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Natalie Boon
Ministry of Health
Yi Xuan Lee
Ministry of Health
Anusha Munusamy
Ministry of Health
Muhammad Shafiq Abd Rahman
Ministry of Health
Wei Heng Chew
Ministry of Health
Rosnah Ismail
Faculty of Medicine UKM
Rosnah Sutan
Faculty of Medicine UKM
Hazlina Mahadzir
Hospital Canselor Tuanku Muhriz UKM
Mohd Shahrir Mohamed Said
drshahrir70@gmail.com

Faculty of Medicine UKM

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Natalie Boon[3], Yi Xuan Lee[3], Anusha Munusamy[3], Muhammad Shafiq Bin Abd Rahman[3], Wei Heng Chew[3],Rosnah Ismail[1], Rosnah Sutan[1], Hazlina Mahadzir[2], Mohd Shahrir Mohamed Said[1]

1. Faculty of Medicine Universiti Kebangsaan Malaysia
2. Internal Medicine Department Hospital Canselor Tuanku Muhriz
3. Ministry of Health Malaysia

1st Author: Natalie Boon	nattie_87@hotmail.com
Co – Author Rosnah Ismail	drrose@ppukm.ukm.edu.my
Co – Author Rosnah Sutan	rosnah.sutan@ukm.edu.my
Co – Author Hasliza Mahadzir	drhazlina2013@gmail.com
Co – Author Chew Wei Heng	weiheng126p@gmail.com
Co – Author Anusha a/p Munusamy	anushamunusamy2@gmail.com
Co – Author Lee Yi Xuan	yixuan005@gmail.com
Co – Author Muhammad Shafiq bin Abd Rahman	syafiqabdrh@gmail.com

Corresponding author and Senior Consultant
drshahrir70@gmail.com

Declarations

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ABSTRACT

Risk Of Fall In The Elderly Rheumatoid Arthritis Patients And Its Associated Factors

Natalie Boon[3], Yi Xuan Lee[3], Anusha Munusamy[3], Muhammad Shafiq Bin Abd Rahman[3], Wei Heng Chew[3],Rosnah Ismail[1], Rosnah Sutan[1], Hazlina Mahdzir[2], Mohd Shahrir Mohamed Said[1]
1. Faculty of Medicine Universiti Kebangsaan Malaysia
2. Internal Medicine Department Hospital Canselor Tuanku Muhriz
3. Ministry of Health Malaysia

Introduction and Methods: This study was done in two phases.

The first phase was a phenomenological study which included RA patients aged ≥65 years old at Rheumatology Clinic, Hospital Canselor Tuanku Muhriz (HCTM).

The second phase involved an observational, cross-sectional study was conducted among elderly RA patients. Clinical data, Disease Activity Score-28 (DAS-28), medication usage, comorbidities, and laboratory markers, were collected. Participants underwent 5 times sit-to-stand test and functional assessment done.

Results: For the first phase**,** data saturation was achieved at 10 participants. 9 themes and 21 subthemes were generated.

As for the second phase, out of 83 participants, 17 (20.5%) reported falls. Notably, fallers had significantly lower serum albumin levels (36.0 vs. 37.5 g/L; p=0.038), suggesting nutritional vulnerabilities.
Comorbidities significantly associated with falls included cardiovascular disease (35% vs. 11%; p=0.022) and other miscellaneous comorbidities (65% vs. 26%; p=0.002).
Leflunomide significantly predicted increased fall risk (OR=6.55, p=0.029), whereas NSAIDs demonstrated a protective effect (OR=0.03, p=0.024).
Functional assessments identified significantly longer 5 times sit-to-stand test times (18s vs. 9s; p<0.001), increased dependence on walking aids (59% vs. 20%; p=0.004), and difficulties with overhead reaching (41% vs. 4.5%; p<0.001) among fallers.
A predictive model demonstrated strong discriminative capability (AUC=0.87) and good calibration (Hosmer-Lemeshow p=0.57).

Conclusion: The first phase of the study provided a deep understanding of geriatric, RA, and falls from patients' perspective.

The second phase of the study underscores multifactorial fall risk among elderly RA patients, emphasising functional performance, specific medication usage and comorbid conditions.

Introduction

Falls can lead to physical trauma, which in turn lead to varying degrees of restriction of activity and decreased quality of life and are of far greater consequence in the elderly. It was estimated that 30% of people over the age of 65 who live in the community experience at least one fall in a year and are observed to be strongly correlated to increasing age (1). Reports suggest that nearly 50% of these falls result in some form of physical trauma, with falls considered to be a leading cause of hospitalisation, morbidity, disability and mortality in the elderly (2). The effects also extend to the economy, with annual costs of approximately $USD 31 billion in the United States (3).

Falls in the elderly are caused by a diverse set of factors. Factors that have been shown within the literature to predispose falls in the elderly includes; i) the use of drugs, especially polypharmacy and psychoactive medicines, ii) chronic and/or degenerative diseases such as diabetes, cardiovascular disease or Parkinsons, iii) frailty leading to muscle strength reductions, gait difficulty and reduced functional limits, iv) issues of imbalance caused by orthostasis, vertigo and dizziness, v) hearing and visual problems, vi) depression, vii) incontinence, viii) arthritis, ix) pain, and x) other factors such as gender and history of falls (3-5). Many of these factors do not act in isolation but are players within a complex game of cause and effect. As an example, studies have reported the possible relationship between blood pressure, anti-hypertensive therapy and the risk of falls among elderly hypertensive patients (1). Other studies have failed to show any association between blood-pressure patterns and the risk of falls (6). This example displays the complexity of epidemiological inquiries about falls in the elderly.

Rheumatoid arthritis (RA) is a chronic autoimmune disease which causes severe morbidity with a worldwide adult prevalence of 0.2 to 1.2%. Major complaints in RA are swelling and pain of the affected joints, stiffness, fatigue, and joint destruction. Patients with RA often experience difficulties in postural control, which is typically seen in balance problems with activities of daily living, such as walking and stair climbing, in extreme cases. Patients with RA are at an increased risk of falls for various reasons, including the presence of muscle weakness and stiff or painful joints of the lower extremities resulting in impaired physical activity and alterations in gait and balance. Since RA patients may have lower bone mineral density compared to healthy individuals, they are also at an increased risk of fractures. Fractures are associated with high morbidity and mortality, making fall prediction an important prevention issue in osteoporotic RA population (7).

In 2010, only 5% of the Malaysian population was aged over 65 years, and by 2040, this is expected to increase to 14.5% (8). As outlined within the demographic transition model, Malaysia is facing an ageing population, as is experienced by many other high- and middle-income countries. An ageing population poses a real challenge to society and healthcare systems, as disease burden increases while simultaneously increasing the productive population's costs (9). A total of 7.2% of the population will be 65 and older as of 2020, necessitating a review of policies urgently to improve the nation's preparedness for elderly care.

A multicenter survey of rheumatoid arthritis patients from the Ministry of Health Rheumatology Centers in Malaysia conducted in 2008 collected a total number of 1084 RA that was under follow-up (10). The mean age group was 49.6 +/- 11.8 years at that point of time. This group of patients would largely occupy today's Malaysian elderly RA patients pool in addition to those newly diagnosed over the years.

Falls are a common event in patients with RA. Previous studies have found that about 68% of patients with RA have an increased risk of falling. Despite the commonness and the often-severe consequences, falls are still an underestimated and poorly researched issue of RA. Age and related co-morbidities are considered the most critical risk factor for falls within the elderly population.

Additionally, disease duration does not seem to play a role. Very few studies have been performed on falls and RA. These have resulted in the identification of several risk factors. Hence there is an urgent need to study the risk of falling in a geriatric patient with rheumatoid arthritis for better management, treatment and referral (3).
Despite the suggested burden, there remains almost no local evidence on the risk of falls in elderly or rheumatoid arthritis patients besides the work of Yeong et al. (11). This suggests an urgency for research within the unique context of Malaysia.

Primary Objective

To identify risk factors associated with falls in elderly rheumatoid arthritis (RA) patients at PPUKM

Secondary Objectives

1. To examine associations between sociodemographic characteristicsand the occurrence of falls in elderly RA patients.
2. To evaluate the relationship of patient comorbidities with fall risk.
3. To investigate the influence of RA disease activity (DAS-28 score) on fall occurrence in older adults with RA.
4. To assess the relationship of functional performance measures on fall risk in this population.
5. To assess the association of treatment on fall risk in this population.

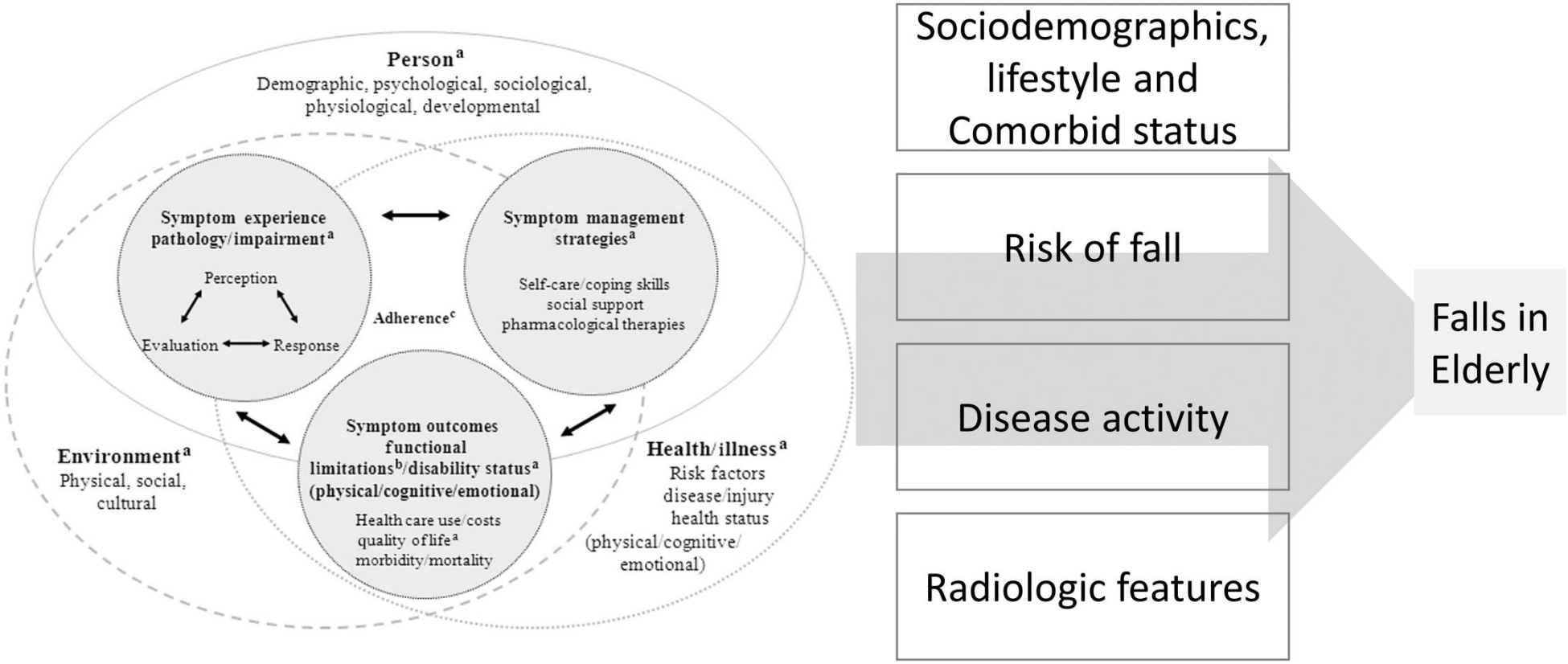


Figure 1. A conceptual framework for studying the associated factors of falls in elderly individuals with rheumatoid arthritis (Adapted (12).

Materials and Methods

3.0 Study design and recruitment procedures

This is an observational, cross- sectional study design. Data were collected from the Rheumatoid Arthritis Clinic held at Rheumatology Clinic at Pusat Perubatan Universiti Kebangsaan Malaysia (PPUKM) between 1st January 2024 to 1st July 2024. All patients aged ≥65 years with a diagnosis of RA (based on the 2010 ACR/EULAR classification criteria) and at least 1 year of continuous follow-up at the clinic were considered (13). All methods were performed in accordance with the relevant guidelines and regulations. Electronic records and clinic-based registers were screened for eligibility, applying the following criteria:

Inclusion criteria

a. Rheumatoid arthritis patients (diagnosed via 2010 ACR/EULAR criteria)
b. Age ≥65 years
c. Follow-up at PPUKM Rheumatology Clinic for ≥1 year before data extraction

Exclusion criteria

a. Age <65 years
b. Lost to follow-up
c. Diagnosis of Rheumatoid Arthritis has not been established or in the midst of workup
d. Bedridden, or unable to stand without manned assistance

Prior to data collection, all eligible patients were contacted. Those who consented were scheduled for a dedicated clinic visit, during which disease activity was re-assessed, and standardised performance tests were conducted.

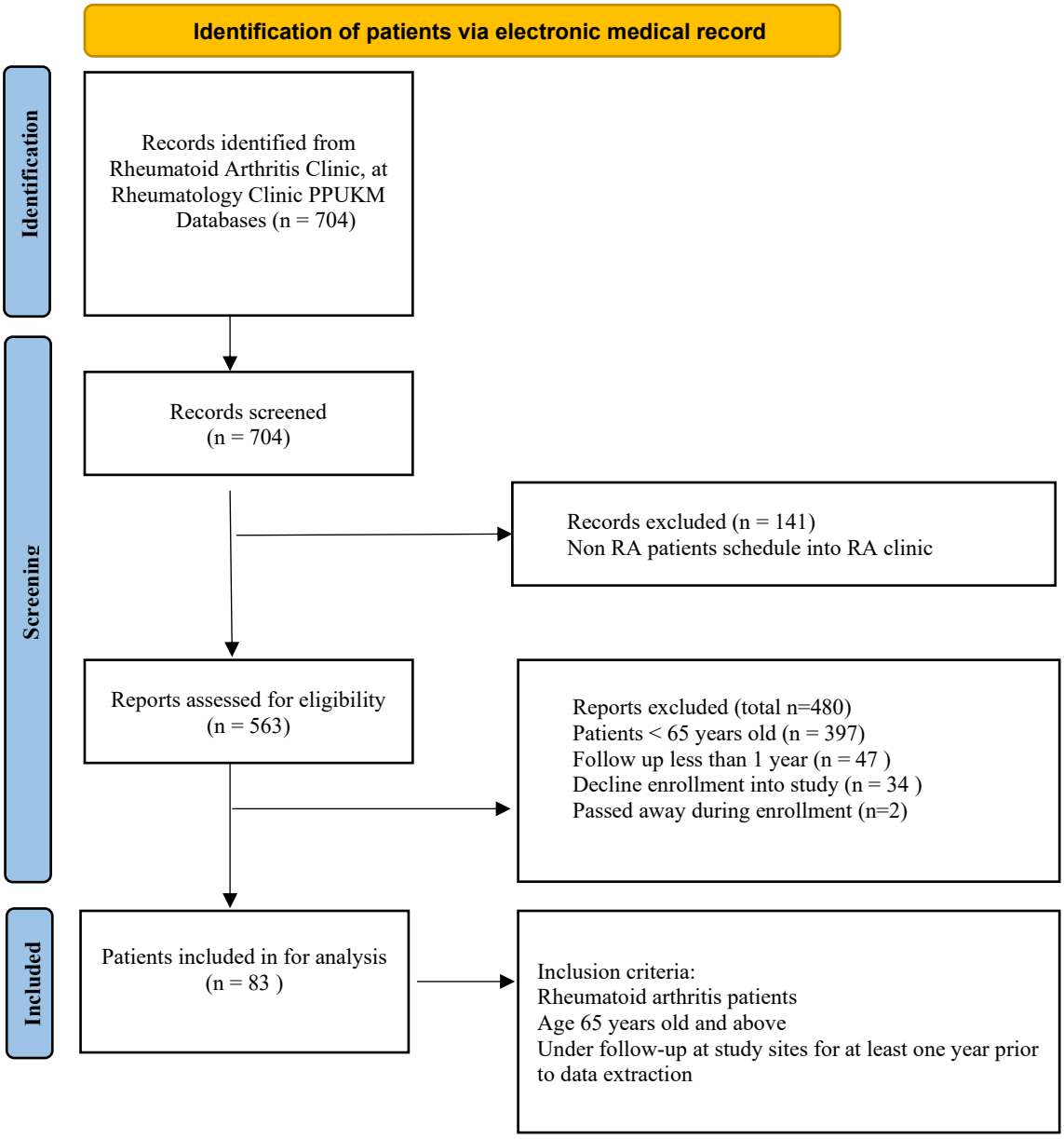
Patient case records were reviewed to extract baseline sociodemographic details (age, sex, ethnicity), clinical variables (comorbidities, including date of diagnosis), and medication history (drug type, initiation date, modifications). Standard data extraction sheets and a detailed codebook (Appendix 1) were used to ensure consistency.

Disease activity was measured via the Disease Activity Score-28 (DAS-28). For each patient, we extracted DAS-28 values and relevant laboratory variables (ESR, CRP, haemoglobin, total white cell count, platelet count) from the latest documented assessment before the fall. Swollen joint counts and tender joint counts were also retrieved.

All consenting participants underwent repeat disease activity assessment and standardised performance tests upon return to the clinic. These tests included: i) 5 times sit to stand test (measured in seconds), and 2) Functional performance questionnaire assessment.

Patients with Rheumatoid arthritis were diagnosed based on the 2010 American College of Rheumatology/ European League Against Rheumatism classification criteria for RA. The elderly within this study are defined as any individual aged 65 and above. The Prevention of Falls Network Europe (ProFaNE) definition of falls, which is defined as a "sudden unintentional change in position causing one to land on a lower level", was utilized in identifying falls.

After screening the clinic registry and inviting all potentially eligible individuals, a total of 83 patients were successfully recruited. Of these, 66 had not experienced a fall, whereas 17 reported at least one fall in the preceding year. Figure 2 illustrates the flow of participant recruitment and follow-up, including initial eligibility screening, documentation of refusals or dropouts, and the final cohort included in the study.



Data were entered and cleaned using SPSS (IBM® SPSS, version XX). Numeric distributions (e.g. age, DAS-28, laboratory values) were examined via histograms and the Shapiro–Wilk test to assess normality. Categorical variables (e.g. gender, comorbidities, medication use) were coded per the codebook. Missing or invalid entries were cross-checked against source records, with any unresolved discrepancies noted.

To confirm robustness, additional sensitivity checks were performed where feasible (e.g. removing outliers or imputing missing data). The final model's calibration and classification metrics (e.g. accuracy, AUC, pseudo R^2 values) were documented.

Ethical Approval

This study was approved by the Research Ethics Committee of the National University of Malaysia (UKM) with the registration code FF-2021-086.

Results

The descriptive analysis included 83 elderly rheumatoid arthritis (RA) patients, with 66 (79.5%) reporting no falls and 11 (20.5%) reporting falls. The median age was comparable between groups (70 vs. 71 years, p=0.4). Most participants were female (82% among non-fallers and 76% among fallers, p=0.7. Racial distribution was similar between fallers and non-fallers (Malay ~47-48%, Chinese ~35-36%, Indian ~14-18%), with no statistically significant difference (p=0.9). Demographic comparability between fallers and non-fallers is observed, with no statistically significant differences observed in age, gender, or ethnicity (Table 1).

Table 1 Demographic and Anthropometric Characteristics of Elderly Rheumatoid Arthritis Patients by Fall Status (N=83)

	Fall Status		
	No, N = 66[1]	Yes, N = 17[1]	p-value[2]
Sex			0.7
Female	54 (82%)	13 (76%)	
Male	12 (18%)	4 (24%)	
Age (years)	70.0 (68.0, 74.0)	71.0 (68.0, 74.0)	0.4
Age (months)	5.0 (1.0, 8.8)	4.0 (1.0, 7.0)	0.4
Ethnicity			0.9
Chinese	24 (36%)	6 (35%)	
Indian	9 (14%)	3 (18%)	
Malay	32 (48%)	8 (47%)	
Others	1 (1.5%)	0 (0%)	

[1]n (%); Median (IQR)

[2]Fisher's exact test; Wilcoxon rank sum test; Wilcoxon rank sum exact test

Disease activity, measured by Disease Activity Score-28 (DAS-28), did not significantly differ between fallers and non-fallers (median DAS-28: 3.23 vs. 2.98, p=0.2). Similarly, tender and swollen joint counts showed no significant difference between groups, though fallers had slightly higher proportions of patients with ≥5 tender joints (18% vs. 11%). Patient global health scores trended higher (worse health perception) in fallers (median score 30 vs. 20 in non-fallers), although the difference was not statistically significant (p=0.10). Notably, albumin levels were significantly lower among fallers (median 36.0 g/L) compared to non-fallers (37.5 g/L, p=0.038). No statistically significant differences were found in other biochemical markers including CRP, ESR, haemoglobin, platelet count, white cell count, creatinine, or lipids (Table 2).

Table 2 Disease Activity and Clinical Laboratory Indicators in Elderly Rheumatoid Arthritis Patients by Fall Status (N=83)

	Fall Status		
	No, N = 66[1]	Yes, N = 17[1]	p-value[2]
Disease Activity			
Tender Joint			0.4
More than 1	7 (11%)	3 (18%)	
None	59 (89%)	14 (82%)	
Swollen Joint			0.15
More than 1	4 (6.1%)	3 (18%)	
None	62 (94%)	14 (82%)	
Patient QoL Score (Global Health)	20 (10, 30)	30 (20, 40)	0.10
Disease Activity Score-28	2.98 (2.43, 3.29)	3.23 (2.40, 3.80)	0.2
Systolic Blood Pressure	136 (127, 143)	132 (114, 148)	0.5
Diastolic Blood Pressure	70 (66, 78)	70 (68, 75)	0.8
Heart Rate	78 (67, 87)	75 (68, 82)	0.8
Clinical Laboratory Indicators			
Hemoglobin	12.20 (11.50, 13.00)	12.10 (11.50, 13.00)	0.8
Total White Cell	6.85 (6.10, 7.90)	6.90 (4.50, 8.20)	0.5
Platelet	277 (241, 324)	282 (259, 330)	0.6
Urea	4.50 (3.60, 5.10)	4.70 (3.40, 5.90)	0.7
Creatinine	73 (60, 80)	70 (52, 84)	0.3
Albumin	37.5 (36.0, 39.8)	36.0 (35.0, 38.0)	0.038
Alanine Transaminase	21 (15, 29)	22 (15, 26)	0.6
Aspartate Transaminase	25 (20, 31)	26 (20, 33)	0.9
Missing	1	0	
Cholesterol	4.84 (4.38, 5.22)	4.85 (4.16, 5.04)	0.6
Missing	1	0	
High Density Lipid	1.37 (1.16, 1.66)	1.44 (1.18, 1.70)	0.5
Missing	1	0	
Low Density Lipid	2.76 (2.42, 3.29)	2.74 (2.30, 2.96)	0.7
Triglyceride	1.05 (0.83, 1.36)	1.06 (0.73, 1.30)	0.6
Glycated Hemoglobin	5.70 (5.50, 6.10)	5.70 (5.35, 5.85)	0.2
Missing	7	2	
C-Reactive Protein	0.33 (0.15, 0.75)	0.46 (0.19, 1.37)	0.5
Missing	3	1	
Erythrocyte Sediment Rate	35 (19, 58)	46 (19, 56)	0.6

[1]n (%); Median (IQR)

[2]Fisher's exact test; Wilcoxon rank sum test

Prevalence of comorbidities was broadly comparable across both groups, though cardiovascular disease was significantly more common among fallers (35%) compared to non-fallers (11%), p=0.022. Other comorbidities showed similar proportions across both groups, including hypertension (47% fallers vs. 32% non-fallers, p=0.2), dyslipidaemia (41% vs. 27%, p=0.3), diabetes mellitus (18% vs. 21%, p >0.9), and osteoarthritis (29% vs. 23%, p=0.5). The category “other comorbidities” was significantly higher among fallers (65% vs. 26%, p=0.002). No significant differences were identified in other listed conditions such as osteoporosis, gout, respiratory disease, or chronic kidney disease (Table 3).

*Others comorbidities here included breast carcinoma(n=4), metastatic brain carcinoma (n=1), ovarian carcinoma (n=1), diffuse large B cell Lymphona (n=1), Alzheimer’s disease (n=1), dementia (n=1), history of knee or hip replacement (n=2), degenerative spine issues (n= 6), history of stroke (n=1), thyroid disorder (n=3).

Table 3 Disease Activity and Clinical Laboratory Indicators in Elderly Rheumatoid Arthritis Patients by Fall Status (N=83)

	Fall Status		
	No, N = 66[1]	Yes, N = 17[1]	p-value[2]
Rheumatoid Arthritis Type			>0.9
Seronegative	4 (6.1%)	1 (5.9%)	
Seropositive	62 (94%)	16 (94%)	
Lung Fibrosis	10 (15%)	1 (5.9%)	0.4
Systemic Lupus Erythematosus	2 (3.0%)	1 (5.9%)	0.5
Osteoarthritis	15 (23%)	5 (29%)	0.5
Osteoporosis	5 (7.6%)	0 (0%)	0.6
Gout	4 (6.1%)	0 (0%)	0.6
Diabetes Mellitus	14 (21%)	3 (18%)	>0.9
Hypertension	21 (32%)	8 (47%)	0.2
Dyslipidaemia	18 (27%)	7 (41%)	0.3
Chronic Kidney Disease	4 (6.1%)	1 (5.9%)	>0.9
Cardiovascular Disease	7 (11%)	6 (35%)	0.022
Respiratory Disease	7 (11%)	3 (18%)	0.4
Hepatic Disease	5 (7.6%)	2 (12%)	0.6
*Other Comorbidities	17 (26%)	11 (65%)	0.002

[1]n (%)

[2]Fisher's exact test; Pearson's Chi-squared test

Significant differences in medication usage emerged for hydroxychloroquine and acetylcholinesterase inhibitors (donepezil). Hydroxychloroquine use was significantly higher among fallers (65%) compared to non-fallers (33%, p=0.018). Acetylcholinesterase inhibitor usage was also significantly higher in fallers (18% vs. 0% non-fallers, p=0.007). Prednisolone was frequently used by both groups (82% in fallers and 76% in non-fallers), with no significant difference (p=0.8). Similarly, methotrexate and leflunomide use was higher among fallers, but these differences were not statistically significant. Other medications including NSAIDs, biologics (adalimumab, tocilizumab), anti-platelets, anticoagulants, statins, and osteoporosis-related medications (denosumab, bisphosphonates) did not differ significantly between groups (Table 4).

Performance on standardised tests significantly differed between fallers and non-fallers. The 5 time sit to stand test revealed that fallers required significantly longer times (median: 18 seconds) than non-fallers (median: 9 seconds, p<0.001). Fallers also showed greater dependence on walking aids (59% vs. 20%, p=0.004). Significant difficulties were noted among fallers for reaching activities (41% vs. 4.5%, p<0.001), walking (24% vs. 0%, p=0.001), arising (18% vs. 0%, p=0.007), and grooming (12% vs. 0%, p=0.040). Among those reporting falls, the majority (82%) experienced a single fall, with weakness (40%) and missteps (33%) as primary reported causes. Most fallers required assistance to get up (85%), and a notable proportion (42%) reported some injury, although injury type and severity varied. Specific injuries included tooth fracture, coccygeal pain, thigh pain, and back pain, although these were infrequent and not systematically assessed (Table 5).

Table 4 Medication Usage Patterns in Elderly Rheumatoid Arthritis Patients by Fall Status (N=83)

	Fall Status		
	No, N = 66[1]	Yes, N = 17[1]	p-value[2]
Prednisolone	50 (76%)	14 (82%)	0.8
Hydroxychloroquine	22 (33%)	11 (65%)	0.018
Methotrexate	28 (42%)	8 (47%)	0.7
Leflunomide	17 (26%)	8 (47%)	0.088
Sulfasalazine	16 (24%)	2 (12%)	0.3
Tocilizumab	1 (1.5%)	0 (0%)	>0.9
Tofacitinib	2 (3.0%)	2 (12%)	0.2
Baricitinib	0 (0%)	1 (5.9%)	0.2
Adalimumab	2 (3.0%)	0 (0%)	>0.9
Etanercept	1 (1.5%)	0 (0%)	>0.9
Denosumab	2 (3.0%)	1 (5.9%)	0.5
NSAIDs	21 (32%)	3 (18%)	0.4
Gabapentin	3 (4.5%)	1 (5.9%)	>0.9
Tramadol	12 (18%)	2 (12%)	0.7
Antiplatelets	5 (7.6%)	4 (24%)	0.080
Anticoagulants	2 (3.0%)	0 (0%)	>0.9
Statins	30 (45%)	9 (53%)	0.6
Bisphosphonates	11 (17%)	1 (5.9%)	0.4
Calcium Tablets	46 (70%)	12 (71%)	>0.9
Calcitriol	15 (23%)	7 (41%)	0.14
ACE Inhibitors	9 (14%)	2 (12%)	>0.9
Angiotensin II Receptor Blockers (ARB)	7 (11%)	3 (18%)	0.4
Calcium Channel Blocker (CCB)	26 (39%)	9 (53%)	0.3
Beta Blocker	8 (12%)	4 (24%)	0.3
Diuretics	5 (7.6%)	1 (5.9%)	>0.9
Alpha Blocker (Tamsulosin)	2 (3.0%)	0 (0%)	>0.9
5-Alpha Reductase Inhibitors	1 (1.5%)	0 (0%)	>0.9
Allopurinol	7 (11%)	0 (0%)	0.3
Biguanides (Metformin)	11 (17%)	2 (12%)	>0.9
Sulfonylurea (Gliclazide)	2 (3.0%)	0 (0%)	>0.9
SGLT2 Inhibitors	1 (1.5%)	1 (5.9%)	0.4
Proton Pump Inhibitor	19 (29%)	8 (47%)	0.2
Anti-epileptic	2 (3.0%)	1 (5.9%)	0.5
Insulins	4 (6.1%)	0 (0%)	0.6
Acetylcholinesterase Inhibitors (Donepezil)	0 (0%)	3 (18%)	0.007
Levothyroxine	1 (1.5%)	1 (5.9%)	0.4

[1]n (%), [2]Fisher's exact test; Pearson's Chi-squared test

Table 5 Fall Characteristics, Functional Performance, and Dependence on Walking Aids in Elderly Rheumatoid Arthritis Patients by Fall Status (N=83)

	Fall Status		
Variables	No, N = 66[1]	Yes, N = 17[1]	p-value[2]
5 times sit-to stand Test	9 (8, 11)	18 (11, 999)	<0.001
History of Fall in the Past 1 Year			
No of Falls in 1 Year			<0.001
0	66 (100%)	0 (0%)	
1	0 (0%)	14 (82%)	
2	0 (0%)	2 (12%)	
3	0 (0%)	1 (5.9%)	
Cause of Fall			>0.9
Dizziness	0 (0%)	4 (27%)	
Misstep	0 (0%)	5 (33%)	
Weakness	0 (0%)	6 (40%)	
Unsure	66	2	
Get Up by Yourself			>0.9
Assisted	0 (0%)	11 (85%)	
Yes	0 (0%)	2 (15%)	
No	66	4	
Injury Status Post Fall	0 (0%)	5 (42%)	>0.9
No injury	66	5	
Activities requiring assistance in the past 1 week			
Dressing & Grooming	0 (0%)	2 (12%)	0.040
Arising from sitting position	0 (0%)	3 (18%)	0.007
Eating & Feeding self	0(0%)	0(0%)	
Walking on flat ground	0 (0%)	4 (24%)	0.001
Using Walking Aid	13 (20%)	10 (59%)	0.004
Maintaining Self-hygiene	0 (0%)	1 (5.9%)	0.2
Reach above head for Objects	3 (4.5%)	7 (41%)	<0.001
Grip Car door/ Water faucet	0(0%)	0(0%)	
Getting in/out of car	0 (0%)	1 (5.9%)	0.2

[1]Median (IQR); n (%)

[2]Wilcoxon rank sum test; Fisher's exact test

Univariate and Multivariable Regression

In univariate analysis, demographic predictors including sex, age, and ethnicity were not significantly associated with falls. Male sex showed an odds ratio (OR) of 1.38 (95% CI: 0.34–4.75, p=0.6), while age presented an OR of 1.05 per one-year increase (95% CI: 0.96–1.16, p=0.3). Ethnicity, with Chinese as reference, showed no significant association for Indian (OR 1.33, 95% CI: 0.24–6.29, p=0.7) or Malay ethnicity (OR 1.00, 95% CI: 0.31–3.40, p>0.9). In multivariable analysis, these demographic predictors remained statistically non-significant (all p>0.3) (Table 6).

Table 6 Demographic Predictors of Falls among Elderly Rheumatoid Arthritis Patients (N=83)

	Univariate			Multivariable		
	OR[1]	95% CI[1]	p-value	OR[1]	95% CI[1]	p-value
Sex						
Female	Reference			Reference		
Male	1.38	0.34, 4.75	0.6	1.34	0.32, 4.86	0.7
Age (years)	1.05	0.96, 1.16	0.3	1.05	0.95, 1.15	0.3
Ethnicity						
Chinese	Reference			Reference		
Indian	1.33	0.24, 6.29	0.7	1.28	0.22, 6.32	0.8
Malay	1.00	0.31, 3.40	>0.9	1.09	0.32, 3.84	0.9
Others	1.00	0.12, 7.80	>0.9	1.00	0.04, 9.45	>0.9

Note: BMI, Height, Weight removed from UV and MV model as they did not have any variation
[1]OR = Odds Ratio, CI = Confidence Interval

Univariate analysis identified several potential predictors (p≤0.25), including swollen joint count (OR=0.30, 95% CI: 0.06–1.67, p=0.14), DAS-28 score (OR=1.56, 95% CI: 0.89–2.82, p=0.12), patient global QoL score (OR=1.02, 95% CI: 1.00–1.05, p=0.08), albumin level (OR=0.87, 95% CI: 0.74–1.02, p=0.08), ALT level (OR=0.95, 95% CI: 0.57, 1,28, p=0.8), and HbA1c (OR=0.87, 95% CI: 0.56–1.30, p=0.5). In multivariable analysis, none remained significant, though similar trends persisted (Table 7).

Table 7 Disease Activity Indicators and Clinical Laboratory Predictors of Falls (N=83)

	Univariate			Multivariable		
	OR[1]	95% CI[1]	p-value	OR[1]	95% CI[1]	p-value
Tender Joint						
More than 1	Reference			Reference		
None	0.55	0.13, 2.81	0.4	1.99	0.02, 5.19	0.8
Swollen Joint						
More than 1	Reference			Reference		
None	0.30	0.06, 1.67	0.14	0.05	0.00, 6.86	0.3
Patient QoL Score (Global Health)	1.02	1.00, 1.05	0.08	1.02	0.97, 1.08	0.4
Disease Activity Score-28	1.56	0.89, 2.82	0.12	0.49	0.04, 5.12	0.5
Systolic Blood Pressure	0.98	0.95, 1.02	0.4	1.03	0.97, 1.10	0.4
Diastolic Blood Pressure	0.98	0.92, 1.03	0.4	0.92	0.79, 1.04	0.2
Heart Rate	0.99	0.95, 1.04	0.7	1.03	0.95, 1.12	0.5
Urea	0.96	0.69, 1.09	0.7	0.92	0.40, 2.07	0.8
Creatinine	1.0	0.97, 1.02	0.7	1.01	0.96, 1.06	0.7
Cholesterol	0.86	0.45, 1.57	0.6	1.04	0.33, 3.49	>0.9
High Density Lipid	0.84	0.40, 1.63	0.6			
Missing	1.14	0.51, 2.22	0.7			
Low Density Lipid	0.87	0.74, 1.02	0.08	0.87	0.66, 1.09	0.3
Triglyceride	0.97	0.92, 1.02	0.3	0.93	0.81, 1.04	0.2
Albumin	0.87	0.74, 1.02	0.08	1.03	0.92, 1.17	0.6
Alanine Transaminase	0.95	0.57, 1.28	0.8	0.81	0.23, 1.53	0.7
Aspartate Transaminase	0.43	0.12, 1.02	0.15	0.27	0.04, 1.05	0.13
C-Reactive Protein	1.00	0.99, 1.01	0.6	1.00	0.99, 1.02	0.5
Glycated Hemoglobin	0.87	0.56, 1.30	0.5	1.47	0.70, 3.36	0.3

Note: HDL, LDL and TG removed from Model as they were multicollinear
[1]OR = Odds Ratio, CI = Confidence Interval

Cardiovascular disease (OR=4.60, 95% CI: 1.27–16.6, p=0.018) and "other" comorbidities (OR=5.28, 95% CI: 1.74–17.5, p=0.004) significantly predicted falls in univariate analysis. Lung fibrosis (OR=0.35, p=0.3), hypertension (OR=1.90, p=0.2), dyslipidaemia (OR=1.87, p=0.3), respiratory disease (OR=1.81, p=0.4), and hepatic disease (OR=1.63, p=0.6) were all not significant.. Multivariable analysis retained cardiovascular disease (OR=27.6, p=0.014), lung fibrosis (OR=0.02, p=0.029), and "other" comorbidities (OR=11.0, p=0.012) as significant predictors (Table 8).

In univariate analysis, significant predictors were hydroxychloroquine (OR=3.67, p=0.023), antiplatelet medications (OR=3.75, p=0.073), leflunomide (OR=2.56, p=0.094), calcitriol (OR=2.38, p=0.13), beta-blockers (OR=2.23, p=0.2), proton pump inhibitors (OR=2.20, p=0.2), and SGLT2 inhibitors (OR=4.06, p=0.3). Multivariable analysis identified NSAID use as significantly protective (OR=0.03, p=0.024) and hydroxychloroquine (HCQ, OR=28.7, p>0.05) and tofacitinib (OR=97.3, p=0.067) showed a trend towards significance (Table 9).

Table 8 Comorbidities as Predictors of Falls in Elderly Rheumatoid Arthritis Patients (N=83)

	Univariate			Multivariable		
	OR[1]	95% CI[1]	p-value	OR[1]	95% CI[1]	p-value
Rheumatoid Arthritis Type						
Seronegative	Reference			Reference		
Seropositive	1.03	0.14, 20.9	>0.9	0.36	0.01, 19.2	0.6
Lung Fibrosis						
No	Reference			Reference		
Yes	0.35	0.02, 2.04	0.3	0.02	0.00, 0.33	0.029
Systemic Lupus Erythematosus						
No	Reference			Reference		
Yes	2.00	0.09, 22.2	0.6	1.14	0.03, 23.5	>0.9
Osteoarthritis						
No	Reference			Reference		
Yes	1.42	0.40, 4.52	0.6	0.94	0.14, 5.32	>0.9
Diabetes Mellitus						
No	Reference			Reference		
Yes	0.80	0.17, 2.88	0.7	0.11	0.01, 1.07	0.081
Hypertension						
No	Reference			Reference		
Yes	1.90	0.63, 5.69	0.2	1.14	0.16, 6.88	0.9
Dyslipidaemia						
No	Reference			Reference		
Yes	1.87	0.60, 5.64	0.3	1.60	0.25, 9.99	0.6
Chronic Kidney Disease						
No	Reference			Reference		
Yes	0.97	0.05, 7.13	>0.9	3.16	0.10, 69.0	0.5
Cardiovascular Disease						
No	Reference			Reference		
Yes	4.60	1.27, 16.6	0.018	27.6	2.67, 755	0.014
Respiratory Disease						
No	Reference			Reference		
Yes	1.81	0.36, 7.44	0.4	5.88	0.75, 48.5	0.085
Hepatic Disease						
No	Reference			Reference		
Yes	1.63	0.22, 8.40	0.6	4.40	0.38, 49.7	0.2
Other Comorbidities						
No	Reference			Reference		
Yes	5.28	1.74, 17.5	0.004	11.0	1.87, 86.7	0.012

Note: Osteoporosis, Gout were removed from Model as they did not have any variation
[1]OR = Odds Ratio, CI = Confidence Interval

Table 9 Medication Use as Predictors of Falls in Elderly Rheumatoid Arthritis Patients (N=83)

	Univariate			Multivariable		
	OR[1]	95% CI[1]	p-value	OR[1]	95% CI[1]	p-value
Prednisolone						
No	Reference			Reference		
Yes	1.49	0.42, 7.06	0.6	3.88	0.23, 6.47	0.3
Hydroxychloroquine						
No	Reference			Reference		
Yes	3.67	1.23, 11.9	0.023	28.7	1.73, 47.4	0.019
Methotrexate						
No	Reference			Reference		
Yes	1.21	0.41, 3.54	0.7	3.46	0.29, 41.2	0.3
Leflunomide						
No	Reference			Reference		
Yes	2.56	0.84, 7.79	0.094	27.2	1.17, 63.3	0.040
Sulfasalazine						
No	Reference			Reference		
Yes	0.42	0.06, 1.70	0.3	0.05	0.01, 10.3	0.3
Tofacitinib						
No	Reference			Reference		
Yes	4.27	0.48, 38.0	0.2	97.3	0.73, 134.0	0.067
Denosumab						
No	Reference					
Yes	2.00	0.09, 22.2	0.6			
NSAIDs						
No	Reference			Reference		
Yes	0.46	0.10, 1.60	0.3	0.01	0.00, 0.63	0.024
Gabapentin						
No	Reference					
Yes	1.31	0.06, 11.0	0.8			
Tramadol						
No	Reference			Reference		
Yes	0.60	0.09, 2.53	0.5	2.16	0.06, 81.2	0.7
Antiplatelets						
No	Reference			Reference		
Yes	3.75	0.83, 16.2	0.073	58.4	0.58, 5,925	0.084
Statins						
No	Reference					
Yes	1.35	0.46, 4.01	0.6			
Bisphosphonates (Fosamax)						
No	Reference			Reference		
Yes	0.31	0.02, 1.80	0.3	3.46	0.09, 136	0.5
Calcium						
No	Reference			Reference		
Yes	1.04	0.34, 3.63	>0.9	0.69	0.04, 12.5	0.8
Calcitriol						
No	Reference			Reference		
Yes	2.38	0.75, 7.33	0.13	1.31	0.06, 30.0	0.9
ACE Inhibitors						
No	Reference			Reference		
Yes	0.84	0.12, 3.73	0.8	0.01	0.00, 7.71	0.2
Angiotensin II Receptor Blockers (ARB)						

	Univariate			Multivariable		
	OR[1]	95% CI[1]	p-value	OR[1]	95% CI[1]	p-value
No	Reference					
Yes	1.81	0.36, 7.44	0.4			
Calcium Channel Blocker (CCB)						
No	Reference			Reference		
Yes	1.73	0.59, 5.17	0.3	17.8	0.68, 46.8	0.084
Beta Blocker						
No	Reference					
Yes	2.23	0.53, 8.29	0.2			
Diuretics						
No	Reference			Reference		
Yes	0.76	0.04, 5.18	0.8	1.70	0.05, 58.7	0.8
Biguanides (Metformin)						
No	Reference			Reference		
Yes	0.67	0.10, 2.84	0.6	2.12	0.06, 78.2	0.7
SGLT2 Inhibitors						
No	Reference					
Yes	4.06	0.16, 107	0.3			
Proton Pump Inhibitor						
No	Reference			Reference		
Yes	2.20	0.73, 6.62	0.2	10.7	0.98, 11.8	0.052
Anti-epileptic						
No	Reference			Reference		
Yes	2.00	0.09, 22.2	0.6	0.29	0.00, 28.9	0.6
Levothyroxine						
No	Reference			Reference		
Yes	4.06	0.16, 107	0.3	65.3	0.36, 11,807	0.12

Note: Denosumab, SGLT2i, Insulins, Gabapentin, Statins, Beta blockers, ARBs removed from MV model as they were multicolinear. Baricitinib, Adalimumab, Etanercept, Alpha Blocker (Tamsulosin), 5-Alpha Reductase Inhibitors, Allopurinol, Acetylcholinesterase Inhibitors (Donepezil), Sulfonylurea (Gliclazide), Insulins, Subcutaneous Tocilizumab and Anticoagulants were removed from model as they did not have any variation

[1]OR = Odds Ratio, CI = Confidence Interval

In univariate analysis, functional performance tests significantly associated with falls included difficulty reaching (OR=14.7, p<0.001), 5 time sit-to-stand time (OR=1.00, p<0.001), and the use of a walking aid (OR=5.82, p=0.002). In multivariable analysis, difficulty in reaching remained significantly predictive (OR=9.33, p=0.034), while 5 time sit-to stand test retained borderline significance (OR=1.00, p=0.084). This is shown in Table 10.

Table 10 Functional Performance Tests as Predictors of Falls in Elderly Rheumatoid Arthritis Patients (N=83)

	Univariate			Multivariable		
	OR[1]	95% CI[1]	p-value	OR[1]	95% CI[1]	p-value
5 times sit-to stand Test	1.00	1.00, 1.01	<0.001	1.01	1.01, 1.02	0.007
Walking Aid						
No	Reference			Reference		
Yes	5.82	1.90, 19.0	0.002	1.06	0.13, 5.48	>0.9
Reach above head for Objects						
No	Reference			Reference		
Yes	14.7	3.50, 77.7	<0.001	9.33	1.27, 91.7	0.034

Note: Cause of fall, Get up by yourself, Injury status, Eating & Feeding self, Grip, Dressing & Grooming, Walking on flat ground, Getting in/out of car, Maintaining Self-hygiene, removed from Model as they did not have any variation

[1]OR = Odds Ratio, CI = Confidence Interval

4.1 Multivariable Regression

Among demographic and clinical predictors, no significant associations were found with falls. Specifically, older age was not significantly associated (OR=0.95, 95% CI: 0.68-1.24, p=0.7). Similarly, higher disease activity measured by DAS-28 (OR=1.30, 95% CI: 0.31–7.48, p=0.7), patient quality-of-life score (OR=0.97, 95% CI: 0.88–1.04, p=0.4), and serum albumin level (OR=1.12, 95% CI: 0.78–1.10, p=0.7) were not significantly predictive. Among comorbidities, lung fibrosis demonstrated a significant relationship with falls (OR=24.4, 95% CI: 1.04, 139.2, p=0.02). Other comorbidities showed a trend toward increased odds of falls but without statistical significance (OR=4.95, 95% CI: 0.39–106, p=0.2). Cardiovascular disease, hypertension, dyslipidemia, and diabetes were not retained in the final model. Medication usage analysis identified leflunomide as significantly associated with increased odds of falls (OR=52.5, 95% CI: 3.44-257.3, p=0.014). Calcitriol use was associated with increased odds but only at borderline statistical significance (OR=32.0, 95% CI: 0.98–361.8, p=0.077). Hydroxychloroquine use showed an increased odds ratio (OR=8.25, 95% CI: 0.61–270, p=0.15), though not statistically significant. Antiplatelet medication use (OR=23.2, 95% CI: 0.21-459.7, p=0.2), beta-blocker use (OR=8.70, 95% CI: 0.30–554, p=0.2), and proton pump inhibitors (OR=2.52, 95% CI: 0.21–554, p=0.5) were not significantly predictive but had p-values indicating potential trends. Functional performance predictors revealed that patients using a walking aid had significantly greater odds of falls (OR=26.5, 95% CI: 1.66–195.5, p=0.046). The 5 time sit-to-stand test was not statistically significant (OR=1.00, 95% CI: 1.00–1.01, p=0.2) (Table 11).

Table 11 Multivariable Logistic Regression Analysis Predicting Falls among Elderly Rheumatoid Arthritis Patients (N=83)

	OR[1]	95% CI[1]	p-value
Age (years)	0.95	0.68, 1.24	0.7
Disease Activity Score-28	1.30	0.31, 7.48	0.7
Patient QoL Score (Global Health)	0.97	0.88, 1.04	0.4
Albumin	1.12	0.78, 1.70	0.5
Glycated Hemoglobin	0.18	0.01, 0.80	0.02
Cardiovascular Disease			
No		Reference	
Yes	3.29	0.05, 120	0.5
Lung Fibrosis			
No		Reference	
Yes	24.4	1.04, 139.2	0.02
Other Comorbidities			
No		Reference	
Yes	4.95	0.39, 106	0.2
Hydroxychloroquine			
No		Reference	
Yes	8.25	0.61, 270	0.15
Antiplatelets			
No		Reference	
Yes	23.2	0.21, 459.7	0.2
Leflunomide			
No		Reference	
Yes	52.5	3.44, 257.3	0.01
Calcitriol			
No		Reference	
Yes	32.0	0.98, 361.8	0.05
Beta Blocker			
No		Reference	
Yes	8.70	0.30, 554	0.2
Proton Pump Inhibitor			
No		Reference	
Yes	2.52	0.21, 41.4	0.5
Tofacitinib			
No		Reference	
Yes	6.38	0.02, 467.7	0.5
5 time sit to stand Test	1.00	1.00, 1.01	0.2
Walking Aid			
No		Reference	
Yes	26.5	1.66, 195.5	0.046

Note: Swollen joints and Reach above head for Objects were removed from MV model as they were multicolinear.
[1]OR = Odds Ratio, CI = Confidence Interval

4.2 Risk Prediction for Falls

Lung fibrosis significantly increased the odds of experiencing a fall (OR=18.0, 95% CI: 1.04–118.1; p=0.10). Medication usage revealed leflunomide significantly associated with increased odds of falls (OR=6.55, 95% CI: 1.30–42.5; p=0.029), while calcitriol use was not significantly associated (OR=2.89, 95% CI: 0.52–16.5; p=0.2). Functional performance tests indicated a highly significant association between longer 5 times sit-to-stand test times and increased fall risk (OR=1.00, 95% CI: 1.00–1.01; p=0.005). Difficulty reaching objects above the head significantly increased the likelihood of falls (OR=15.2, 95% CI: 1.41–303; p=0.041). Other variables retained in the final model but not significantly associated with falls included DAS-28 score (OR=1.25, 95% CI: 0.47–

3.44; p=0.7), glycated hemoglobin (HbA1c, OR=0.82, 95% CI: 0.37–1.38; p=0.5), patient global QoL score (OR=1.00, 95% CI: 0.95–1.05; p>0.9), and the use of walking aids (OR=1.06, 95% CI: 0.09–7.92; p>0.9) (Table 12).

Model diagnostics demonstrated good predictive performance. The area under the ROC curve (AUC) was 0.87, indicating strong discriminative capability for fall risk prediction. Other diagnostic metrics further supported the model's robustness: McFadden R^2 was 0.44, suggesting acceptable model fit. Cox-Snell and Nagelkerke R^2 values were both reported at 0.57 and 0.57 respectively, reflecting a moderate to good model fit. The Hosmer-Lemeshow test, a measure of model calibration, produced a non-significant chi-square statistic (χ^2=6.726, p=0.566), indicating adequate calibration. The optimal threshold for classifying patients at risk for falls, based on the Youden Index, was identified as 0.254 (Figure 2).

Table 12 Final Multivariable Predictive Model for Falls among Elderly Rheumatoid Arthritis Patients (N=83)

	OR[1]	95% CI[1]	p-value
Disease Activity Score-28[2]	1.25	0.47, 3.44	0.7
Glycated Hemoglobin[3]	0.82	0.37, 1.38	0.5
Patient QoL Score (Global Health)[2]	1.00	0.95, 1.05	>0.9
Lung Fibrosis[3]			
No	—	—	
Yes	18.0	1.04, 118.1	0.10
Leflunomide[3]			
No	—	—	
Yes	6.55	1.30, 42.5	0.029
Calcitriol[3]			
No	—	—	
Yes	2.89	0.52, 16.5	0.2
5 times sit-to-stand Test[2]	1.00	1.00, 1.01	0.005
Walking Aid[3]			
No	—	—	
Yes	1.06	0.09, 7.92	>0.9
Reach above head for Objects[2]			
No	—	—	
Yes	15.2	1.41, 303	0.041

[1]OR = Odds Ratio, CI = Confidence Interval

[2]A-priori selection, [3]Model based stepwise selection

Model diagnostics for final model- Area under the ROC curve (AUC) = 0.87; McFadden R^2 = 0.44; Cox-Snell R^2 = 0.57; Nagelkerke R^2 = 0.57; Hosmer-Lemeshow χ^2 = 6.73 (p = 0.57); Optimal classification threshold (Youden Index) = 0.25.

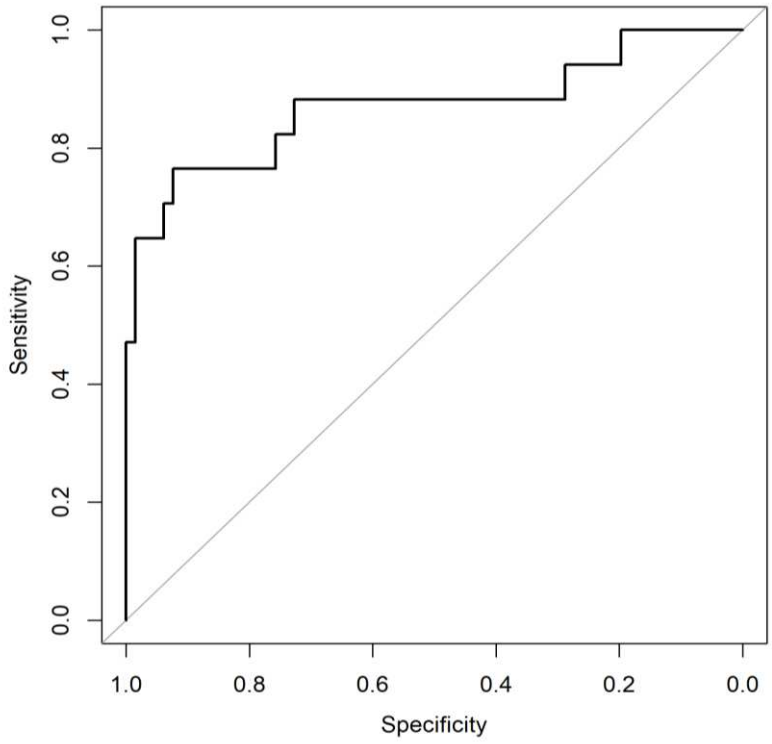


Figure 3. Receiver Operating Characteristic (ROC) Curve for the Final Multivariable Logistic Regression Model Predicting Falls in Elderly Rheumatoid Arthritis Patients (AUC = 0.87), Optimal classification threshold (Youden Index) = 0.25.

6. Discussion

The present study aimed to explore multifactorial determinants of fall risk in an elderly rheumatoid arthritis (RA) cohort, focusing on disease activity measures (e.g. DAS-28), comorbidity profiles, medication usage, and functional performance tests. Overall, our results revealed a complex interplay between traditional RA parameters and geriatric factors, with some findings—like lung fibrosis showing a significant association with falls—deviating from conventional expectations. Notably, lower albumin levels in fallers highlighted subtle nutritional vulnerabilities (potentially reflecting sarcopenia), while medications such as hydroxychloroquine, leflunomide, and acetylcholinesterase inhibitors emerged as possible pharmacological contributors to falls. Meanwhile, widely regarded fall-risk indicators in older adults—like functional limitations (5 times sit-to-stand test times, overhead reaching difficulties)—demonstrated strong predictive power independent of inflammatory burden. The data thus suggest that, although active RA pathology can worsen physical function, measuring disease activity alone may be insufficient to gauge fall risk. Comorbid conditions—particularly cardiovascular disease and chronic lung pathology—also proved pivotal, underscoring the importance of holistic geriatric care. Importantly, a newly developed falls prediction model (area under the ROC curve = 0.87) provided a preliminary but promising framework for clinicians to stratify risk, guiding interventions such as targeted rehabilitation, medication reviews, and nutritional support. Yet, the small sample size and largely cross-sectional study design preclude definitive causal inferences. These findings nevertheless bridge critical knowledge gaps, emphasizing that future research should integrate prospective designs with robust sample sizes, while also addressing key confounders like confounding by indication for certain drugs, unmeasured environmental variables, and comprehensive functional assessments. In doing so, more precise prevention strategies could be formulated, potentially lowering the substantial clinical and socioeconomic burdens that falls impose on elderly RA populations. The subsequent discussion sections elaborate on these central themes—disease activity versus functional performance, medication impacts, and comorbidity roles—and propose targeted recommendations for enhancing geriatric RA care.

Falls are significantly influenced by impaired functional performance, particularly among elderly RA patients, with measures such as the 5 times sit to stand test and difficulties in daily tasks like reaching overhead, walking, and rising from chairs strongly associated with increased fall risk. These findings align closely with existing literature, which consistently emphasises the importance of musculoskeletal function, lower limb strength, and balance in predicting falls among older adults (14). Elderly RA patients typically exhibit compromised musculoskeletal function due to joint pain, stiffness, and inflammatory joint damage, which exacerbate the age-related decline in muscle strength and mobility. Compared to their non-RA counterparts, RA patients frequently experience greater functional limitations, including poorer performance on 5 times sit to stand test and other standardised assessments, such as the Timed Up-and-Go (TUG) test (15).
While high RA disease activity (e.g. elevated DAS28 score) can contribute to fall risk via pain, joint damage, and instability, direct measures of functional impairment appear to better predict falls. Evidence here suggests that traditional disease activity scores are less potent fall-risk indicators than assessments of mobility, balance, and disability. For example, a cross-sectional study of 108 RA patients found that higher DAS28 was associated with greater fall risk (DAS28 >3.5 conferred ~9-fold higher odds of high fall risk) (16). Within the literature, the Health Assessment Questionnaire (HAQ) disability index had an even stronger impact – patients with HAQ >0.94 had a 27-fold increased odds of high fall risk(16). This indicates that functional status (ability to perform daily activities) outweighs inflammatory indices in predicting falls. Similarly, RA patients with

a history of falls tend to have worse balance and mobility metrics: those who fell show slower Timed Up-and-Go and gait speed, poorer one-leg stand time, and lower balance scores compared to non-fallers. In one series, fall-prone RA patients had significantly higher DAS28 and symptom scores, but also markedly higher HAQ scores and impaired performance on the Tinetti and Berg balance tests. A 2023 meta-analysis of 34 studies identified key risk factors for falls in RA, including use of a walking aid (OR ~1.6), history of falls or fractures, polypharmacy, and dizziness (17). Notably, measures of lower extremity function emerged as critical predictors, whereas composite disease activity was not highlighted as a significant independent factor. Prospective data reinforce the primacy of functional measures: in a 1-year study, objective physical performance tests predicted falls better than sarcopenia or RA disease metrics. Older RA patients with poor balance (low FICSIT-4 score) and higher disability (HAQ) had significantly higher fall rates, whereas sarcopenia (low muscle mass definition) and inflammatory markers were not directly associated (18). Given this evidence, assessments of gait, balance, and strength provide superior predictive value for falls over DAS28. Tools like the Short Physical Performance Battery (including chair-rise and gait speed tests) have been recommended to stratify fall risk in RA (18). In clinical practice, integrating functional assessments (e.g. chair-rising time, need for walking aids, balance tests) with disease activity scores offers a more comprehensive fall risk evaluation. Active disease control remains important to prevent pain and joint damage that indirectly contribute to falls. However, evaluating patients' real-world functional limitations is often more immediately useful for identifying those at highest risk of falling and guiding targeted fall-prevention interventions. Sarcopenia, characterised by progressive loss of muscle mass, strength, and function, further contributes to functional impairment and fall risk in RA patients. Rheumatoid arthritis accelerates the onset and severity of sarcopenia due to persistent systemic inflammation, reduced physical activity, and prolonged corticosteroid therapy, all of which directly induce muscle protein catabolism and impair muscle regeneration (18). While some studies have found direct correlations between sarcopenia and fall risk in elderly RA patients, (19) others suggest that functional performance deficits measured by specific tasks (such as chair-rise time or reaching tests) may be more immediately predictive than muscle mass alone (18). This highlights the complexity of falls as an outcome, emphasising that functional measures may better encapsulate the patient's overall vulnerability than isolated biological markers like muscle mass alone. Indeed, RA-specific joint impairments significantly impact mobility and balance. Shoulder and arm involvement commonly limits overhead reaching tasks, while lower limb disease affects gait stability, walking endurance, and ability to safely rise from a seated position (14). RA patients often display slower walking speeds, reduced leg strength, and impaired balance even when inflammation is controlled, suggesting structural joint changes and chronic pain create ongoing functional deficits (19). Consequently, standard functional tests such as the chair-rise test become particularly sensitive indicators of fall risk. Clinically, integrating such straightforward functional assessments into routine RA management could effectively identify patients at heightened risk for falls, facilitating timely implementation of targeted interventions such as strength training, balance exercises, and rehabilitation programs specifically adapted for RA patients (15, 18).

Falls among elderly RA patients pose significant risks, and medication use emerged as a critical factor associated with this risk. In this study, hydroxychloroquine (HCQ) and acetylcholinesterase inhibitors (donepezil) usage were significantly higher among fallers compared to non-fallers, suggesting these medications may play an important role in influencing fall risk. While hydroxychloroquine is not traditionally categorised among medications commonly associated with increased fall risk, there is emerging evidence

supporting its potential neuromuscular adverse effects (20). Chronic use of HCQ has been documented to cause rare but clinically significant neuromuscular complications such as proximal muscle weakness and peripheral neuropathy (21). These neuromuscular side effects can subtly impair balance and motor coordination, making elderly patients particularly vulnerable to falls, especially if the symptoms remain subclinical or unrecognised during routine clinical assessments.

The findings related to acetylcholinesterase inhibitors like donepezil, frequently prescribed for elderly patients with cognitive impairment, offer intriguing insights. Although some studies indicate that donepezil improves gait stability through enhanced cognitive functioning (22), its use was significantly associated with increased falls in the current population. This may reflect the medication's known cardiovascular side effects, particularly bradycardia and orthostatic hypotension due to enhanced parasympathetic tone (22). These cardiovascular effects could induce transient episodes of dizziness or syncope, directly precipitating falls. It is important to note that previous studies found that donepezil reduced fall risk in cognitively impaired patients by improving gait and dual-task performance (22). Its association with increased falls in this RA cohort may also reflect a poorer functional status in this group to begin with due to the underlying existing cognitive impairment.

Leflunomide, emerged as a significant predictor in the multivariable regression model. This finding aligns with reports in other studies highlighting leflunomide's potential neurotoxic effects, particularly peripheral neuropathy (23). Leflunomide-induced neuropathy, characterised by sensory deficits and motor weakness in the lower limbs, could impair proprioception and stability, significantly elevating fall risk. Thus, although less common compared to other DMARDs, clinicians must remain vigilant for neurological symptoms in elderly RA patients treated with leflunomide.

Interestingly, NSAIDs demonstrated a protective effect against falls in this study. This contrasts with prior evidence suggesting NSAIDs as a risk factor due to dizziness or orthostatic hypotension (24). However, pain control achieved with NSAIDs might indirectly enhance functional mobility, thereby reducing falls among rheumatoid arthritis patients. The protective effect observed here emphasises the complex balance between managing RA-related pain and minimising adverse medication effects.

Lastly, glucocorticoids such as prednisolone did not emerge as significant predictors of falls in this study, despite their known association with myopathy and osteoporosis, both of which are established contributors to falls in elderly patients (25). The lack of significant association may reflect uniform steroid use across RA groups, obscuring differential effects. Nevertheless, clinicians should remain vigilant for glucocorticoid-induced muscle weakness and osteoporosis when managing elderly RA patients on chronic steroid therapy.

6.1 Significance of Comorbidities & Biomarkers

In our cohort of elderly RA patients, cardiovascular disease (CVD) was present in 35% of fallers versus 11% of non-fallers ($p=0.022$), highlighting a strong association between CVD comorbidity and fall risk. This finding aligns with broader evidence that RA patients have a high propensity to fall (annual fall incidence ~10–54%) due to both RA-specific factors and general health factors (19). Prior studies in RA have emphasised joint-related issues (pain, lower extremity deformities) and functional impairment as key fall predictors (19). However, general risk factors common in older adults—such as multiple comorbidities and polypharmacy—also contribute to falls in RA (19). Our results underscore that among comorbid conditions, CVD may be particularly impactful. While some RA-focused studies did not single out CVD, they did identify proxies like anti-hypertensive use and dizziness (often related to cardiac medications or orthostatic hypotension) as significant fall risk factors (26). Comparably, in other chronic disease populations, CVD comorbidity has been linked to elevated fall risk. For example, a

systematic review in COPD patients found that a history of coronary heart disease and higher comorbidity burden were associated with increased falls (27). Thus, our finding that CVD is over-represented in RA fallers is consistent with the literature on both RA and other chronic illnesses, suggesting that cardiovascular health is a critical component of fall risk in frail populations.

CVD can contribute to falls through multiple, often interconnected, pathophysiological mechanisms. Orthostatic hypotension is a well-recognized pathway: many cardiac patients experience impaired blood pressure reflexes or take antihypertensive medications that lead to drops in blood pressure on standing, causing dizziness or syncope (Denfeld et al., 2022). Cardiac arrhythmias (such as atrial fibrillation or bradyarrhythmias) can similarly reduce cerebral perfusion (due to irregular or slow cardiac output) and precipitate fainting or balance loss (26).Structural heart disease and heart failure often result in reduced exercise tolerance and physical frailty, which manifest as muscle weakness, slow gait, and poor balance (26). Autonomic dysfunction may also play a role; for instance, baroreflex impairment in older cardiac patients can exacerbate orthostatic drops in pressure (21). Additionally, patients with CVD frequently use multiple medications (beta-blockers, diuretics, vasodilators, etc.), and polypharmacy is known to increase fall risk via side effects like dizziness and cognitive dulling (26). The American Heart Association now recognises that adults with CVD are at high risk of falls, with one survey-based analysis showing 40–60% of cardiac patients have at least moderate fall risk (26).

The finding that lung fibrosis significantly increased the odds of falls in elderly rheumatoid arthritis (RA) patients (OR=18.0, 95% CI: 1.04–139.2, p=0.10) aligns with emerging literature suggesting that chronic respiratory conditions can exacerbate fall risk, rather than mitigate it. This is consistent with findings from broader research on chronic respiratory conditions, particularly chronic obstructive pulmonary disease (COPD) and idiopathic pulmonary fibrosis (IPF), where impaired respiratory function, reduced physical stamina, and systemic deconditioning contribute to a heightened risk of falls (28).Patients with interstitial lung disease (ILD), such as that commonly seen in RA, often experience compromised pulmonary mechanics characterised by reduced lung volumes, impaired gas exchange, and decreased oxygen saturation during exertion (29). These physiological limitations inevitably diminish functional capacity and increase the risk of dizziness, muscle weakness, and fatigue—all established contributors to falls. A study examining physical function in RA patients with ILD highlighted significant deficits in muscular strength and endurance compared to RA patients without ILD, further supporting the mechanistic rationale that links respiratory dysfunction to increased fall risk (29).The physical impairments seen in RA-associated lung fibrosis—such as decreased pulmonary reserve and lower-limb muscle atrophy—are strongly associated with impaired balance and mobility deficits, two critical determinants of falls in older populations (21, 27). Additionally, lung fibrosis and other chronic respiratory diseases in RA are associated with systemic inflammation and sarcopenia, both implicated in an increased vulnerability to falls. Sarcopenia in particular is prevalent among patients with chronic inflammatory and respiratory conditions, leading to pronounced muscle weakness, reduced physical performance, and impaired balance (27). Chronic hypoxemia observed in patients with advanced fibrotic lung disease further exacerbates muscle wasting and fatigue, directly influencing gait instability and balance impairments. Therefore, the link between RA-associated lung fibrosis and increased fall risk is physiologically plausible, mediated through reduced aerobic capacity, systemic inflammation, and sarcopenia-related functional impairments.

This finding has important clinical implications. Early identification of RA patients with lung fibrosis as a subgroup at increased fall risk could facilitate targeted interventions, such as pulmonary rehabilitation programs aimed at improving respiratory

function, enhancing muscular strength, and reducing systemic inflammation. Studies suggest that pulmonary rehabilitation can significantly improve physical performance, reduce fatigue, and subsequently diminish fall risk among chronic lung disease patients (30). RA-specific interventions that integrate pulmonary rehabilitation elements, including aerobic training, strength exercises, and balance training, should be considered for patients exhibiting signs of pulmonary involvement.

Sarcopenia, as mentioned earlier, and malnutrition are common in elderly patients with rheumatoid arthritis (RA) and contribute to muscle weakness and falls (31). Approximately one-third of RA patients ≥65 years have compromised nutritional status (28.9% at risk of malnutrition, 2.6% malnourished) (32). Serum albumin is a key marker of nutritional state and frailty; about 10% of older RA patients show low albumin (<3.8 g/L) (32). As a negative acute-phase protein, albumin declines with chronic inflammation and poor intake, reflecting protein-energy malnutrition and risk of muscle wasting. Indeed, albumin is used in geriatric nutrition indices (e.g. Geriatric Nutritional Risk Index) that correlate with Mini Nutritional Assessment scores (32). RA patients with low albumin and malnutrition exhibit reduced physical function and strength. In one cross-sectional study, those with impaired nutrition had significantly worse quality of life and physical performance than well-nourished peers (32, 33). Chronic RA inflammation (cytokine excess) promotes catabolism and "rheumatoid cachexia," characterised by loss of muscle mass and strength despite stable weight. Consequently, sarcopenia prevalence in RA is higher than in healthy aging, reported in 20–60% of patients (31). Low muscle mass and poor muscle strength in RA (e.g. weak grip strength, slow gait) lead to functional decline. Notably, sarcopenia in RA is causally linked to falls and fractures (31). Malnutrition further exacerbates frailty – malnourished RA patients are more limited in daily activities and often meet frailty criteria, indicating diminished muscle function and balance (33). In older adults generally, poor nutritional status (low calf circumference, low albumin) correlates with increased fall risk. Thus, serum albumin serves as a convenient biomarker of nutritional and muscle health in RA. Identifying hypoalbuminemia in elderly RA patients is clinically important, as it signals malnutrition and sarcopenia that heighten fall risk through reduced muscle strength and functional reserve.

Significance of Falls Prevention Prediction Model

The final predictive model for falls in elderly rheumatoid arthritis (RA) patients demonstrates strong discriminative capacity (AUC=0.87), aligning with machine learning approaches in broader geriatric populations (AUC 0.73-0.88) (34). The identified association between leflunomide use and increased fall risk (OR=6.55) corroborates pharmacovigilance studies linking disease-modifying antirheumatic drugs to instability through mechanisms like neuromuscular effects, though contrasts with some literature emphasizing glucocorticoids as primary culprits (19, 35). The strong predictive value of functional measures – particularly 5 times sit to stand time (OR=1.00, p=0.005) and overhead reaching difficulty (OR=15.2) – parallels biomechanical research highlighting proximal muscle weakness and limited shoulder mobility as fall precursors in RA (19). While the model's incorporation of lung fibrosis (OR=18.0) introduces novel pathophysiological considerations absent from conventional fall risk frameworks (Gade et al., 2021), the wide confidence intervals suggest need for validation in larger cohorts. The retained but non-significant DAS-28 association (OR=1.25, p=0.7) contrasts with longitudinal studies demonstrating inflammation-mediated functional decline as a key fall pathway potentially reflecting this model's focus on medication-adjusted rather than disease activity-driven risks (19). Calibration metrics (Hosmer-Lemeshow p=0.57) surpass many existing clinical prediction tools (36, 37), though the moderate McFadden R^2 (0.44) indicates unaccounted variables like environmental factors or subclinical neuropathy described in other assessments (35). Compared to EHR-derived models

emphasizing vital signs and comorbidities, this RA-specific approach better captures disease-relevant mediators like upper extremity dysfunction, suggesting tailored models may outperform generic fall risk algorithms in chronic inflammatory populations (37). External validation should address sample size limitations (N=83) and compare performance against hybrid machine learning/biomechanical models achieving AUC>0.90 in broader musculoskeletal cohorts (34, 37).

One of the key strengths of this study lies in the detailed clinical and laboratory data collected, spanning both conventional rheumatoid arthritis (RA) disease metrics and more nuanced biochemical parameters. By measuring ESR, CRP, lipid profiles, albumin, and other laboratory indicators alongside the Disease Activity Score-28 (DAS-28), the investigation captures a multifaceted view of each patient's inflammatory status, nutritional state, and cardiometabolic risk. Such comprehensive profiling is invaluable when interpreting fall risks, as it allows potential mechanistic links—such as malnutrition or chronic inflammation—to be uncovered and quantified. In parallel, the study integrates functional assessments at multiple levels, notably including the chair-rising test, difficulty with activities of daily living (ADLs), and overhead reaching. These objective performance measures reflect the real-world challenges faced by elderly RA patients, who may struggle with joint pain, instability, and reduced muscle strength. Coupling laboratory-based disease metrics (e.g. DAS-28) with clinically observed functional impairments provides a robust framework for discerning how inflammatory pathology aligns, or fails to align, with physical capability and fall susceptibility. This dual focus—on both objective laboratory endpoints and real-world functional measures—ensures that the results are not confined to a narrow, disease-centric perspective. Instead, the study situates each participant's disease biology within their daily functional reality. By doing so, it creates an integrative dataset that can reveal subtle contributors to fall risk, such as mild hypoalbuminemia or borderline joint tenderness, while also capturing overt markers like difficulty in chair-rising or reliance on walking aids. Moreover, systematically evaluating physical performance tasks ensures that potential confounders, like pain adaptation or restricted range of motion, are recognised. Taken together, the clinical and lab synergy presented in this study significantly enhances the depth and granularity of the analyses, reinforcing the credibility of the conclusions drawn about risk factors for falls in elderly RA populations.

Another notable strength is the real-world clinical setting from which data were derived. The population examined reflects elderly RA patients routinely seen in standard rheumatology and geriatric care contexts, rather than a highly selected clinical trial cohort or narrow demographic. This diversity of participants—encompassing varied ages, comorbidities, medication regimens, and disease severities—improves the external validity and generalizability of the findings to everyday clinical practice. Indeed, older adults with RA rarely present with isolated joint disease; they often face multimorbidity, polypharmacy, and unique socioenvironmental stressors. The study emulates realistic complexities that clinicians encounter by including a broad spectrum of comorbid conditions and extensive medication usage patterns. As a result, the identified associations, such as the potential neuromuscular effects of hydroxychloroquine or the interplay between cardiovascular disease and falls, carry practical clinical significance. Furthermore, capturing functional tests like overhead reaching and chair-rising in a non-experimental context lends ecological validity to the observed fall-related deficits. Patients might perform these tasks in their usual clinical environment under less controlled conditions, mirroring real-life performance constraints more accurately than a specialised research laboratory would. This approach, therefore, uncovers how daily barriers—pain, decreased grip strength, or limited balance—manifest in standard care

pathways, rather than artificially optimised conditions. Additionally, the real-world approach illuminates how widely prescribed medications (e.g. prednisolone, leflunomide, donepezil) affect older adults with RA in naturalistic use, where adherence, comorbidity, and polypharmacy interplay. Integrating these contextual data with robust functional measures strengthens the argument that clinicians can utilise these findings to shape clinical decisions (e.g. periodic neuromuscular screening for patients on certain DMARDs, or targeted fall-prevention counselling for those with established CVD). Overall, the study's real-world setting ensures broad applicability of its conclusions, bridging the gap between controlled research protocols and the complex realities of geriatric rheumatology practice.

A final major strength is the development of a falls prediction model that appears consistent with current literature while also innovating in its inclusion of RA-specific parameters. With model diagnostics demonstrating acceptable fit and strong discriminative capability—evidenced by an area under the ROC curve (AUC) of 0.87—the predictive performance is on par with, or exceeds, many generalised fall risk tools reported in geriatric research. This underscores the value of tailoring risk algorithms to chronic inflammatory populations, as generic instruments often overlook disease-specific factors like DMARD usage or RA-related mobility impairments. By incorporating variables such as leflunomide use, calcitriol usage, and functional performance metrics (e.g. overhead reaching), the model adopts a more nuanced viewpoint of how RA pathophysiology intersects with geriatric fall mechanisms. The multivariable analyses also highlight unique associations, such as the relationship between lung fibrosis and elevated fall risk, or the apparently protective role of NSAIDs in certain contexts, lending further novelty to this predictive framework. Moreover, the model's calibration (Hosmer-Lemeshow $p=0.57$) suggests that it neither overfits nor systematically misestimates fall probabilities, thus offering clinicians and researchers a balanced tool for identifying high-risk individuals. This predictive capacity is critically important in geriatric RA management, where proactive fall prevention is essential to preserve function and minimise hospitalisations, fractures, or long-term disability. Although external validation in larger cohorts would strengthen its clinical utility, the model's alignment with existing evidence—such as the primacy of functional impairment and certain medication signals—implies that these findings are not spurious. Altogether, constructing a well-calibrated, disease-specific model for fall risk represents a clear strength of this study, bridging observed associations into a practical, implementable tool. Consequently, clinicians could apply this model to guide targeted interventions, optimise DMARD regimens, and integrate rehabilitative programs, thereby potentially mitigating the substantial burden of falls in elderly RA populations.

A primary limitation of this study stems from its small sample size and relatively low number of fallers, which undermines the statistical power needed to detect subtle associations or to confidently rule out type II errors. While significant findings emerged—such as the association between leflunomide and falls—large confidence intervals suggest considerable uncertainty. Indeed, the wide ranges observed for odds ratios underscore that certain predictors may be over- or under-estimated. This underpowered context can also inflate the influence of random effects, potentially accounting for surprising findings (e.g., the apparent protective effect of NSAIDs). Moreover, the low incidence of fallers restricts our ability to fully dissect dose-response relationships or to stratify by duration of medication use. Multicollinearity among variables (e.g., between certain comorbidities and medication usage) further complicates the interpretation, as it can mask or overstate the significance of individual predictors. Although statistical strategies, such as removing collinear variables and focusing on a parsimonious model, were employed, the limited

sample size remains a formidable constraint. Larger cohorts or pooled data from multiple centers would be desirable to confirm the robustness of these findings, improve precision, and delineate the complex interactions among medications, comorbidities, and functional impairments in fall risk.

Secondly, the study design—primarily cross-sectional with retrospective elements—precludes definitive causal inferences. We identified associations between certain variables (e.g., medication usage, functional performance deficits) and fall risk, but cannot ascertain whether these factors precipitated falls or were themselves consequences of prior falls or disease progression. For example, individuals using walking aids or reporting difficulty with overhead reaching may already have adapted their daily activities due to earlier falls, rather than these impairments acting solely as precipitants. Similarly, hydroxychloroquine or leflunomide use could be higher in patients with more aggressive or refractory disease who are inherently more vulnerable to falls, independent of medication side effects. Longitudinal or prospective methodologies with rigorous follow-up would better resolve temporal relationships. Such designs would allow for repeated measures of disease activity, medication regimens, and functional performance, clarifying the directionality of observed associations. A prospective approach could also improve accuracy in reporting fall events, reducing recall bias and enabling real-time documentation of medication changes. Without these temporal data, the current study's results remain associations rather than confirmed cause-and-effect pathways.

Generalisability also poses a challenge, as the study population was drawn from a specific clinical setting and may not reflect the broader demographic or clinical variation in elderly RA cohorts worldwide. Cultural, genetic, and healthcare system differences could modify fall risks or medication usage patterns. For instance, the proportion of patients on hydroxychloroquine or leflunomide in other regions might be different, potentially altering the observed effect sizes. Similarly, baseline prevalence of comorbidities such as cardiovascular disease or lung fibrosis can vary based on local epidemiology, rendering direct extrapolation of our results to all RA populations uncertain. The absence of complete anthropometric data (e.g., missing height measurements) in many participants further curtails the scope of analyses, particularly regarding body mass index and muscle mass estimates. Additional barriers such as variation in healthcare access, physiotherapy availability, and differing medication formularies further complicate external validity. Researchers and clinicians seeking to adapt our model or findings should account for these contextual factors and, ideally, replicate or validate the results in other RA cohorts with diverse ethnic and clinical backgrounds.

Finally, there are unaddressed or incompletely modeled variables that might refine or reshape the interpretation of fall risk in this population. In particular, confounding by indication remains a notable concern for medication findings, especially hydroxychloroquine and leflunomide. Patients receiving these therapies often have more severe or treatment-refractory RA, which might independently drive functional decline and fall propensity. Moreover, the study did not quantitatively evaluate medication side effects, such as hydroxychloroquine-induced visual impairment or leflunomide-related neuropathy, thus limiting the ability to distinguish between disease severity effects and direct drug toxicities. Additional data sources—such as validated fall risk questionnaires, objective measures of vision and proprioception, or imaging-based assessments of skeletal muscle mass—were not incorporated into the predictive model. This leaves potential confounders (e.g., subclinical neuropathy, environmental hazards, or psychosocial factors like fear of falling) insufficiently accounted for, potentially

obscuring the true magnitude of each variable's contribution. Future work might integrate more robust pharmacovigilance tracking (e.g., prospective adverse event monitoring) or advanced imaging to quantify sarcopenia and bone density. Similarly, refining the predictive model through larger datasets, with explicit attention to dose-response relationships and longitudinal progression, would better elucidate medication-specific risks and interactions. Until then, the current results, while informative, should be viewed as a starting point, underscoring a multifactorial framework of elderly RA fall risk rather than offering complete certainty.

Building on this study's findings, **larger, prospective investigations** are warranted to establish clearer causal links between specific risk factors and falls in elderly rheumatoid arthritis (RA) patients. The significant associations reported here—such as those involving lung fibrosis and medication usage—were identified in a relatively small cohort, limiting precision and statistical power. Prospective, adequately powered designs could better determine whether, for instance, leflunomide use truly precedes changes in neuromuscular function or merely correlates with more severe disease. To achieve this, **collaborative, multicentre studies** across rheumatology clinics in Malaysia and the broader ASEAN region should implement **standardised data-collection protocols**, thereby addressing variability in prescribing patterns, healthcare resources, and ethnic compositions. Such efforts would enable more robust subgroup analyses (e.g. medication duration, dose–response relationships), clarifying potential confounding by indication.

Additionally, **prospective tracking of falls**—ideally via real-time or near-real-time documentation—would minimise recall bias and provide contextual details on environmental or activity-related fall triggers. This high-quality longitudinal evidence would not only help validate or refute the associations noted here but also support the **trial and further refinement** of the study's predictive model. Given that the current model demonstrated strong discriminative capacity despite the small sample size, its application in a larger cohort could test its generalisability, gauge feasibility in routine practice, and guide potential recalibration if local population characteristics differ significantly. Ultimately, these expanded data would better inform **region-specific guidelines** for medication safety, rehabilitative interventions, and practical fall-prevention strategies—especially those reflecting local cultural practices and healthcare infrastructures. By integrating model-derived risk assessments into routine clinical workflows, clinicians could more proactively identify high-risk individuals and deliver targeted interventions, thus advancing preventive care for elderly RA patients throughout Malaysia and the ASEAN region.

The pronounced role of functional impairments (e.g. difficulty in chair-rising or overhead reaching) in fall risk highlights the need for integrated fall-prevention programmes within routine RA care. Key interventions should include periodic functional assessments—such as chair-rising tests or balance screenings—complementing standard measures like the Disease Activity Score-28 (DAS-28). When deficits are identified, tailored physiotherapy focusing on lower-limb strength, proprioception, and core stability could help restore functional independence, while occupational therapy could address practical adaptations for daily tasks (e.g., safer ways of reaching overhead). In Malaysia and neighbouring ASEAN nations, where healthcare settings vary, adopting resource-appropriate solutions—like group-based exercise sessions in local clinics or community halls—may expand accessibility. Furthermore, addressing home environment hazards is vital, given that mobility constraints and polypharmacy can increase fall likelihood. Simple measures, such as improved lighting, handrails, or removing slippery mats, can considerably reduce risk. These interventions should be multidisciplinary, involving

rheumatologists, geriatricians, and therapists, who can collaboratively track progress over time. Aligning such fall-prevention activities with the existing care pathways addresses the interplay of RA-related joint damage, muscle weakness, and comorbidities, ultimately aiming to reduce both fall incidence and the associated healthcare burden.

Our results identify certain medications—particularly hydroxychloroquine and leflunomide—as having potential neuromuscular or other side-effects that could predispose elderly RA patients to falls. Though these drugs can be essential in managing refractory or aggressive disease, periodic medication reviews could balance therapeutic benefits against emerging risks. Pharmacist-led reconciliation within a multidisciplinary clinic, including geriatric input, would be especially valuable. For instance, routine checks for ocular toxicity in hydroxychloroquine-treated patients, or neurological assessments for those on leflunomide, may detect early deficits that exacerbate instability or gait disturbance. Polypharmacy minimisation further remains crucial: older adults often take numerous agents for concurrent conditions (e.g. hypertension, dyslipidaemia), some of which could induce orthostatic hypotension or sedation. Regularly evaluating each medication's necessity, and exploring safer alternatives (such as topical NSAIDs or lower-dose corticosteroids where feasible), would mitigate iatrogenic risk factors. Collaboration with pharmacists in the Malaysian/ASEAN context is widely feasible, given that many public clinics already emphasise medication counselling. By systematically cross-checking drug profiles, monitoring side-effect emergence, and considering dose reductions when RA disease activity allows, clinicians can optimise therapeutic regimens and reduce unintended contributions to fall risk.

The modest but significant difference in albumin levels between fallers and non-fallers raises concern that subclinical malnutrition or muscle wasting (sarcopenia) may heighten fall risk. Proactive nutritional screening—using tools like the Mini Nutritional Assessment (MNA) or Geriatric Nutritional Risk Index (GNRI)—should become routine for older RA patients, especially those showing early signs of frailty, weight loss, or hypalbuminaemia. Identifying malnutrition would guide timely dietary interventions, such as protein supplementation or meal planning to support muscle mass maintenance. When dietary protein intake is culturally limited or joint pain hinders shopping and food preparation, referral to a dietitian or community-based nutritional support service could prove invaluable. In resource-constrained areas, group education programmes might highlight affordable protein sources (e.g. eggs, beans) and simple preparation methods that accommodate arthritic constraints. Concurrently, physical rehabilitation programmes focusing on resistance exercises can complement dietary strategies, fostering muscle anabolism. Given that RA inflammation can exacerbate catabolism, controlling disease activity with nutritional optimisation may more effectively preserve function. By consistently monitoring albumin and other dietary markers, rheumatology teams can detect and address nutritional risks early, potentially mitigating an under-recognised contributor to fall susceptibility.

Lastly, although disease activity scores remain vital for managing RA, our findings indicate that functional performance tests—like chair-rising time or overhead reach capability—are more directly predictive of falls. Clinicians should thus incorporate these simple, cost-effective measures into routine evaluations. Timed functional tests reflect real-world tasks and highlight deficits not captured by inflammatory markers alone. For example, an older patient with well-controlled DAS-28 scores could still struggle with tasks such as rising from a low chair or balancing on uneven ground. Identifying these deficits facilitates targeted interventions, including gait or balance retraining referrals. Standardising these assessments across rheumatology clinics in Malaysia and the ASEAN

region could refine risk stratification and enhance the treat-to-target paradigm by extending it to physical function. Parallel monitoring of disease markers ensures that anti-inflammatory strategies are not overlooked, but the ultimate goal is to maintain autonomy and prevent injury. This emphasis on real-life function echoes geriatric approaches, where quality of life and daily independence matter as much as controlling disease activity. Future research may explore how best to blend these functional metrics into existing RA management protocols, ensuring that each patient's unique risk profile is recognised and addressed systematically.

Conclusion

This study evaluated multifactorial contributors to fall risk in elderly rheumatoid arthritis (RA) patients, highlighting medication usage, comorbid conditions, nutritional status, and functional performance. Despite a relatively small sample and cross-sectional design, several noteworthy findings emerged. Medications like hydroxychloroquine, leflunomide, and acetylcholinesterase inhibitors showed potential neuromuscular or cardiovascular side effects linked with increased fall risk, underlining the importance of vigilant pharmacovigilance. Comorbidities, particularly cardiovascular disease and lung fibrosis, demonstrated strong associations with falls, suggesting that holistic geriatric management is central to mitigating risk. Moreover, functional measures—5 times sit to stand time, overhead reaching difficulty, and performance in daily tasks—consistently outperformed classical inflammatory indices (e.g. DAS-28) in predicting falls. This indicates that while controlling disease activity remains a cornerstone of RA care, assessing patients' real-world mobility and balance limitations may be more critical in preventing accidents. The finding of lower serum albumin in fallers also points to subclinical malnutrition and sarcopenia as subtle, yet significant, contributors to decreased muscle strength and stability. Despite these insights, the study's modest sample size and retrospective elements constrain its capacity to infer causality. Larger, prospective investigations are therefore vital for verifying associations and establishing the sequence of events leading to falls. Notably, the newly developed falls prediction model—demonstrating robust discriminative capability (AUC=0.87)—requires external validation in bigger, more diverse cohorts. Such efforts could refine risk estimates, adapt the model to variations in medication regimens and ethnic populations, and confirm its practical utility in clinical settings. Key recommendations emphasise systematic medication reviews to detect drug-induced neuromuscular deficits, routine functional and nutritional screening, and integrated fall-prevention strategies involving rheumatologists, geriatricians, and therapists. By combining standard disease activity monitoring with functional performance assessments, clinicians can adopt a multidimensional RA care approach. Looking ahead, effective fall prevention in elderly RA patients holds promise for reducing healthcare burdens and improving quality of life. By building on this study's findings—addressing limitations through larger prospective designs, validating the predictive model, and tailoring interventions to local contexts—healthcare providers can implement evidence-based measures that promote safety, maintain independence, and enhance overall outcomes in this vulnerable demographic.

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