unplanned hospitalization and mortality in AD patients [?], making fall prevention and control a critical component of comprehensive AD management [?]. However, in real-world clinical practice, fall-related information is often underreported or unwitnessed.

Furthermore, individuals with cognitive impairment are more prone to memory deficits, and physicians' awareness of fall events remains low. This leads to increased uncertainty when determining "fall-related hospitalization" at the time of admission, thereby raising the risk of underdiagnosis and misjudgment [?]. Therefore, identifying high-risk characteristics and conducting risk stratification centered on the severe outcome of "fall-related hospitalization" is of great significance for optimizing the assessment and management of AD patients.

In recent years, clinical prediction models have been widely applied in the medical field. These models can quantify an individual's risk level for a specific outcome by integrating multi-dimensional information, providing a basis for subsequent stratified management [?]. In the field of fall risk prediction models, previous studies on community-dwelling and hospitalized elderly populations have accumulated substantial evidence. These models generally suggest that fall risk is closely related to multi-dimensional factors such as demographic characteristics, fall history, the musculoskeletal system, nutritional status, comorbidities, and high-risk medications [?]. These findings provide a basis for the selection of independent variables in this study. However, applying existing fall risk prediction models directly to the management of AD patients still faces significant limitations. First, most existing models were developed for the general elderly population and lack consideration of AD-specific risk factors, such as cognitive function and neuropsychiatric symptoms, which may result in insufficient performance in identifying risk among AD patients [?]. Second,

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Many models utilize retrospective data collection methods, which, while convenient [?], often rely on the recall of patients or their families for fall outcomes. This can introduce recall bias [?]; some scholars argue that such measurement errors may be a primary reason for the poor performance of existing models [?]. Third, some models depend on information such as balance tests or home environment assessments. These variables are difficult to obtain from routine medical records or in primary care settings, which limits the practical clinical application and promotion of these models [?].

Based on these challenges, this study intends to use clinical information available

in routine medical records to construct and internally validate a risk stratification tool suitable for primary care settings. This tool will be used to identify high-risk characteristics of “fall-related hospitalization” in AD patients, providing a reference for the stratified assessment and management of these patients.

This study adopts the relatively objective “fall-related hospitalization” records in medical documents as the outcome indicator. This approach not only focuses on severe fall-related outcomes that require hospitalization and incur higher medical burdens but also effectively reduces recall bias. This study constructs a diagnostic prediction model based on cross-sectional information, intended only for risk assessment and stratified identification at the current time point, rather than for causal inference or prognostic prediction of future events.

## Materials and Methods

A total of 1,078 AD patients recorded in the Dementia Database of Hubei Provincial Hospital of Traditional Chinese Medicine from January 2020 to October 2025 were initially screened. According to the preset exclusion criteria: (1) those who were long-term bedridden or unable to stand or walk ( $n = 10$ ); (2) those with missing data for key predictors such as fall history or medication records ( $n = 81$ ). Ultimately, 987 patients were included as research subjects. The subjects were randomly divided into a training set ( $n = 690$ ) and a validation set ( $n = 297$ ) according to a 7:3 ratio. The specific flowchart is shown in [Figure 1: see original paper]. This study has been approved by the Ethics Committee of Hubei Provincial Hospital of Traditional Chinese Medicine (HBZY2025-C37-02).

### 1.2 结局指标

In this study, the occurrence of fall-related hospitalization events among patients with Alzheimer’s Disease (AD) was defined as the primary outcome variable. A positive outcome was defined as hospitalization resulting from trauma caused by a fall, while a negative outcome was defined as hospitalization due to other non-fall-related conditions.

For the purposes of this research, a fall is defined as a sudden, involuntary, and unintentional change in body position that results in the patient landing on a lower level; falls directly caused by other acute medical events were excluded. Trauma associated with these events includes, but is not limited to, soft tissue injuries, joint dislocations, fractures, and other fall-related physical injuries. This definition aims to utilize objective hospitalization records to enhance the sensitivity of case identification while maintaining specificity, thereby effectively controlling for recall bias.

### 1.3 候选变量

Based on previous studies [?, ?] and clinical experience, we selected potential candidate variables that are easily accessible within primary healthcare institutions. Two researchers independently extracted the initial record data for each variable from the electronic medical record system. Prior to data extraction, all researchers underwent standardized training and demonstrated high internal consistency (Kappa value  $\geq 0.75$ ). Any discrepancies in the extracted results were resolved through arbitration by a third senior researcher.

#### 1.3.1 一般资料

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General information collected for this study includes age, gender, marital status, Body Mass Index (BMI), smoking history, alcohol consumption history, history of falls, osteoarthritis, osteoporosis, high-risk behavioral and psychological symptoms of dementia (BPSD), insomnia, Parkinson's disease, visual impairment, hearing impairment, and the Charlson Comorbidity Index (CCI). Since fall-related hospitalization was defined as the primary outcome event for this study, the index fall leading to admission was not included in the history of falls. Marital status was categorized as "married" or "unmarried" (including single, divorced, or widowed). BMI was classified as normal ( $18.5 \sim 23.9 \text{ kg/m}^2$ ), underweight ( $< 18.5 \text{ kg/m}^2$ ), or overweight ( $> 23.9 \text{ kg/m}^2$ ).

High-risk BPSD refers to specific symptoms that may increase the risk of falling, including agitation, aggression, hallucinations, delusions, wandering, or significantly impulsive behavior. A patient was defined as having high-risk BPSD if they exhibited at least one of these symptoms. Visual impairment was defined by meeting either of the following criteria: (1) a diagnosis of one or more ophthalmic diseases, such as cataracts, glaucoma, or macular degeneration, that impacted daily activities; or (2) medical records containing descriptions such as "significant visual decline" or "blindness."

Similarly, hearing impairment was defined by meeting either of the following criteria: (1) clinical diagnoses of conditions likely to cause hearing loss, such as "presbycusis" or "sensorineural hearing loss"; or (2) medical records documenting "hearing impairment" or "deafness" that resulted in communication difficulties, or the regular use of hearing aids. The CCI was utilized to quantify the burden of comorbidities. Given that all study subjects were patients with Alzheimer's Disease (AD), the "dementia" component was excluded from the calculation of the total CCI score to eliminate collinearity and ensure an accurate assessment of the impact of other comorbidities.

#### 1.3.2 评估量表

All baseline assessments were based on the patient's typical condition during the month prior to admission. These evaluations were conducted by medical

personnel through a combination of clinical examinations of the patients and interviews with their caregivers. The Barthel Index was employed to assess the patients' activities of daily living (ADL), with a total score of <60 indicating the presence of ADL impairment [?]. Cognitive function was evaluated using the Clinical Dementia Rating (CDR) scale, and the severity of dementia was graded according to the total score: 1 point for mild, 2 points for moderate, and 3 points for severe [?].

### 1.3.3 实验室检查指标

These indicators include hemoglobin (HGB) and albumin (ALB) levels. For HGB, levels between 115 and 150 g/L are considered normal, while levels <115 g/L are classified as decreased and >150 g/L as elevated. For ALB, levels  $\geq$  40 g/L are classified as non-decreased, while levels <40 g/L are classified as decreased.

### 1.3.4 药物因素

This study focuses on medications commonly prescribed to patients with Alzheimer's Disease (AD) that are associated with an increased risk of falls. Data collection was based on long-term medication records prior to the current admission, specifically targeting three categories: (1) sedative-hypnotics, (2) antipsychotics, and (3) antidepressants.

To ensure mutually exclusive classification, medications meeting the criteria for multiple categories were assigned to a single category based on the following hierarchy of priority: sedative-hypnotics > antipsychotics > antidepressants. In the case of compound preparations, each active pharmaceutical ingredient was categorized individually according to its respective class. The total score for high-risk medication categories ranged from 0 to 3 points. This score was calculated by assigning a value to each of the three categories (1 if the medication was used, 0 if not) and summing the results.

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## Statistical Methods

Statistical analyses were performed using R software (version 4.4.2) and SPSS (version 25.0). Patients were randomly assigned to a training set and a validation set at a 7:3 ratio (random seed: 124) for model development and performance evaluation, respectively. Baseline characteristics of both sets were presented and analyzed; categorical data were expressed as relative numbers and compared between groups using the  $\chi^2$  test. In the training set, potential predictive variables were initially screened using Least Absolute Shrinkage and Selection Operator (LASSO) regression with 10-fold cross-validation. Subsequently, multivariable Logistic regression analysis was employed to identify independent predictors and construct the final model (using the `glm` function in the `stats` package).

Multicollinearity among the included variables was assessed using the Variance Inflation Factor (VIF), after which a nomogram was constructed (using the `rms` package). Internal validation was performed using the Bootstrap method. Model discrimination was evaluated by the Area Under the Receiver Operating Characteristic (ROC) curve (AUC) using the `pROC` package. Model calibration was assessed via calibration curves (`rms` package) and the Hosmer-Lemeshow test (`ResourceSelection` package). Finally, the clinical utility of the model was evaluated using Decision Curve Analysis (DCA) with the `rmda` package, as shown in [Figure 1: see original paper]. A p-value of  $P < 0.05$  was considered statistically significant.

A total of 1,078 inpatients diagnosed with Alzheimer' s Disease (AD) between January 2020 and October 2025 were retrieved from the Dementia Database of Hubei Provincial Hospital of Traditional Chinese Medicine. Patients who were bedridden long-term or those with missing key data ( $n = 91$ ) were excluded from the study.

The incidence rate was 27.96%. There were no statistically significant differences between the training and validation sets ( $P > 0.05$ ) regarding fall-related hospitalization, gender, age, marital status, smoking, alcohol consumption, disease duration, Clinical Dementia Rating (CDR) score, Activities of Daily Living (ADL) score, Body Mass Index (BMI), history of falls, osteoarthritis, osteoporosis, high-risk Behavioral and Psychological Symptoms of Dementia (BPSD), insomnia, Parkinson' s disease, visual impairment, hearing impairment, Charlson Comorbidity Index (CCI), hemoglobin (HGB), albumin (ALB), or high-risk medication use, as detailed in .

## 2.2 基于 LASSO 回归筛选变量

The occurrence of fall-related hospitalization in patients with Alzheimer' s Disease (AD) was defined as the dependent variable, while the remaining 21 factors listed in Table 1 served as independent variables. The specific assignment and coding of each variable are detailed in Table 2 .

The Least Absolute Shrinkage and Selection Operator (LASSO) regression with 10-fold cross-validation was employed to screen the independent variables. As the penalty parameter  $\lambda$  increases, the degree of compression applied to the coefficient estimates of each independent variable also intensifies. Consequently, the coefficients of variables with a minor impact on the dependent variable are gradually reduced to zero, thereby decreasing the total number of variables included in the final model. In this study,  $\lambda_{1se} = 0.0411$  was selected as the optimal model parameter. At this  $\lambda$  value, eight variables were identified: disease duration, Clinical Dementia Rating (CDR) score, history of falls, osteoarthritis, osteoporosis, high-risk Behavioral and Psychological Symptoms of Dementia (BPSD), albumin (ALB), and high-risk medication use, as shown in Figure 2 [Figure 2: see original paper].

### 2.3 多因素 Logistic 回归分析结果

Multivariate logistic regression analysis was performed using fall-related hospitalization as the dependent variable and the eight indicators identified through LASSO regression as independent variables. The results demonstrated that disease duration, Clinical Dementia Rating (CDR) score, history of falls, osteoarthritis, osteoporosis, high-risk Behavioral and Psychological Symptoms of Dementia (BPSD), albumin (ALB) levels, and the number of high-risk medications were significant predictors.

A total of 987 cases were ultimately included and randomly assigned to either the training set ( $n = 690$ ) or the validation set ( $n = 297$ ) using a 7:3 ratio.

Validation set ( $n = 297$ )

Discrimination analysis: Receiver Operating Characteristic (ROC) curve

Calibration analysis: Hosmer-Lemeshow test and calibration curves

Multivariate analysis: Logistic regression

Model presentation: Nomogram

Decision Curve Analysis (DCA):

A nomogram was constructed by incorporating disease duration, CDR score, history of falls, osteoarthritis, osteoporosis, high-risk BPSD, ALB, and high-risk medications, which can be utilized to predict the risk of fall-related hospitalization in patients with Alzheimer' s disease (AD). Note: AD = Alzheimer' s disease; ROC = Receiver Operating Characteristic; DCA = Clinical Decision Curve; CDR = Clinical Dementia Rating; BPSD = Behavioral and Psychological Symptoms of Dementia; ALB = Albumin.

### 结果

Log Lambda

Results: The Nomogram risk model was well-established and demonstrates strong clinical utility.

Univariate analysis: LASSO regression

Binary classification bias

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Log Lambda

Note: Figure A displays the coefficient curves for the 21 variables; Figure B illustrates the selection of optimal variables through 10-fold cross-validation, where the left vertical line represents Lambda.min and the right vertical line represents Lambda.1se.

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(n=690)

(n=297)

## Fall-Related Hospitalizations

Falls represent a significant public health challenge, particularly among aging populations, leading to a substantial burden of fall-related hospitalizations. These incidents often result in severe physical injuries, long-term disability, and a marked decline in the quality of life for patients. Beyond the immediate clinical impact, fall-related admissions place a heavy financial strain on healthcare systems worldwide due to the costs associated with acute care, surgical interventions, and subsequent rehabilitation.

## Risk Factors and Clinical Implications

The etiology of fall-related hospitalizations is multifactorial, involving a complex interplay between intrinsic and extrinsic factors. Intrinsic factors include age-related physiological changes, such as impaired balance, muscle weakness (sarcopenia), and sensory deficits, as well as chronic comorbidities like cardiovascular disease and neurological disorders. Extrinsic factors often involve environmental hazards, such as poor lighting or slippery surfaces, and pharmacological influences, particularly the use of polypharmacy or medications that affect central nervous system stability.

When a fall necessitates hospitalization, the clinical outcomes are frequently complicated by secondary issues. Common injuries include hip fractures, traumatic brain injuries (TBI), and soft tissue trauma. For elderly patients, the immobilization required during recovery can lead to further complications, such as pressure ulcers, pneumonia, and deep vein thrombosis. Furthermore, the psychological impact—often termed “fear of falling”—can lead to self-imposed activity restriction, which paradoxically increases the risk of future falls through further physical deconditioning.

## Prevention and Management Strategies

Addressing the high rate of fall-related hospitalizations requires a comprehensive, multidisciplinary approach focused on both prevention and optimized clinical management. Evidence-based prevention strategies include regular strength and balance training, home safety assessments, and medication reviews to reduce the use of high-risk drugs. In the clinical setting, early mobilization and personalized rehabilitation protocols are essential for improving functional recovery and reducing the length of hospital stays.

Recent advancements in healthcare technology, particularly in the fields of machine learning and deep learning, offer promising tools for fall risk prediction.

By analyzing electronic health records (EHR) and gait data, these models can identify high-risk individuals before a fall occurs, allowing for targeted interventions. Ultimately, reducing fall-related hospitalizations depends on integrating these technological innovations with community-based public health initiatives to foster a safer environment for vulnerable populations.

(n=690)

(n=297)

499 (72.32)

212 (71.38)

581 (84.20)

254 (85.52)

191 (27.68)

85 (28.62)

109 (15.80)

43 (14.48)

360 (52.17)

158 (53.20)

415 (60.14)

181 (60.94)

330 (47.83)

139 (46.80)

275 (39.86)

116 (39.06)

≤ 60 years old

25 (3.62)

7 (2.36)

621 (90.00)

262 (88.22)

61-70 years old

79 (11.45)

27 (9.09)

69 (10.00)

35 (11.78)

71–80 years old

205 (29.71)

95 (31.99)

The population aged over 80 years.

381 (55.22)

168 (56.57)

377 (54.64)

147 (49.49)

313 (45.36)

150 (50.51)

510 (73.91)

230 (77.44)

180 (26.09)

67 (22.56)

479 (69.42)

215 (72.39)

211 (30.58)

82 (27.61)

## High-Risk Behavioral and Psychological Symptoms of Dementia (BPSD)

### Introduction

Behavioral and Psychological Symptoms of Dementia (BPSD) represent a broad spectrum of non-cognitive reactions occurring in subjects with dementia. These symptoms include agitation, aberration, anxiety, elation, irritability, depression, apathy, disinhibition, delusions, hallucinations, and sleep or appetite changes. Among these, “high-risk BPSD” refers to a specific subset of behaviors—such as severe aggression, wandering with high risk of injury, and acute psychosis—that pose immediate threats to the safety of the patient, caregivers, and the surrounding environment.

## Clinical Significance of High-Risk BPSD

High-risk BPSD is a critical clinical challenge in the management of neurodegenerative diseases. These symptoms are often the primary driver for early institutionalization, increased healthcare costs, and significant caregiver burnout. Unlike chronic cognitive decline, high-risk behavioral episodes often require urgent intervention. If left unmanaged, they can lead to physical injuries, legal complications, and a rapid decline in the patient's quality of life.

## Pathophysiology and Triggers

The emergence of high-risk BPSD is generally attributed to a complex interaction between neurobiological factors and environmental triggers.

1. **Neurobiological Factors:** Structural changes in the frontal and temporal lobes, as well as neurochemical imbalances involving serotonin, dopamine, and acetylcholine, are closely linked to impulse control and emotional regulation.
2. **Environmental and Psychosocial Triggers:** Factors such as overstimulation, physical pain, unmet needs (e.g., hunger or thirst), and caregiver stress can exacerbate underlying vulnerabilities, leading to acute behavioral outbursts.

## Assessment and Management Strategies

Effective management of high-risk BPSD requires a multi-modal approach that prioritizes safety while addressing the root causes of the behavior.

- **Assessment:** Clinical tools such as the Neuropsychiatric Inventory (NPI) and the Cohen-Mansfield Agitation Inventory (CMAI) are essential for quantifying the severity of symptoms. For high-risk cases, a rapid assessment of physical health (to rule out delirium or infection) is mandatory.
- **Non-Pharmacological Interventions:** These remain the first line of defense. Strategies include sensory stimulation, music therapy, and environmental modification to reduce triggers.
- **Pharmacological Interventions:** In acute high-risk situations where non-pharmacological methods fail, the use of antipsychotics, mood stabilizers,

648 (93.91)

274 (92.26)

42 (6.09)

23 (7.74)

641 (92.90)

278 (93.60)

49 (7.10)  
19 (6.40)  
465 (67.39)  
194 (65.32)  
225 (32.61)  
103 (34.68)  
653 (94.64)  
280 (94.28)  
37 (5.36)  
17 (5.72)  
656 (95.07)  
288 (96.97)  
34 (4.93)  
9 (3.03)  
512 (74.20)  
214 (72.05)  
178 (25.80)  
83 (27.95)  
245 (35.51)  
113 (38.05)  
185 (26.81)  
73 (24.58)  
427 (61.88)  
172 (57.91)  
260 (37.68)  
111 (37.37)  
235 (34.06)  
114 (38.38)  
28 (4.06)  
11 (3.70)  
181 (26.23)

76 (25.59)

509 (73.77)

221 (74.41)

Clinical Dementia Rating (CDR) Score

Activities of Daily Living (ADL) Score

354 (51.30)

155 (52.19)

336 (48.70)

142 (47.81)

415 (60.14)

184 (61.95)

High-risk medication use refers to the clinical administration of drugs that carry a significant risk of causing serious injury or life-threatening adverse events when used incorrectly. While these medications are essential for treating specific conditions, their narrow therapeutic index or complex dosing requirements necessitate stringent monitoring and specialized management protocols. Common categories of high-risk medications include anticoagulants, insulin, opioids, and chemotherapy agents. Ensuring patient safety in this context requires a multi-faceted approach, integrating clinical decision support systems, standardized labeling, and rigorous double-check procedures to minimize the potential for medication errors.

133 (19.28)

49 (16.50)

205 (29.71)

87 (29.29)

142 (20.58)

64 (21.55)

265 (38.41)

120 (40.40)

157 (22.75)

64 (21.55)

63 (9.13)

26 (8.75)

651 (94.35)

279 (93.94)

39 (5.65)

18 (6.06)

Note: CDR = Clinical Dementia Rating, ADL = Activities of Daily Living, BPSD = Behavioral and Psychological Symptoms of Dementia, CCI = Charlson Comorbidity Index, HGB = Hemoglobin, ALB = Albumin.

The influencing factors associated with fall-related hospitalizations in patients with Alzheimer' s Disease (AD) ( $P < 0.05$ ) are presented in Table 3 .

#### 2.4 AD 患者跌倒相关住院风险预测模型的构建与验证

Based on the results of the multivariate logistic regression analysis, a nomogram model was constructed to predict the risk of fall-related hospitalization in patients with Alzheimer' s Disease (AD), as shown in [Figure 3: see original paper]. The model was validated using data from the training and validation sets, respectively. ROC analysis revealed that the Area Under the Curve (AUC) for the training set was 0.753 (95% CI = 0.711-0.795), while the AUC for the validation set was 0.794 (95% CI = 0.734-0.853).

These results indicate that the model possesses good discriminative ability, as illustrated in [Figure 4: see original paper]. Calibration curves demonstrated a high degree of consistency between the predicted and ideal curves for both the training and validation sets [Figure 5: see original paper]. Furthermore, the results of the Hosmer-Lemeshow test (training set:  $\chi^2 = 7.882$ ,  $P = 0.445$ ; validation set:  $\chi^2 = 8.474$ ,  $P = 0.389$ ) and the Brier scores (training set: 0.160; validation set: 0.153) both suggest that the model has excellent calibration. Decision Curve Analysis (DCA) indicated that when the threshold probability for predicting fall-related hospitalization risk in AD patients ranges between 0.1 and 0.8, the patients derive a net benefit.

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CDR Score

Female = 0, Male = 1

$\leq 60$  years = 1, 61-70 years = 2, 71-80 years = 3,  $> 80$  years = 4

Married = 0, Unmarried = 1

High-risk BPSD

No = 0, Yes = 1

No = 0, Yes = 1

$\leq 5$  years = 0,  $> 5$  years = 1

High-risk medication

Mild dementia = 1, Moderate dementia = 2, Severe dementia = 3

ADL Score

No impairment = 0, Impairment = 1

Normal = 0, Underweight = 1, Overweight = 2

No = 0, Yes = 1

No = 0, Yes = 1

No = 0, Yes = 1

High-risk BPSD

No = 0, Yes = 1

No = 0, Yes = 1

No = 0, Yes = 1

No = 0, Yes = 1

No = 0, Yes = 1

Risk of hospitalization due to falls

Note: CDR = Clinical Dementia Rating; BPSD = Behavioral and Psychological Symptoms of Dementia; fall-induced trauma in AD patients.

$\leq 5$  points = 0,  $> 5$  points = 1

HGB (g/L)

Normal = 0, Decreased = 1, Elevated = 2

ALB (g/L)

Not reduced = 0, reduced = 1

OR (95%CI)

$<0.001$

2.843 (1.862~4.342)

The Clinical Dementia Rating (CDR) is a global scale used to assess the severity of cognitive and functional impairment in patients with dementia, particularly Alzheimer's disease. It is widely regarded as a gold standard in clinical research and diagnostic settings.

## 1. Overview of the CDR Scale

The CDR is a clinician-rated scale based on a semi-structured interview with the patient and a reliable informant (such as a family member or caregiver). Unlike brief cognitive screening tools that focus solely on test performance, the

CDR evaluates the impact of cognitive decline on daily life and functional independence.

The assessment covers six specific domains of cognitive and functional performance: - **Memory** - **Orientation** - **Judgment and Problem Solving** - **Community Affairs** - **Home and Hobbies** - **Personal Care**

## 2. Scoring and Interpretation

Each of the six domains is rated on a five-point scale of impairment: - **0**: None - **0.5**: Questionable / Very Mild - **1**: Mild - **2**: Moderate - **3**: Severe

In some specialized research contexts, a score of **4** (Profound) or **5** (Terminal) may be used to describe the final stages of the disease.

## 3. Calculation Methods

There are two primary ways to report CDR results:

1. **Global CDR Score**: This is calculated using a standardized algorithm (often the “Washington University CDR Assignment Rules”). The Global Score categorizes the patient into a single stage (e.g., CDR 1). The Memory domain is considered the primary category, while the other five are secondary.
2. **CDR Sum of Boxes (CDR-SB)**: This is the numerical sum of the scores across all six domains. The CDR-SB provides a more granular, continuous scale (ranging from 0 to 18). It is increasingly used in clinical trials because it is more sensitive to subtle changes in disease progression over time than the Global Score.

## 4. Clinical Significance

The CDR is essential for staging the progression of dementia: - **CDR 0**: Indicates normal cognitive functioning. - **CDR 0.5**: Often corresponds to Mild Cognitive Impairment (MCI) or the very earliest stages of Alzheimer’s disease. - **CDR 1, 2, and 3**: Represent the progression from mild to severe dementia, characterized by increasing loss

<0.05

1.275 (1.010~1.610)

<0.001

7.779 (3.515~17.213)

<0.05

1.757 (1.068~2.892)

<0.001

2.481 (1.692~3.638)

## High-Risk Behavioral and Psychological Symptoms of Dementia (BPSD)

### Introduction

Behavioral and Psychological Symptoms of Dementia (BPSD) represent a broad spectrum of non-cognitive reactions occurring in patients with dementia. These symptoms include agitation, aggression, depression, anxiety, apathy, psychosis, and sleep disturbances. Among these, “high-risk BPSD” refers to a specific subset of behaviors—such as severe physical aggression, wandering with a high risk of getting lost, and suicidal ideation—that pose an immediate threat to the safety and well-being of the patient, their caregivers, and the surrounding environment.

### Clinical Significance of High-Risk BPSD

The presence of high-risk BPSD is often a primary driver for the institutionalization of patients with dementia. These symptoms significantly increase caregiver burden and are associated with a more rapid decline in the patient’s functional abilities and quality of life. From a clinical perspective, identifying high-risk symptoms early is crucial for implementing targeted interventions and preventing adverse outcomes, such as physical injury or emergency hospitalizations.

### Assessment and Identification

Accurate assessment of high-risk BPSD requires a multi-dimensional approach. Standardized tools, such as the Neuropsychiatric Inventory (NPI) and the Cohen-Mansfield Agitation Inventory (CMAI), are frequently used to quantify the frequency and severity of these symptoms. However, high-risk scenarios often necessitate real-time monitoring. Recent advancements in machine learning and wearable technology have enabled the development of predictive models that can identify behavioral triggers before they escalate into high-risk events.

### Management Strategies

The management of high-risk BPSD typically follows a hierarchical approach, prioritizing non-pharmacological interventions as the first line of defense.

1. **Non-Pharmacological Interventions:** These include environmental modifications (e.g., reducing sensory overload), person-centered care, and behavioral therapy. Tailoring the environment to the patient’s past preferences and routines can significantly mitigate triggers for aggression and wandering.

2. **Pharmacological Interventions:** When non-pharmacological methods are insufficient and the risk of harm is imminent, pharmacological treatment may be necessary. This often involves the cautious use of antipsychotics, antidepressants, or mood stabilizers. However, clinicians must balance the benefits against the significant risks, including increased mortality and cerebrovascular events in elderly patients with dementia.

### Conclusion

High-risk BPSD presents a complex challenge in the care of dementia patients. Effective management requires a combination of

<0.01

2.193 (1.229~3.914)

<0.05

1.781 (1.128~2.814)

High-risk medication use refers to the clinical administration of drugs that carry a significant risk of causing serious injury or life-threatening adverse events when used incorrectly. While these medications are essential for treating specific conditions, their narrow therapeutic index or complex dosing requirements necessitate rigorous monitoring and standardized protocols to ensure patient safety.

In the context of healthcare systems and machine learning research, identifying and managing high-risk medication use involves analyzing large-scale electronic health records (EHRs) to predict adverse drug events (ADEs). Key categories of high-risk medications typically include anticoagulants, insulin, opioids, and chemotherapy agents. Effective management strategies focus on clinical decision support systems, automated screening tools, and the application of deep learning models to detect patterns of inappropriate prescribing or potential drug-drug interactions before they reach the patient.

<0.001

1.466 (1.191~1.805)

<0.001

The net rate of return is > 0, as shown in Figure 6 [Figure 6: see original paper].

1 - Specificity

Fall-related hospitalization: No = 0, Yes = 1

CDR Score

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## 讨论

AD is the most common type of dementia [?], and its incidence of falls is significantly higher than that of non-AD populations of the same age [?]. Among the 987 AD patients included in this study, 276 cases (27.96%) were classified as fall-related hospitalizations, which is consistent with previous research findings [?]. The incidence of fractures following a fall is significantly higher in AD patients compared to healthy control groups [?], and patients with cognitive impairment also face a higher risk of hip fractures than those with normal cognition [?]. Furthermore, serious complications resulting from immobilization after a fracture—such as pulmonary infections, pressure ulcers, and embolism—significantly increase mortality rates [?]. Therefore, accurately identifying AD patients at high risk for falls and implementing targeted interventions is critical.

1 - Specificity. Note: A represents the training set, B represents the validation set; ROC = Receiver Operating Characteristic, AUC = Area Under the Curve. fall-induced trauma in AD patients

Note: A represents the training set, B represents the validation set.

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Decision threshold probability. Note: A represents the training set, and B represents the validation set.

Implementing preventive measures is of great significance for reducing fall-related hospitalization rates, improving patient quality of life, and alleviating the medical burden. However, in primary healthcare settings, there is often a lack of simple and effective tools to systematically evaluate the risk of fall-related hospitalization in patients with Alzheimer's Disease (AD). Consequently, this study developed and validated a clinical prediction model based on easily accessible indicators—including disease duration, Clinical Dementia Rating (CDR) score, history of falls, osteoarthritis, osteoporosis, high-risk Behavioral and Psychological Symptoms of Dementia (BPSD), albumin (ALB) levels, and high-risk medication use. This model is designed to assist primary medical personnel in the accurate identification and intervention of high-risk patients.

Compared with previous studies, this research defines the outcome measure as “fall-related hospitalization” traceable through medical records. This focus on severe events requiring clinical intervention ensures that outcome determination is more robust and easier to verify. Furthermore, the model incorporates specific indicators reflecting the burden of AD, such as disease duration, CDR score, and high-risk BPSD, which better align with the risk profile of this specific population. Additionally, all variables used in the model are derived from routinely available medical histories, scale assessments, laboratory tests, and medication information in primary care. By avoiding reliance on additional, difficult-to-

standardize assessment metrics, the model is more suitable for widespread clinical application.

The clinical utility of this model is primarily reflected in risk quantification and the triggering of management protocols during the admission assessment phase. When an AD patient is admitted with an incomplete medical history, unclear fall circumstances, or inconsistent records, it can be clinically challenging to determine whether the current admission is fall-related. In such cases, after completing routine history taking, scale assessments, basic laboratory tests, and medication reconciliation, clinicians can calculate the model risk to quantify the probability of fall-related hospitalization. This assists in deciding whether further inquiry, focused physical examination, or appropriate imaging evaluation is necessary, thereby reducing the risk of missed or misdiagnosis. Simultaneously, the model can trigger management plans for modifiable factors—such as the review and adjustment of high-risk medication prescriptions, nutritional risk screening and support, bone health assessment and intervention, and graded BPSD management and care optimization—to reduce omissions where risks are “recorded but not addressed,” ultimately improving the standardization of care. For patients already confirmed to be admitted due to a fall, this model is not intended for event prediction.

### 3.1 反映 AD 疾病核心负担的指标

Previous studies have confirmed that the risk of falls in patients with Alzheimer’s Disease (AD) is elevated even in the early stages of the disease progression [?]. However, whether a longer disease duration independently increases the risk of falls remains a subject of ongoing investigation.

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This area remains a subject for further exploration. The present study found that a disease duration of more than 5 years in patients with Alzheimer’s Disease (AD) is a significant risk factor for fall-related hospitalization (OR=2.843, 95% CI=1.862-4.342). From a pathophysiological perspective, a longer disease duration implies more extensive neurodegeneration. This progression not only leads to the deterioration of motor and sensory functions but is also likely to cause structural damage to central balance control networks, thereby compromising postural stability [?].

Concurrently, high Clinical Dementia Rating (CDR) scores (OR=1.275, 95% CI=1.010-1.610) and the presence of high-risk Behavioral and Psychological Symptoms of Dementia (BPSD) (OR=2.193, 95% CI=1.229-3.914) both increased the risk of fall-related hospitalization in AD patients. These findings are consistent with previous research [?]. On one hand, AD-related cognitive impairment—particularly the degradation of executive function, attention, and visuospatial abilities—directly undermines the neurological foundations required to maintain balance and safe gait [?]. On the other hand, high-risk BPSD can increase fall risk through multiple mechanisms: agitation, aggression, impulsiv-

ity, and wandering behaviors may lead directly to accidental movements, while hallucinations and delusions can induce erroneous environmental interactions, further elevating the risk of falling.

Consequently, a comprehensive assessment of the aforementioned disease burden indicators is instrumental in identifying high-risk populations for AD-related fall hospitalizations. For patients with a disease duration exceeding 5 years, high CDR scores, or comorbid high-risk BPSD, it is recommended to implement rehabilitation training to improve cognitive and balance functions. Furthermore, behavioral interventions and environmental modifications should be utilized to manage BPSD-related risky behaviors, thereby mitigating the risk of severe falls.

### 3.2 反映机体脆弱性的指标

The results of this study demonstrate that osteoporosis ( $OR = 2.481$ ,  $95\% CI = 1.692-3.638$ ), osteoarthritis ( $OR = 1.757$ ,  $95\% CI = 1.068-2.892$ ), and low albumin (ALB) levels ( $OR = 1.781$ ,  $95\% CI = 1.128-2.814$ ) are significant risk factors for fall-related hospitalization in patients with Alzheimer's Disease (AD). These indicators, which reflect physiological frailty, may increase the risk of falling through multiple pathways. Osteoarthritis and osteoporosis are frequently accompanied by chronic pain and restricted mobility, which can easily trigger a vicious cycle of "pain-limited mobility-muscle atrophy," thereby significantly increasing the risk of falls [?]. Furthermore, osteoporosis reduces bone strength, ensuring that even minor falls can lead to severe consequences such as fractures [?].

Hypoalbuminemia serves not only as a marker of malnutrition but is also frequently associated with systemic inflammatory states [?]. This inflammatory state may exacerbate central neuroinflammation and neurodegeneration by compromising the integrity of the blood-brain barrier [?]. Such processes can indirectly lead to a decline in motor function and postural instability, thereby increasing susceptibility to falls [?]. Consequently, for AD patients presenting with osteoporosis or osteoarthritis, it is essential to break the "pain-limited mobility" cycle and enhance bone strength through measures including pain management, anti-inflammatory therapy, anti-osteoporotic treatment, and rehabilitative exercise. Additionally, clinicians should regard hypoalbuminemia as a warning sign of systemic inflammation and malnutrition, warranting early nutritional intervention and inflammation management.

### 3.3 反映关键事件与医源性风险的指标

The results of this study indicate that a history of previous falls ( $OR = 7.779$ ,  $95\% CI = 3.515 \sim 17.213$ ) is a significant risk marker for fall-related hospitalization in patients with Alzheimer's Disease (AD). Given the substantial magnitude of this effect size, interpretation should be approached with caution; a history of falls likely serves as an integrated indicator of multiple underlying

factors, including frailty, gait or balance impairments, and environmental or caregiving conditions.

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Due to unquantified factors, the possibility of residual confounding remains. A meta-analysis has shown that the annual recurrent fall rate among patients with Alzheimer's Disease (AD) is as high as 42.08%, highlighting the significant predictive value of fall history for future falling events [?]. Mechanistically, a history of falls is not only a concentrated manifestation of multisystem decline—including neuromuscular, balance, and cognitive functions—but also tends to trigger a vicious cycle of “fear of falling - activity restriction - further functional deterioration” [?]. Therefore, for AD patients with a history of falls, it is recommended that the prevention of recurrent falls be the core of management. Specific measures should include strengthening supervision, modifying the home environment, and implementing rehabilitation training.

High-risk medication use (OR=1.466, 95% CI=1.191-1.805) is an iatrogenic risk factor for falls in AD patients, which is consistent with previous research findings [?]. More than 90% of AD patients experience Behavioral and Psychological Symptoms of Dementia (BPSD) [?], and sedative-hypnotics, antipsychotics, and antidepressants are commonly used to control these symptoms [?]. However, these drugs may increase the risk of falls through central adverse effects (such as exacerbating cognitive impairment, extrapyramidal reactions, and orthostatic hypotension) and peripheral adverse effects (such as decreased muscle tone and slowed reaction times) [?]. Consequently, clinical decision-making in the treatment of AD combined with BPSD should carefully weigh the benefits against the risks. It is recommended that non-pharmacological therapies be prioritized; if pharmacological treatment is necessary, it should follow the principles of “lowest effective dose and short-term application,” while avoiding the concurrent use of multiple drugs that increase fall risk to maximize patient safety [?].

This study constructed and validated a clinical prediction model specifically for fall-related hospitalization risk in AD patients. The model encompasses disease-specific indicators (disease duration, CDR score, high-risk BPSD), physical vulnerability indicators (osteoarthritis, osteoporosis, low ALB), and key events and iatrogenic indicators (fall history, high-risk medication). Multicollinearity tests were performed on the included variables, and the results showed that all Variance Inflation Factor (VIF) values were <5, indicating no significant collinearity between variables and the formation of a robust comprehensive risk assessment system from complementary perspectives. This model is suitable for the admission assessment of AD patients, particularly when medical history clues are incomplete or the correlation with falls is difficult to determine. It can be used to quantify the risk of fall-related hospitalization and perform stratified identification, thereby supporting the prioritized tracing of fall-related clues and necessary examinations for high-risk patients, reducing the risk of missed identification and misjudgment.

Limitations of this study: (1) The cross-sectional design limits the inference of causal relationships. Future prospective cohort studies are planned to further evaluate the causal association between key factors and fall-related hospitalizations based on improved confounding control.

- (2) The data source is single-center, necessitating multi-center external validation to improve the generalizability of the model. (3) To control for recall bias and obtain more objective outcome measures, this study aimed specifically to identify serious fall events such as fall-related hospitalizations. While this design focuses on outcomes with a high clinical burden, the conclusions are accordingly not applicable to minor fall events in outpatient, emergency, or community settings that were not included in the study. Future research could link more comprehensive health data to construct a fall risk assessment system covering different levels of severity. (4) To facilitate the promotion of the model, this study only included variables available in routine medical records and failed to include pre-hospital fall context information, such as the home environment, time of fall, location, and activity context. Because such information often lacks structured recording in retrospective data,

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it is difficult to quantify uniformly, and the model may insufficiently reflect these modifiable factors. Subsequent studies could supplement data collection using standardized questionnaires or home assessments within a prospective cohort to further refine the model. (5) Regarding interactions, this study evaluated several key interaction terms in an extended analysis but found no stable performance gains; therefore, interaction terms were not included in the main model.

Author Contributions: Li Jiao was responsible for research design, data cleaning, statistical analysis, drawing figures and tables, and drafting the initial manuscript; Xiang Qingwei and Liu Jinjin were responsible for research implementation and feasibility analysis; Peng Lang, Zhou Jianjie, and Yang Qiong were responsible for quality control and proofreading; Mei Yingbing, Liu Hui, and Fang Yingsong were responsible for data collection; Tan Zihu was responsible for proposing the research ideas, supervision, guidance, and revision of the final version of the paper, and is overall responsible for the article.

The authors declare no conflicts of interest.

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## Correlation Between [Variable] and the Severity of Coronary Artery Lesions and Early Prognosis in Elderly Patients [J]. International Journal of Geriatrics

### Abstract

**Objective:** To investigate the correlation between [Variable/Biomarker] and the severity of coronary artery lesions, as well as its impact on early prognosis in elderly patients with coronary heart disease.

**Methods:** A total of [Number] elderly patients diagnosed with coronary heart disease at our hospital from [Date] to [Date] were selected as the research subjects. Based on the results of coronary angiography, patients were categorized into different groups according to the severity of their lesions (e.g., single-vessel, double-vessel, and multi-vessel disease groups). The Gensini score was utilized to quantify the degree of coronary artery stenosis. [Variable] levels were measured upon admission. Patients were followed up for [Duration] to observe the occurrence of major adverse cardiovascular events (MACE) to evaluate early prognosis.

**Results:** The levels of [Variable] were significantly higher in patients with multi-vessel disease compared to those with single-vessel disease ( $P < 0.05$ ). A positive correlation was observed between [Variable] levels and the Gensini score ( $r = 0.XX, P < 0.01$ ). Furthermore, the incidence of MACE in the high [Variable] group was significantly higher than in the low [Variable] group during the follow-up period. Multivariate Cox regression analysis indicated that [Variable] is an independent risk factor for poor early prognosis in elderly patients with coronary artery disease.

**Conclusion:** The level of [Variable] is closely related to the severity of coronary artery lesions in elderly patients. Monitoring this indicator may provide significant clinical value for the assessment of disease severity and the prediction of early cardiovascular outcomes.

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## Introduction

Coronary heart disease (CHD) remains a leading cause of morbidity and mortality among the elderly population worldwide. As the global population ages, the clinical management of elderly patients with complex coronary artery lesions has become increasingly challenging. The severity of coronary artery stenosis is not only a critical indicator for determining surgical intervention strategies but also a primary determinant of long-term and early-stage prognosis.

Recent studies have suggested that various biomarkers and clinical indices play a pivotal role in the progression of atherosclerosis. However, the specific correlation between [Variable] and the anatomical complexity of coronary lesions—often measured by the Gensini score—remains a

reduce falls in people with Alzheimer' s disease: study protocol for a

Journal of [Journal Name], 2025, 47(3): 1-6. DOI: 10.3969/j.issn.1674-7593.2026.03.007.

## Abstract

This paper investigates the integration of advanced machine learning techniques within complex system modeling. By leveraging deep learning architectures, we propose a novel framework for predictive analysis that enhances computational efficiency while maintaining high accuracy. The results demonstrate that the proposed method significantly outperforms traditional statistical models in handling non-linear data distributions. This research provides a theoretical foundation for future applications in large-scale data processing and autonomous decision-making systems.

## Introduction

In recent years, the rapid development of machine learning and deep learning has revolutionized the field of data science. Complex systems, characterized by high dimensionality and non-linear interactions, pose significant challenges for traditional analytical methods. As data volume grows exponentially, there is an urgent need for more robust algorithms that can extract meaningful patterns from noisy environments.

The primary objective of this study is to address the limitations of existing models by introducing a hybrid approach. By combining the interpretability

of classical statistical methods with the powerful representation capabilities of neural networks, we aim to achieve a balance between performance and transparency. This paper is organized as follows: Section 2 reviews related work; Section 3 details the methodology and mathematical formulations; Section 4 presents the experimental results; and Section 5 concludes the study.

## Methodology

### 3.1 Problem Formulation

Consider a system where the state variables are represented by the vector  $x \in \mathbb{R}^n$ . The goal is to find a mapping function  $f : \mathbb{R}^n \rightarrow \mathbb{R}^m$  such that the prediction error is minimized. We define the objective function as:

$$\min_{\theta} \mathcal{L}(\theta) = \sum_{i=1}^N \|y_i - f(x_i; \theta)\|^2 + \lambda R(\theta)$$

where  $\theta$  represents the model parameters,  $y_i$  is the ground truth, and  $R(\theta)$  is a regularization term used to prevent overfitting. In this context,  $\lambda$  serves as the hyperparameter controlling the trade-off between bias and variance.

[Figure 1: see original paper]

### 3.2 Deep Learning Architecture

The proposed architecture

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