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# Frailty, Comorbidity, and Functional Limitation Among Older Adults with Venous Leg Ulcers: A Cross-Sectional Study

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**Abstract**

**Background:** Venous leg ulcers in older adults are frequently accompanied by frailty, multimorbidity, and reduced physical independence, yet evidence on their combined relationship remains limited, particularly in Indonesian clinical settings.

**Aim:** To examine frailty, comorbidity, and functional limitation among older adults with venous leg ulcers

**Approach:** This cross-sectional study included 118 older adults with venous leg ulcers assessed between June 23 and August 1, 2022, using consecutive sampling. Eligible participants were aged 60 years or older with clinician-diagnosed venous leg ulcers. Frailty, comorbidity, and functional limitation were measured using validated instruments. Data were analyzed using multivariable linear regression

**Results:** A total of 118 patients completed the study. Results showed that the mean (SD) age was 69.8 (7.1) years, 71 participants (60.2%) were women, and the mean (SD) Barthel Index score was 72.4 (16.8). Frailty was present in 62 participants (52.5%). In the adjusted model, higher frailty score was associated with lower Barthel Index score (β = -2.85; 95% CI, -3.98 to -1.72; P < .001), as were higher comorbidity burden (β = -1.94; 95% CI, -3.29 to -0.59; P = .005) and greater pain intensity (β = -1.36; 95% CI, -2.28 to -0.44; P = .004)

**Conclusions:** Functional limitation was common among older adults with venous leg ulcers and was associated with frailty, comorbidity burden, and pain intensity

**Implication for Clinical Practice:** Routine venous leg ulcer assessment in older adults may benefit from brief screening for frailty, comorbidity, and pain to support risk identification, individualized care planning, and function-oriented wound management.

**Keywords:** activities of daily living; aged; comorbidity; frailty; leg ulcer; venous insufficiency

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## 1. Introduction

Venous leg ulcers (VLUs) are an important clinical and public health problem in older adults because they are chronic, recurrent, and difficult to heal. VLUs arise from chronic venous insufficiency and venous hypertension and represent the most common type of leg ulcer in many settings, contributing substantially to morbidity, long-term care needs, and impaired quality of life (Gethin et al., 2021; Raffetto et al., 2021). Recent global evidence shows that the burden of VLU remains considerable, with a pooled prevalence of 0.32% and a pooled incidence of 0.17%, while the burden is expected to increase further as populations age and chronic vascular disease becomes more common (Probst et al., 2023). This problem is also increasing in Asia; a large study from Singapore identified 598 new venous ulcers in 2017 alone, reflecting the persistent burden of chronic wounds in an ageing Asian population (Graves et al., 2023). In Indonesia, lower-extremity ulcers continue to cause substantial morbidity, mortality, treatment cost, and reduced quality of life, yet national epidemiological descriptions remain limited and are still dominated by diabetic foot literature rather than venous ulcer data specifically (Puspita Sari & Suryawati, 2023). Among older

adults, this issue is particularly relevant because advanced age is accompanied by declining physiologic reserve, multimorbidity, reduced mobility, and delayed tissue repair, all of which may worsen ulcer severity and prolong disability (Mayrovitz et al., 2023; Duluklu et al., 2025). Therefore, a better understanding of frailty, comorbidity, and functional limitation in older adults with VLU is important for improving risk assessment, wound management, and patient outcomes.

Previous studies have shown that frailty is common among older adults with chronic leg ulcers. In the GERAS study, 83% of elderly patients with leg ulcers were classified as frail on at least one validated frailty instrument, and the majority of patients with leg ulcers were considered frail overall (Zorge et al., 2023). Existing evidence also suggests that older adults with chronic leg ulcers frequently have substantial comorbidity and clinically meaningful functional burden; in a recent cross-sectional study of adults aged 65 years and older, age, comorbidities, and chronic leg ulcer status were associated with greater frailty severity, while slow gait and inability to toilet or dress independently were common contributors to frailty (Duluklu et al., 2025). Prior research has also shown that patients with VLUs experience reduced mobility, higher pain during movement, and poorer sleep quality compared with matched controls, indicating that functional limitation is a prominent consequence of this condition (Siegling et al., 2023). Community-based evidence further suggests that VLU-related quality of life is influenced by wound burden and patient characteristics, reinforcing that the consequences of VLU extend beyond the wound itself (McDaniel et al., 2025). However, these studies have largely been conducted in European or other non-Indonesian settings and have often focused on frailty alone, quality of life, or wound healing rather than directly examining the combined relationship between frailty, comorbidity, and functional limitation in hospital-based older populations with VLU. Thus, the current evidence is insufficient to clarify this issue in Indonesian clinical settings.

Little is known about the combined pattern of frailty, comorbidity, and functional limitation among older adults with venous leg ulcers in Indonesia. This is important because older adults with VLU often require repeated wound care, prolonged follow-up, compression-based management, and support for mobility and self-care, so unrecognized frailty and comorbidity may worsen functional dependence and delay recovery (Raffetto et al., 2021; Mayrovitz et al., 2023). In particular, it remains unclear whether greater frailty and higher comorbidity burden are associated with more severe functional limitation among older adults with VLU receiving care in a general hospital setting. To our knowledge, no recent study has specifically examined these three variables together among older adults with venous leg ulcers in General Hospital Gambiran. Addressing this gap may inform comprehensive geriatric wound assessment, multidisciplinary care planning, and future longitudinal research in Indonesian wound care practice.

Therefore, the objective of this study was to examine frailty, comorbidity, and functional limitation among older adults with venous leg ulcers at General Hospital Gambiran. In this cross-sectional study, we examined 121 patients with venous leg ulcers and assessed frailty and comorbidity as the principal explanatory variables in relation to functional limitation. The primary outcome was functional limitation, with secondary outcomes including frailty status and comorbidity burden. We hypothesized that higher frailty and greater comorbidity would be associated with more pronounced functional limitation in older adults with venous leg ulcers.

## 2. Method

### *2.1 Study Design*

This study used a hospital-based cross-sectional design to examine the associations of frailty and comorbidity with functional limitation among older adults with venous leg ulcers treated at General Hospital Gambiran, Indonesia. The main objective was to quantify functional limitation and to assess whether higher frailty and greater comorbidity burden were associated with worse functional performance in this patient group. Data collection was conducted from 23 June 2022 to 1 August 2022. The study was prepared and reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guideline. No

prospective protocol registration number was available for this study.

*2.2 Ethics Approval and Informed Consent*

The study protocol was reviewed and approved by the Ethics Committee of STIKES Baptis Kediri, with approval number 4221.21/SK/BK/2022. All participants provided written informed consent before enrollment. For participants with visual difficulty or limited reading ability, the consent form was read aloud by a trained research nurse, and written consent was documented after the participant confirmed understanding and willingness to participate.

*2.3 Setting and Participants*

The study was conducted in the outpatient wound care service of General Hospital Gambiran. The source population consisted of all older adults with venous leg ulcers who attended the wound clinic during the study period. The target population was adults aged 60 years or older with clinically documented venous leg ulcers who were receiving routine wound care and were able to complete study procedures. Recruitment and assessment were undertaken continuously during routine clinic visits between June 23, 2022, and August 1, 2022.

*2.4 Eligibility Criteria and Sampling*

Participants were eligible if they were aged 60 years or older, had a clinician-diagnosed venous leg ulcer, attended the study clinic during the recruitment period, and were able to communicate sufficiently to complete the interview and functional assessment. Venous leg ulcer diagnosis was based on clinical evaluation documented by the treating wound-care team, including ulcer location in the gaiter region and clinical features consistent with chronic venous disease. Patients were excluded if they had an acute critical illness requiring emergency referral, severe cognitive impairment that prevented reliable interview completion without a proxy, a major amputation, a nonvenous ulcer as the primary wound diagnosis, or incomplete questionnaire and medical record data. A consecutive sampling approach was used. All eligible patients presenting during the study period were screened, and those who fulfilled the criteria and consented were enrolled sequentially until the available source population was exhausted.

*2.5 Sample Size*

The available clinic population during the study period comprised 121 patients, and this fixed accessible population was used as the sampling frame. Because the study aimed to evaluate multivariable associations between frailty, comorbidity, and functional limitation in older adults with chronic leg ulceration, sample adequacy was checked against a regression-based minimum requirement. A recent cross-sectional study in older adults with chronic leg ulcers reported clinically meaningful associations of frailty severity with age, comorbidities, and ulcer status, supporting the use of a medium effect assumption for multivariable modeling in this population (Duluklu et al., 2025). Using G*Power 3.1 for linear multiple regression with an assumed medium effect size ($f^2 = 0.15$), $\alpha = 0.05$, power = 0.80, and 6 to 7 predictors, the minimum required sample was approximately 98 to 103 participants, indicating that the final analytic sample of 118 participants was adequate for the planned analysis (Faul et al., 2009). Of the 121 eligible patients screened, 3 were excluded because of incomplete interviews or incomplete record data, leaving 118 patients for the final analysis.

*2.6 Variables*

The primary outcome was functional limitation, defined as the level of dependence in basic activities of daily living measured by the Barthel Index total score. Lower Barthel Index scores indicated greater dependence and more severe functional limitation. The main predictors were frailty, measured using the Groningen Frailty Indicator (GFI), and comorbidity burden, measured using the Charlson Comorbidity Index (CCI). Based on the theoretical and empirical literature on chronic wounds and geriatric vulnerability, the adjusted model also considered age, sex, body mass index (BMI), ulcer duration, and pain intensity as potential covariates because these factors may influence both frailty status and functional limitation in older adults with venous leg ulcers (Duluklu et al., 2025; Siegling et al., 2023; Shin & Han, 2025). For descriptive purposes, functional limitation was categorized as total dependence, severe dependence, moderate dependence, slight dependence, or independence according to established Barthel Index score ranges, while the primary

regression analysis used the continuous total score to preserve information (Barros et al., 2022; Zhang et al., 2026).

*2.7 Data Sources and Measurement*

Study data were obtained from structured face-to-face interviews, review of medical records, and direct clinical assessment performed during the same clinic visit. Interview data included frailty, pain intensity, and sociodemographic characteristics. Medical records were used to confirm diagnosis, comorbidities, ulcer duration, treatment history, and relevant clinical information. Anthropometric measurements used routinely in the clinic, including body weight and height, were obtained from the medical record or measured on the assessment day when unavailable. All assessments were performed by trained nurses and wound-care personnel who completed a standardized orientation session before data collection began.

*2.7.1 Demographic and Clinical Characteristics*

Demographic and clinical variables were collected in one structured form and included age, sex, marital status, educational level, occupation, smoking status, alcohol use, BMI, duration of venous leg ulcer, recurrence history, wound laterality, and current treatment status. These variables were selected because older age, chronic disease burden, obesity, pain, and prolonged ulcer duration have been associated with worse wound outcomes, poorer mobility, and higher frailty burden in older adults with chronic leg ulcers (Duluklu et al., 2025; Raffetto et al., 2021; Siegling et al., 2023). BMI was calculated as weight in kilograms divided by height in meters squared.

*2.7.2 Assessment of Frailty*

Assessment of frailty: Frailty was defined as multidimensional vulnerability resulting from reduced physiologic reserve and decreased resilience to stressors in later life (Duluklu et al., 2025). Frailty was assessed using the Groningen Frailty Indicator, a 15-item questionnaire covering physical, cognitive, social, and psychological domains and administered once during the enrollment visit through interviewer-guided questioning. Each item is scored dichotomously, yielding a total score from 0 to 15, with higher scores indicating greater frailty burden. In wound and geriatric studies, a score of 4 or higher is commonly used to indicate frailty, and this threshold was retained in the present study for descriptive classification (Zorge et al., 2023; Duluklu et al., 2025). Recent psychometric evidence for the Chinese GFI reported acceptable diagnostic accuracy, with an optimal frailty cut point of 3, sensitivity of 88.2%, and specificity of 79.6%, supporting its utility as a screening instrument in older adults, although cut points may vary slightly by language version and setting (Huang et al., 2022).

*2.7.3 Assessment of Comorbidity*

Assessment of comorbidity: Comorbidity was defined as the cumulative burden of chronic coexisting diseases present in addition to the index venous leg ulcer condition (Shin & Han, 2025). Comorbidity burden was measured using the Charlson Comorbidity Index, a weighted clinical index based on 19 comorbid conditions, with assigned weights from 1 to 6 and a total score calculated as the sum of all applicable conditions. The CCI was completed once at baseline using medical records and patient confirmation to minimize omission of treated chronic diseases. In the descriptive analysis, CCI scores were summarized continuously and also grouped as 0, 1–2, and 3 or higher to reflect increasing comorbidity burden. The CCI is not a symptom questionnaire and therefore does not use a diagnostic symptom cutoff; rather, higher scores indicate a greater cumulative burden and worse expected prognosis. Contemporary methodological reviews continue to support the CCI as one of the most widely used indices for confounding control and prognostic adjustment in observational research (Shin & Han, 2025).

*2.7.4 Assessment of Functional Limitation*

Assessment of functional limitation: Functional limitation was defined as reduced independence in basic activities of daily living, including self-care and mobility tasks required for routine daily functioning (Barros et al., 2022). Functional limitation was measured using the Barthel Index, a 10-item instrument covering feeding, bathing, grooming, dressing, bowel control, bladder control, toileting, transfers, mobility, and stair use. The scale was administered once during the study visit using interviewer questioning supplemented by observation and clinical confirmation when needed. The total score ranges from 0 to 100,

with higher scores indicating greater independence. For descriptive interpretation, scores were categorized as 0–20 total dependence, 21–60 severe dependence, 61–90 moderate dependence, 91–99 slight dependence, and 100 independence (Barros et al., 2022; Zhang et al., 2026). Recent studies continue to show that the Barthel Index is a valid and reliable measure of functional independence, and very high interrater reliability has been reported in older adult assessment settings, with ICC = 0.98 (Barros et al., 2022; Sato et al., 2026).

*2.7.5 Assessment of Pain Intensity*

Assessment of pain intensity: Pain intensity was defined as the patient's self-reported average wound-related pain severity during the current period of care. Pain was assessed using an 11-point Numeric Rating Scale (NRS), ranging from 0 for no pain to 10 for the worst imaginable pain and was recorded once during the study visit. For descriptive purposes, NRS scores were grouped as mild (1–3), moderate (4–6), and severe (7–10) pain. Self-report numerical pain scales remain appropriate for older adults who can communicate reliably, and contemporary evidence indicates that numerical pain scales have good utility in older persons, with lower response error than visual analogue scales in many settings (Nimmaanrat et al., 2024; Bjelkarøy et al., 2024). Because pain during movement and daily activity is common in venous leg ulcer populations and may affect mobility and function, pain intensity was treated as an a priori covariate in the adjusted model (Siegling et al., 2023).

*2.8 Data Collection Procedure*

Eligible participants were identified during routine outpatient visits by the wound-care clinic team. After eligibility screening and informed consent, demographic and symptom data were collected through a structured face-to-face interview, followed by frailty assessment using the GFI, functional assessment using the Barthel Index, and pain assessment using the Numeric Rating Scale. Comorbidity data were then abstracted from the medical record using the Charlson Comorbidity Index framework and verified with the participant when necessary. Each assessment session required approximately 20 to 30 minutes, depending on the participant's functional status and clinical complexity. Data collection was performed by trained nurse researchers and wound-care staff who received a standard study briefing on eligibility verification, questionnaire administration, chart abstraction, and score calculation before the first patient was enrolled. To improve consistency, all instruments were administered on the same day as the clinic visit, and chart-based variables were checked immediately after the interview.

*2.9 Bias Control*

Several procedures were applied to reduce bias. Selection bias was minimized by using consecutive sampling of all eligible patients attending the clinic during the study period rather than selective enrollment. Information bias was reduced by combining patient interview data with medical record verification for diagnosis, ulcer duration, treatment history, and comorbidities. Recall bias was limited by collecting symptom and functional information during the current visit rather than using long recall periods. To improve measurement consistency, the research team used standardized data-collection forms, prespecified scoring rules, and a brief training session before recruitment began. Completed forms were reviewed on the same day for missing or inconsistent entries, and discrepant chart abstractions were resolved by consensus between the interviewer and a second reviewer.

*2.10 Statistical Analysis*

All statistical analyses were performed using Stata version 3.0. Continuous variables were summarized as mean (SD) when normally distributed or median (IQR) when skewed, and categorical variables were summarized as number and percentage. Distributional assumptions were evaluated using graphical inspection and the Shapiro-Wilk test. In the bivariate analysis, independent-samples t tests or one-way analysis of variance were used for normally distributed continuous outcomes, whereas Mann-Whitney U or Kruskal-Wallis tests were used when distributional assumptions were not met. Associations between categorical variables were examined using the $\chi^2$ test or Fisher exact test as appropriate, and correlations between continuous variables were explored using Pearson or Spearman coefficients depending on data distribution.

The primary multivariable analysis used multiple linear regression with the Barthel Index total score as the dependent variable because the outcome was measured on a continuous scale and the study objective was to estimate the magnitude of association between frailty, comorbidity burden, and functional limitation while adjusting for clinically relevant covariates. The adjusted model included GFI score, CCI score, age, sex, BMI, ulcer duration, and pain intensity. Regression assumptions were checked using residual plots, assessment of homoscedasticity, and multicollinearity diagnostics with variance inflation factors. Effect estimates were reported as unstandardized β coefficients with 95% confidence intervals. As a sensitivity analysis, the Barthel Index was additionally categorized into dependence levels and evaluated using an ordinal model to confirm the direction of the main findings. All tests were 2-sided, and P < .05 was considered statistically significant. Missing data were handled using a complete-case approach because only 3 patients were excluded before final analysis, and the amount of missing data was small. No imputation procedure was applied because the missing proportion was limited and the analytic sample remained above the prespecified minimum requirement.

## 3. Results

### *3.1 Participant Inclusion and Analytic Sample*

During the study period, 121 older adults with venous leg ulcers were screened for eligibility at General Hospital Gambiran. Three patients were excluded because of incomplete interview or medical record data, leaving 118 participants in the final analysis. The analytic participation rate was 97.5%. All available data used in the regression models were complete after exclusion of these 3 cases. Participant characteristics are shown in Table 1.

### *3.2 Participant Characteristics*

The mean (SD) age of the 118 participants was 69.8 (7.1) years, and 71 participants (60.2%) were women. The mean (SD) body mass index was 26.1 (4.2), and the median (IQR) venous leg ulcer duration was 8 (4-14) months. Recurrent ulcers were recorded in 58 participants (49.2%). The median (IQR) Charlson Comorbidity Index score was 2 (1-4), and 62 participants (52.5%) were classified as frail based on a Groningen Frailty Indicator score of 4 or higher. Additional demographic and clinical characteristics are presented in Table 1.

**Table 1.** Participant Characteristics

| Characteristic | Overall sample (N = 118) |
|---|---|
| Age, mean (SD), y | 69.8 (7.1) |
| Women, No. (%) | 71 (60.2) |
| | |
| Primary school or less | 49 (41.5) |
| Secondary school | 44 (37.3) |
| College or higher | 25 (21.2) |
| Body mass index, mean (SD) | 26.1 (4.2) |
| Current smoker, No. (%) | 19 (16.1) |
| Venous leg ulcer duration, median (IQR), mo | 8 (4-14) |
| Recurrent ulcer, No. (%) | 58 (49.2) |
| Pain intensity (NRS), median (IQR) | 5 (3-7) |
| Charlson Comorbidity Index, median (IQR) | 2 (1-4) |
| | |
| 0 | 19 (16.1) |
| 1-2 | 56 (47.5) |
| 3 or higher | 43 (36.4) |
| Groningen Frailty Indicator score, mean (SD) | 4.3 (2.1) |
| Frailty (GFI >= 4), No. (%) | 62 (52.5) |
| Barthel Index score, mean (SD) | 72.4 (16.8) |

### *3.3 Primary Outcome Distribution*

The mean (SD) Barthel Index score was 72.4 (16.8), indicating moderate overall functional limitation in the analytic sample. Forty-four participants (37.3%) had severe or total dependence, 39 (33.1%) had moderate dependence, 25 (21.2%) had slight

dependence, and 10 (8.5%) were independent. Lower Barthel Index scores were observed among participants with frailty, higher comorbidity burden, longer ulcer duration, and greater pain intensity. The distribution of the primary outcome overall and across key subgroups is shown in Table 2.

**Table 2.** Distribution of Functional Limitation (Barthel Index Score) Overall and by Key Subgroups

| Subgroup | Participants, No. | Barthel Index score, mean (SD) |
|---|---|---|
| Overall | 118 | 72.4 (16.8) |
| | | |
| Nonfrail (GFI < 4) | 56 | 82.6 (11.4) |
| Frail (GFI >= 4) | 62 | 63.2 (15.2) |
| | | |
| CCI 0 | 19 | 84.1 (10.6) |
| CCI 1-2 | 56 | 75.8 (14.5) |
| CCI >= 3 | 43 | 63.5 (17.4) |
| | | |
| Mild (NRS 1-3) | 34 | 80.3 (12.7) |
| Moderate (NRS 4-6) | 49 | 72.8 (15.1) |
| Severe (NRS 7-10) | 35 | 63.4 (18.9) |

### *3.4 Unadjusted Associations with Functional Limitation*

In unadjusted linear regression analyses, higher frailty score was associated with lower Barthel Index score (β, -3.42; 95% CI, -4.48 to -2.36; P < .001). Higher comorbidity burden was also associated with lower Barthel Index score (β, -2.51; 95% CI, -3.79 to -1.23; P < .001), as were older age (β, -0.52; 95% CI, -0.91 to -0.13; P = .010), longer ulcer duration (β, -0.61; 95% CI, -1.01 to -0.21; P = .003), and greater pain intensity (β, -1.88; 95% CI, -2.74 to -1.02; P < .001). Sex and body mass index were not associated with the outcome at the prespecified significance level. Unadjusted estimates are presented in Table 3.

**Table 3.** Unadjusted Associations Between Participant Characteristics and Functional Limitation

| Variable | Crude β | 95% CI | P value |
|---|---|---|---|
| Age, per 1-year increase | -0.52 | -0.91 to -0.13 | 0.010 |
| Women vs men | -2.94 | -7.11 to 1.23 | 0.165 |
| Body mass index, per 1-unit increase | -0.41 | -1.03 to 0.21 | 0.192 |
| Ulcer duration, per 1-month increase | -0.61 | -1.01 to -0.21 | 0.003 |
| Pain intensity, per 1-point increase | -1.88 | -2.74 to -1.02 | <0.001 |
| Charlson Comorbidity Index, per 1-point increase | -2.51 | -3.79 to -1.23 | <0.001 |
| Groningen Frailty Indicator, per 1-point increase | -3.42 | -4.48 to -2.36 | <0.001 |

### *3.5 Adjusted Multivariable Associations*

In the adjusted model, frailty score remained associated with lower Barthel Index score (adjusted β, -2.85; 95% CI, -3.98 to -1.72; P < .001). Higher Charlson Comorbidity Index score also remained associated with lower functional status (adjusted β, -1.94; 95% CI, -3.29 to -0.59; P = .005), and greater pain intensity remained associated with lower Barthel Index score (adjusted β, -1.36; 95% CI, -2.28 to -0.44; P = .004). Age, sex, body mass index, and ulcer duration were not statistically associated with the outcome after adjustment. Final multivariable estimates are shown in Table 4.

**Table 4.** Multivariable Associations Between Participant Characteristics and Functional Limitation

| Variable | Adjusted β | 95% CI | P value |
|---|---|---|---|
| Age, per 1-year increase | -0.31 | -0.66 to 0.03 | 0.073 |
| Women vs men | -1.77 | -5.46 to 1.91 | 0.344 |
| Body mass index, per 1-unit increase | -0.18 | -0.72 to 0.36 | 0.510 |

| Variable | Adjusted β | 95% CI | P value |
|---|---|---|---|
| Ulcer duration, per 1-month increase | -0.22 | -0.57 to 0.13 | 0.217 |
| Pain intensity, per 1-point increase | -1.36 | -2.28 to -0.44 | 0.004 |
| Charlson Comorbidity Index, per 1-point increase | -1.94 | -3.29 to -0.59 | 0.005 |
| Groningen Frailty Indicator, per 1-point increase | -2.85 | -3.98 to -1.72 | <0.001 |

Abbreviation: β, unstandardized regression coefficient. All prespecified variables were retained in the adjusted model: age, sex, body mass index, ulcer duration, pain intensity, Charlson Comorbidity Index score, and Groningen Frailty Indicator score.

### *3.6 Sensitivity Analysis*

In a sensitivity analysis using ordinal logistic regression with Barthel Index dependence categories as the outcome, higher frailty score and higher comorbidity burden were associated with greater odds of more severe dependence. Pain intensity showed a similar direction of association, whereas age, sex, body mass index, and ulcer duration were not statistically associated with dependence category. Sensitivity results are presented in Table 5.

**Table 5.** Sensitivity Analysis Using Ordinal Logistic Regression for Barthel Index Dependence Category

| Variable | Adjusted OR | 95% CI | P value |
|---|---|---|---|
| Age, per 1-year increase | 1.03 | 0.99 to 1.08 | 0.128 |
| Women vs men | 1.22 | 0.63 to 2.39 | 0.553 |
| Body mass index, per 1-unit increase | 1.02 | 0.95 to 1.10 | 0.557 |
| Ulcer duration, per 1-month increase | 1.03 | 0.99 to 1.08 | 0.119 |
| Pain intensity, per 1-point increase | 1.18 | 1.01 to 1.38 | 0.039 |
| Charlson Comorbidity Index, per 1-point increase | 1.29 | 1.06 to 1.58 | 0.011 |
| Groningen Frailty Indicator, per 1-point increase | 1.54 | 1.26 to 1.88 | <0.001 |

**Note.** Higher odds ratios indicate greater odds of belonging to a more dependent Barthel Index category

## 4. Discussion.

This cross-sectional study examined the associations of frailty, comorbidity, and pain intensity with functional limitation among older adults with venous leg ulcers treated at General Hospital Gambiran. The main finding was that functional limitation was common in this sample, with a mean Barthel Index score within the moderate dependence range. In the adjusted model, higher frailty score remained associated with lower functional status, and higher Charlson Comorbidity Index score also remained associated with lower Barthel Index score, consistent with the multidimensional vulnerability reported in older adults with chronic leg ulceration (Duluklu et al., 2025). Greater pain intensity was likewise associated with lower functional status, which is clinically relevant because pain is a common and persistent symptom in venous leg ulcer care (Siegling et al., 2023). To our knowledge, this study adds evidence from an underrepresented Indonesian hospital-based wound care setting by examining frailty, comorbidity, and functional limitation together using structured clinical instruments. These findings are relevant because older adults with venous leg ulcers often require care that extends beyond wound closure alone to include preservation of daily functioning and independence (Raffetto et al., 2021).

The association between frailty and lower Barthel Index score was the most prominent finding and may reflect the biological and functional features of frailty itself. Frailty represents reduced physiologic reserve, impaired resilience, muscle weakness, exhaustion, and lower mobility capacity, all of which may be reflected in poorer performance in dressing, toileting, transfers, and walking (Duluklu et al., 2025). A second plausible explanation is that chronic venous leg ulcers are often accompanied by edema, sleep disturbance, recurrent pain, and restricted mobility, which may coexist with frailty-related sarcopenia and amplify daily functional dependence (Siegling et al., 2023). The association between comorbidity burden and lower functional status is also plausible because multimorbidity may increase treatment burden, symptom overlap, fatigue, and physical limitation in older adults with chronic wounds (Chu et al., 2025). In this population, pain may further limit ambulation and self-care behaviors that are needed for both wound management and independent daily living (Siegling et al., 2023). These explanations remain inferential because the cross-sectional design does not

establish temporality or causality, but they support the practical value of integrating geriatric screening and symptom-oriented assessment into routine wound care (Raffetto et al., 2021).

Overall, the present findings were generally consistent with prior literature on chronic leg ulcers and geriatric vulnerability. A recent cross-sectional study reported that chronic leg ulcer status and higher comorbidity burden were associated with greater frailty severity in older adults, which is aligned with the pattern observed in the present analysis (Duluklu et al., 2025). The GERAS study also showed that frailty was highly prevalent among elderly patients with leg ulcers, reinforcing that ulcer care frequently occurs in the context of broader geriatric vulnerability rather than as an isolated skin problem (Zorge et al., 2023). Our findings regarding pain and reduced function were also compatible with prior work showing that patients with venous leg ulcers had poorer mobility, more movement-related pain, and poorer sleep quality than comparison groups (Siegling et al., 2023). In contrast, some previous studies have focused more strongly on wound severity, recurrence, exudate, or quality of life outcomes than on direct measurement of functional limitation, which may explain some differences in emphasis across the literature (Folguera-Álvarez et al., 2022; McDaniel et al., 2025). This study therefore extends prior work by focusing specifically on functional limitation as the primary outcome in an Indonesian hospital setting, where evidence on frailty and comorbidity in venous leg ulcer care remains limited.

This study had several strengths. It used clearly defined venous leg ulcer cases, a consecutive hospital-based sample, and structured instruments to measure frailty, comorbidity burden, and activities of daily living. At the same time, the cross-sectional design precludes determining temporal sequence or causal direction between frailty, comorbidity, pain, and functional limitation. Additional limitations should also be considered. The study was conducted in a single center, which may limit external generalizability to other hospitals, community wound clinics, or nonhospital populations. Some variables relied partly on self-report, which may have introduced reporting error, while residual confounding from factors such as depression, nutritional status, or social support could not be fully excluded. These issues may have reduced precision or obscured weaker associations, so the findings should be generalized cautiously to similar outpatient older-adult wound care populations rather than to all chronic wound populations.

The main clinical implication is that management of venous leg ulcers in older adults may benefit from assessment strategies that extend beyond wound characteristics alone. Routine evaluation of frailty may help clinicians identify patients with lower reserve and higher vulnerability during outpatient wound follow-up (Duluklu et al., 2025). Assessment of comorbidity burden may also support more individualized planning because multiple chronic conditions can complicate self-care, mobility, and treatment adherence in older populations (Chu et al., 2025). Pain screening should also be incorporated into regular review because movement-related pain may interfere with both wound care participation and daily functional independence (Siegling et al., 2023). This study adds contextual evidence from Indonesia using feasible outpatient measures, which may be useful for hospital-based geriatric wound practice. Future longitudinal and multicenter studies are needed to determine whether changes in frailty, comorbidity burden, or pain are associated with subsequent changes in function and wound outcomes over time. In summary, greater frailty, greater comorbidity burden, and higher pain intensity were associated with poorer functional status among older adults with venous leg ulcers, supporting a more integrated geriatric-wound care approach in clinical practice.

## 5. Strengths And Limitations of The Study

This study should be interpreted with several important considerations in mind. First, because the study used a cross-sectional design, the temporal sequence between frailty, comorbidity, pain intensity, and functional limitation could not be established, and the observed associations should not be interpreted as causal. Second, although validated instruments were used, some measurements relied on interviewer-administered and self-reported responses, which may have introduced reporting error or symptom underestimation, particularly for pain and functional performance in older adults. Third, the study was conducted in a single hospital-based wound care setting with a

consecutive outpatient sample, so selection bias may have occurred and the findings may not fully represent older adults with venous leg ulcers in community clinics, tertiary referral centers, or other regions. In addition, residual confounding cannot be excluded because potentially relevant factors such as depressive symptoms, nutritional status, social support, ulcer severity, and treatment adherence were not comprehensively captured in the adjusted model. These sources of imprecision may have attenuated or, in some cases, inflated the magnitude of the observed associations and therefore may limit broader generalizability beyond similar outpatient geriatric wound-care populations. Even so, the study provides clinically useful context-specific evidence, and the findings may still support more careful screening for frailty, comorbidity burden, and pain during routine venous leg ulcer assessment in older adults.

## 6. Implications For Nursing Practice

These findings suggest that clinical practice may benefit from a more integrated assessment approach for older adults with venous leg ulcers, particularly when functional limitation is a relevant concern. Clinicians should be attentive to frailty, comorbidity burden, and pain intensity during routine wound evaluation, because these factors may help identify patients who are more likely to experience reduced independence and may require closer monitoring, individualized support, and function-oriented care planning. At the organizational level, healthcare leaders, educators, and wound care services may consider incorporating brief geriatric screening, standardized pain assessment, and activities-of-daily-living evaluation into outpatient venous ulcer pathways to strengthen multidisciplinary communication and improve risk stratification. Such approaches may support more tailored symptom management, more realistic treatment planning, and better alignment between wound care goals and the patient's overall functional status in everyday practice. These findings may help refine clinical decision-making and supportive care strategies, although longitudinal and interventional studies are still needed to determine how these assessments may be used most effectively over time.

## 7. Conclusions

Functional limitation was common among older adults with venous leg ulcers in this hospital-based sample, and poorer functional status was associated with greater frailty, higher comorbidity burden, and higher pain intensity. These findings suggest that venous leg ulcer care in older adults may benefit from closer attention to multidimensional vulnerability rather than wound characteristics alone. Future longitudinal studies are needed to clarify temporality and to determine how frailty-informed, pain-aware, and function-oriented care strategies may be incorporated into routine clinical practice

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The authors declare no competing interests related to this work.

**Author contribution**
Asmat Burhan conceptualized the study, supervised the project, and drafted the manuscript. Rahmad Effan Farhri Mahendra contributed to data collection, clinical coordination, and data verification. Friman Rosadi contributed to methodology, formal analysis, and manuscript revision. All authors reviewed and approved the final manuscript.

**Data Avaibility**
The data that support the findings of this study are available from the corresponding author upon reasonable request, subject to ethical and institutional considerations.

**References**

Barros, V. dos S., da Silva, J. M., Netto, J. J. M., de Oliveira, B. G. R. B., Andrade, M. S., & Peres, M. F. T. (2022). Barthel Index is a valid and reliable tool to measure the functional independence of cancer patients in palliative care. *BMC Palliative Care, 21*(1), 124. DOI: 10.1186/s12904-022-01017-z

Bjelkarøy, M. T., Benth, J. Š., Simonsen, T. B., Siddiqui, T. G., Cheng, S., Kristoffersen, E. S., & Lundqvist, C. (2024). Measuring pain intensity in older adults: Can the visual analogue scale and the numeric rating scale be used interchangeably? *Progress in Neuro-Psychopharmacology & Biological Psychiatry, 130*, 110925. DOI: 10.1016/j.pnpbp.2023.110925

Chu, L., Etkin, Y., Dowling, C., & Oropallo, A. (2025). Assessment and management of chronic venous, arterial, and diabetic wounds in older adults. *Seminars in Vascular Surgery, 38*(3), 281–290. DOI: 10.1053/j.semvascsurg.2025.06.007

Duluklu, B., Ivory, J., McElvaney, A., Bligh, A., Cahill-Collins, M., Gethin, G., Liew, A., & Sezgin, D. (2025). Frailty and comorbidity in older adults with and without diabetes and chronic leg ulcer: A cross-sectional study. *International Wound Journal, 22*(1), e70119. DOI: 10.1111/iwj.70119

Faul, F., Erdfelder, E., Buchner, A., & Lang, A.-G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods, 41*(4), 1149–1160. DOI: 10.3758/BRM.41.4.1149

Folguera-Álvarez, C., Garrido-Elustondo, S., Rico-Blázquez, M., & Verdú-Soriano, J. (2022). Factors associated with the quality of life of patients with venous leg ulcers in primary care: Cross-sectional study. *The International Journal of Lower Extremity Wounds, 21*(4), 521–528. DOI: 10.1177/1534734620967562

Gethin, G., Vellinga, A., Tawfick, W., O'Loughlin, A., McIntosh, C., Mac Gilchrist, C., Murphy, L., Ejiugwo, M., O'Regan, M., Cameron, A., & Ivory, J. D. (2021). The profile of patients with venous leg ulcers: A systematic review and global perspective. *Journal of Tissue Viability, 30*(1), 78–88. DOI: 10.1016/j.jtv.2020.08.003

Graves, N., Ganesan, G., Tan, K. B., Goh, O. Q. M., Ho, J., Chong, T. T., Bishnoi, P., Carmody, D., Yuh, A. S., Ng, Y. Z., Lo, Z., Enming, Y., Aloweni, F. A. B., Zifei, W., & Harding, K. (2023). Chronic wounds in a multiethnic Asian population: A cost of illness study. *BMJ Open, 13*(9), e065692. DOI: 10.1136/bmjopen-2022-065692

Huang, E. Y. Z., Cheung, J., Liu, J. Y. W., Kwan, R. Y. C., & Lam, S. C. (2022). Groningen Frailty Indicator–Chinese (GFI-C) for pre-frailty and frailty assessment among older people living in communities: Psychometric properties and diagnostic accuracy. *BMC Geriatrics, 22*(1), 788. DOI: 10.1186/s12877-022-03437-1

Mayrovitz, H. N., Wong, S., & Mancuso, C. (2023). Venous, arterial, and neuropathic leg ulcers with emphasis on the geriatric population. *Cureus, 15*(4), e38123. DOI: 10.7759/cureus.38123

McDaniel, J. C., Kim, B., McGowan, D. R., & Tan, A. (2025). Factors associated with quality of life in patients with venous leg ulcers in a community setting: A cross-sectional study. *Health Science Reports, 8*(11), e71441. DOI: 10.1002/hsr2.71441

Nimmaanrat, S., Thepsuwan, A., Tipchatyotin, S., Junpee, A., & Phinkhian, S. (2024). Measuring pain intensity in older patients: A comparison of five scales. *BMC Geriatrics, 24*(1), 556. DOI: 10.1186/s12877-024-05127-6

Probst, S., Saini, C., Gschwind, G., Stefanelli, A., Bobbink, P., Pugliese, M.-T., Cekic, S., Pastor, D., & Gethin, G. (2023). Prevalence and incidence of venous leg ulcers: A systematic review and meta-analysis. *International Wound Journal, 20*(9), 3906–3921. DOI: 10.1111/iwj.14272

Puspita Sari, L. G. M., & Suryawati, N. (2023). Characteristics of lower extremity ulcers among patients treated at Prof. Dr. I.G.N.G. Ngoerah General Hospital, Denpasar, Bali. *Journal of the Medical Sciences (Berkala Ilmu Kedokteran), 55*(4).* DOI: 10.19106/JMedSci005504202302

Raffetto, J. D., Ligi, D., Maniscalco, R., Khalil, R. A., & Mannello, F. (2021). Why venous leg ulcers have difficulty healing: Overview on pathophysiology, clinical consequences, and treatment. *Journal of Clinical Medicine, 10*(1), 29. DOI: 10.3390/jcm10010029

Sato, R., Taniguchi, Y., Watanabe, Y., Nofuji, Y., & Murayama, H. (2026). Declines in activities in daily living of older adults with sarcopenia were associated with gait speed. *Medicina, 62*(2), 263. DOI: 10.3390/medicina62020263

Shin, D. W., & Han, K. (2025). The use of Charlson comorbidity index for observational studies using

administrative data in Korea. *Precision and Future Medicine, 9*(1), 2–14. DOI: 10.23838/pfm.2024.00191

Siegling, M., Härtel, G., Ruegsegger, M., Weibel, L., Hug, K., Stoyanov, J., Sutter, F., & Läuchli, S. (2023). Mobility range, level of pain and sleep quality of patients with venous leg ulcers. *International Wound Journal, 20*(8), 3177–3184. DOI: 10.1111/iwj.14195

Zhang, J., Zhou, M., Liu, A., Ye, R., & Wang, Y. (2026). Determining optimal Barthel Index cutoff scores for predicting Longshi Scale grades across age groups in stroke patients. *Frontiers in Aging, 7*, 1701910. DOI: 10.3389/fragi.2026.1701910

Zorge, N. E., van Asten, S. A. V., Nikolaou, V., Ulrich, M., Hoeksema, H., Kannan, A., Papp, A., Probst, S., Stingl, D., Vuerstaek, J. D. D., & van Hecke, A. (2023). A prospective, multicentre study to assess frailty in elderly patients with leg ulcers (GERAS study). *Journal of the European Academy of Dermatology and Venereology, 37*(2), 428–435. DOI: 10.1111/jdv.18586