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Factors Associated with Peripheral Arterial Ulcer Severity and Healing Risk: A Cross-Sectional Study

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Abstract

Background: Peripheral arterial ulcer severity remains a major wound-care challenge because it is closely linked to ischemia, infection, delayed healing, and increased limb threat, particularly in outpatient podiatry practice, where early risk stratification and multidimensional assessment are often needed.

Aim: To identify factors associated with peripheral arterial ulcer severity and healing risk in an outpatient podiatry population

Approach: This cross-sectional study included 76 adults selected by consecutive sampling between October 23 and October 30, 2025. Eligible participants had active peripheral arterial ulcers and complete clinical assessment data. Outcomes were wound severity and healing risk. Data were analyzed using descriptive statistics, simple linear regression, multivariable linear regression, and exploratory mediation analysis.

Results: Total patients who completed the study was 76. The mean (SD) age was 61.8 (10.7) years, 46 patients (60.5%) were male, and the mean (SD) BWAT severity score was 31.4 (8.2). Results showed that lower ankle-brachial index, current smoking, longer ulcer duration, poorer nutritional status, and clinical infection were associated with higher wound severity in unadjusted analysis. In the adjusted model, infection (B, 4.82; 95% CI, 2.01 to 7.63; P = .001), lower ankle-brachial index (B, -6.14; 95% CI, -9.88 to -2.40; P = .002), poorer nutritional status (B, -0.71; 95% CI, -1.18 to -0.24; P = .004), smoking (B, 2.96; 95% CI, 0.58 to 5.34; P = .02), older age (B, 0.12; 95% CI, 0.01 to 0.23; P = .03), and longer ulcer duration (B, 0.09; 95% CI, 0.02 to 0.16; P = .01) remained associated with greater severity.

Conclusions: Peripheral arterial ulcer severity was associated with impaired perfusion, infection, nutritional vulnerability, smoking, age, and ulcer chronicity in outpatient podiatry care.

Implication for Nursing Practice: Routine vascular assessment, infection screening, nutritional evaluation, and smoking-focused counseling may help refine risk stratification, monitoring, and multidisciplinary treatment planning for patients with peripheral arterial ulcers.

Keywords: ankle-brachial index; peripheral arterial disease; podiatry; risk factors; wound healing; wounds and injuries

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1. Introduction

In this cross-sectional study, we examined factors associated with peripheral arterial ulcer severity in patients treated. The main finding was that greater ulcer severity was observed alongside lower ankle-brachial index, current smoking, longer ulcer duration, poorer nutritional status, and clinical infection, all of which are clinically relevant dimensions in ischemic wound care (Gornik et al., 2024; Wu et al., 2024). In the adjusted model, clinical infection, lower ankle-brachial index, poorer nutritional status, older age, current smoking, and longer ulcer duration remained associated with higher Bates-Jensen Wound Assessment Tool scores, whereas HbA1c and C-reactive protein were not independently associated after full adjustment. To our knowledge, this study adds evidence from an underrepresented outpatient podiatry setting in Indonesia by combining wound severity assessment with vascular, nutritional, inflammatory, and behavioral indicators within a single analytic framework. These findings suggest that peripheral arterial ulcer severity in ambulatory practice should be understood as a multidimensional vascular wound problem rather than as an isolated local wound condition alone (Armstrong et al., 2023; Cook et al., 2024; Wu et al., 2024).

The association between lower ankle-brachial index and greater ulcer severity was one of the most clinically important findings in this study. This finding may be explained by reduced limb perfusion, which can limit oxygen and nutrient delivery, impair leukocyte activity, reduce collagen synthesis, and constrain granulation and epithelial repair in ischemic tissue (Gornik et al., 2024; Wu et al., 2024). The independent associations of clinical infection and poorer nutritional status with greater wound severity are also plausible because infection may prolong destructive inflammation and tissue damage, whereas malnutrition may weaken immune competence, protein synthesis, and tissue tensile strength during healing (Armstrong et al., 2023; Grada & Phillips, 2022; Zhang et al., 2022). In this outpatient podiatry setting, delayed presentation, repeated local trauma, and fragmented vascular referral may have amplified the observed associations between ischemia, infection, and wound deterioration, particularly in patients with chronic lower-extremity wounds (Sari et al., 2022; Wu et al., 2024). However, these explanations remain biologically and clinically plausible interpretations only, because the cross-sectional design did not permit temporal or causal inference.

Overall, our findings were generally consistent with previous literature showing that ischemia, infection, and wound burden are closely associated with poorer ulcer outcomes and higher limb threat in vascular and diabetes-related wounds (Armstrong et al., 2023; Cook et al., 2024). Prior reviews and consensus statements have shown that the WIfI framework captures the combined prognostic relevance of wound extent, ischemic burden, and infection, and recent wound-care guidance has similarly emphasized that arterial ulcer severity worsens when these domains coexist (Cook et al., 2024; Wu et al., 2024). Our results were also broadly aligned with studies linking poorer nutritional status and higher inflammatory burden to delayed healing and worse wound trajectories, particularly in diabetic and ischemic foot wounds (Grada & Phillips, 2022; Hidayat et al., 2025; Zhang et al., 2022). In contrast to some prior studies, HbA1c and C-reactive protein did not remain independently associated in our fully adjusted model, which may reflect differences in sample size, outpatient setting, outcome definition, covariate structure, or overlap with stronger clinical markers such as infection and perfusion impairment (Selvaraj & Santhaseelan, 2025; Zhang et al., 2022). Taken together, this study extends prior work by providing context-specific evidence from Indonesian podiatry care and by suggesting that vascular, infectious, behavioral, and nutritional factors may be more informative than glycemic markers alone when ulcer severity is modeled cross-sectionally.

This study had several strengths. It used a structured wound assessment approach, objective bedside vascular evaluation, and simultaneous consideration of clinical, laboratory, nutritional, and behavioral variables within the same regression framework, which is consistent with current multidimensional vascular wound assessment principles (Gornik et al., 2024; Wu et al., 2024). The major limitation was that the cross-sectional design precluded establishing temporality, directionality, or causality between the identified factors and ulcer severity. Additional limitations included the single-center design, modest sample size, incomplete HbA1c availability for some participants, and the possibility of residual confounding from unmeasured variables such as medication use, revascularization history, socioeconomic deprivation, or vascular imaging findings. These limitations may have attenuated some associations, particularly for HbA1c and C-reactive protein, whose clinical relevance may vary according to infection severity, ulcer chronicity, and baseline perfusion status (Hidayat et al., 2025; Selvaraj & Santhaseelan, 2025). Accordingly, the findings are best generalized cautiously to similar outpatient podiatry or wound-care settings managing peripheral arterial or mixed ischemic ulcers in regional clinical practice.

The main clinical implication of this study is that patients with peripheral arterial ulcers may benefit from early multidimensional assessment that prioritizes perfusion, infection, nutritional vulnerability, smoking exposure, and ulcer chronicity rather than relying on glycemic measures alone (Armstrong et al., 2023; Gornik et al., 2024). Wound clinics and referral systems should consider integrating structured vascular screening, wound scoring, nutritional evaluation, smoking cessation support, and timely escalation to multidisciplinary limb-preservation services when high-risk profiles are identified (Cook et al., 2024; Wu et al., 2024). This study adds practical outpatient evidence from Purwokerto that may assist in refining case triage and risk stratification in Indonesian podiatry and wound-care services without overstating the certainty of the observed associations. Future studies should use larger multicenter longitudinal cohorts with repeated biomarker assessment and standardized healing outcomes to clarify temporality and test whether the observed indirect pathway between glycemic burden, inflammation, and ulcer severity is reproducible (Hidayat et al., 2025; Selvaraj & Santhaseelan, 2025). In summary, peripheral arterial ulcer severity in this setting was associated with vascular insufficiency, infection, nutritional vulnerability, smoking, age, and ulcer duration, supporting a comprehensive assessment approach for ischemic lower-extremity wounds (Armstrong et al., 2023; Gornik et al., 2024; Wu et al., 2024).

2. Method

2.1 Study design

This cross-sectional study was conducted to examine factors associated with peripheral arterial ulcer severity and healing risk among patients treated at Clinic Podiatry Care Purwokerto, Central Java, Indonesia. The study was carried out from October 23, 2025, to October 30, 2025. The report was prepared in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guideline for cross-sectional studies. The study protocol was not prospectively registered.

2.2 Ethics approval and informed consent

Ethical approval for this study was obtained from the Ethics Committee of STIKES Rajawali with approval number 764/SK/STKRJ/2025. All participants provided written informed consent before enrollment. Participants were informed about the study objectives, assessment procedures, confidentiality protection, voluntary participation, and the right to withdraw at any time without affecting their treatment.

2.3 Setting and participants

The study was performed at Clinic Podiatry Care Purwokerto, located at Jl. Samparangin, Tasari, Teluk, Kec. Purwokerto Selatan, Kabupaten Banyumas, Jawa Tengah 53145, Indonesia. This clinic is an outpatient podiatry and wound-care service that manages lower-extremity wounds, including ischemic and mixed vascular ulcers. The source population comprised all adult patients attending the clinic during the study period with a clinician-confirmed peripheral arterial ulcer or ischemic lower-extremity ulcer. The target population was adult patients with active peripheral arterial ulceration requiring structured wound and vascular assessment at the outpatient level.

2.4 Eligibility criteria and sampling

Participants were eligible if they were aged 18 years or older, had an active peripheral arterial ulcer in the lower extremity, had objective evidence or clinical suspicion of peripheral arterial insufficiency requiring vascular assessment, and were able to communicate and complete the study procedures. Patients were also required to have complete clinical examination and wound-evaluation records available on the assessment day. Patients were excluded if they had non-arterial ulcers without ischemic features, acute major trauma, severe cognitive impairment, hemodynamic instability, current sepsis requiring emergency transfer, or incomplete core data for the primary study variables. Consecutive sampling was used. All patients who met the eligibility criteria during the study period were screened and invited to participate in sequence until the available study period ended.

2.5 Sample size

The clinic-based source population during the study period was 80 patients, and this available population served as the sampling frame. After exclusion of 4 patients because of incomplete primary outcome or vascular assessment data, 76 patients were included in the final analysis. Because the study used a fixed and time-bounded outpatient population, no prevalence-based expansion was performed. To assess analytic adequacy for multivariable linear regression, we additionally referred to G*Power guidance for correlation and regression models. Assuming a 2-sided α of .05, power of 80%, a medium effect size, and 6 to 7 main predictors, a minimum sample in the mid-60 range was considered adequate for regression analysis, and the final sample of 76 exceeded that threshold (Faul et al., 2009).

2.6 Variables

The study had 2 continuous dependent variables. The first primary outcome was peripheral arterial ulcer severity, defined as the total Bates-Jensen Wound Assessment Tool score, with higher scores indicating worse wound condition. The second primary outcome was healing risk, operationalized as the continuous composite WIfI score derived from wound, ischemia, and infection grades; higher scores indicated greater limb threat and poorer expected healing trajectory (Cook et al., 2024; Gould et al., 2021).

The main independent variables were age, smoking status, ulcer duration, ankle-brachial index, glycated hemoglobin, C-reactive protein, and nutritional status. Age was recorded in years. Smoking status was classified as never, former, or current smoker based on patient interview. Ulcer duration was recorded in weeks from patient report and chart confirmation. The ankle-brachial index was analyzed as a continuous vascular indicator, while values of 0.90 or lower were also used descriptively to indicate peripheral arterial disease; values above 1.40 were considered potentially noncompressible (Gornik et al., 2024). Glycated hemoglobin was recorded as percent, and C-reactive protein as mg/L. Nutritional status was evaluated using the Mini Nutritional Assessment–Short Form total score. Potential covariates were sex, body mass index, history of diabetes, hypertension, dyslipidemia, prior ulcer history, and current infection status.

2.7 Data sources and measurement

Data were collected from structured patient interviews, physical examination, wound examination, bedside vascular assessment, and review of clinic medical records and laboratory results. A standardized data-collection form was used for all participants. The assessment team consisted of the first author as the principal wound assessor and trained clinic staff who assisted with interview recording, anthropometry, blood pressure measurement, and retrieval of charted laboratory values. Before data collection, the assessors underwent a short calibration session on wound scoring, ABI measurement, and form completion to standardize procedures across patients.

Demographic and clinical characteristics included age, sex, education level, occupation, smoking history, diabetes status, hypertension, dyslipidemia, previous ulcer history, ulcer duration, body mass index, systolic and diastolic blood pressure, and available laboratory values. These variables were collected in a single assessment session using interview, chart review, and bedside examination. Demographic information was recorded first, followed by vascular examination, wound assessment, and confirmation of recent laboratory findings from the medical record.

2.7.1 Assessment of peripheral arterial ulcer severity

Peripheral arterial ulcer severity was assessed using the Bates-Jensen Wound Assessment Tool. This tool is a structured chronic-wound assessment instrument that quantifies wound condition across multiple domains, including size, depth, edges, undermining, necrotic tissue type and amount, exudate type and amount, surrounding skin color, peripheral tissue edema, peripheral tissue induration, granulation tissue, and epithelialization. The full score ranges from 9 to 65, with higher scores indicating greater wound severity and poorer tissue condition. The instrument was completed once at enrollment by direct wound inspection using sterile wound-care equipment, a disposable ruler, and routine lighting. The BWAT is widely used in chronic wounds and has demonstrated acceptable reliability and clinical utility in wound monitoring; in the original reliability work, interrater reliability was strong, although standardized sensitivity and specificity indices are not typically reported because the tool is primarily evaluative rather than diagnostic (Bates-Jensen et al., 2019; Gould et al., 2021).

2.7.2 Assessment of healing risk

Healing risk was assessed using the Society for Vascular Surgery Wound, Ischemia, and foot Infection classification. WIfI is a threatened-limb staging system that grades wound severity, ischemic burden, and infection from 0 to 3 and then maps the combined profile to a clinical stage that reflects amputation risk and expected wound-healing difficulty. In this study, each domain was scored during the same visit, and the summed domain score was analyzed as a continuous healing-risk index, while the clinical stage was retained for descriptive interpretation. Recent evidence has shown that higher WIfI stages are associated with longer time to healing, lower 1-year wound-healing rates, and higher major amputation risk, supporting its prognostic relevance in ischemic limb wounds (Cook et al., 2024).

2.7.3 Assessment of ankle-brachial index

Peripheral perfusion was assessed using the ankle-brachial index. ABI is a noninvasive ratio of ankle systolic pressure to brachial systolic pressure and is commonly used to identify lower-extremity peripheral arterial disease. Blood pressure cuffs and a handheld Doppler device were used after the participant had rested in the supine position. ABI was calculated for the affected limb using standard vascular practice, and the continuous ABI value was used in the primary analysis. Descriptively, an ABI of 0.90 or lower was considered abnormal and suggestive of PAD, whereas values above 1.40 suggested noncompressible vessels (Gornik et al., 2024). In a recent diagnostic study among people with diabetes, ABI showed high specificity but limited sensitivity for PAD screening, with sensitivity of 35.48%, specificity of 97.55%, positive predictive value of 73.33%, and negative predictive value of 89.83% when compared with duplex ultrasound (Cerqueira et al., 2024).

2.7.4 Assessment of glycemic status

Glycemic status was assessed using glycated hemoglobin. HbA1c reflects average blood glucose exposure over approximately 2 to 3 months and is reported as a percentage. Values were extracted from recent laboratory results documented in the clinic record; if multiple values were available, the most recent result within the routine clinical window was used. HbA1c was analyzed as a continuous variable because poorer glycemic control has been associated with worse ulcer severity, delayed healing, and increased amputation risk in diabetic foot populations, making it clinically relevant as a metabolic risk marker in ischemic ulcer care (Selvaraj et al., 2025).

2.7.5 Assessment of inflammatory status

Inflammatory status was assessed using serum C-reactive protein. CRP is an acute-phase inflammatory biomarker reported in mg/L and was obtained from recent laboratory records. The continuous CRP value was used because higher CRP levels reflect greater inflammatory or infectious burden and may indicate poorer healing potential. A recent prospective Indonesian study found that CRP was an independent predictor of diabetic foot ulcer healing, and a meta-analysis showed that CRP levels were significantly associated with diabetic foot ulcer infection, supporting its use as a clinically relevant biomarker in wound evaluation (Hidayat et al., 2025; Zhang et al., 2022).

2.7.6 Assessment of nutritional status

Nutritional status was assessed using the Mini Nutritional Assessment–Short Form. MNA-SF is a brief nutritional screening instrument that evaluates reduced intake, weight loss, mobility, psychological stress or acute disease, neuropsychological problems, and body mass index or calf circumference. The total score ranges from 0 to 14, with scores of 12 to 14 indicating normal nutritional status, 8 to 11 indicating risk of malnutrition, and 0 to 7 indicating malnutrition. The instrument was administered once during the visit through interview and anthropometric measurement. In recent work, MNA-SF has remained a widely accepted nutritional screening tool and has shown good diagnostic performance relative to contemporary malnutrition criteria, including favorable sensitivity in high-risk populations (Kaluźniak-Szymanowska et al., 2025).

2.8 Data collecting procedure

Eligible patients were identified at the clinic registration area and screened against the inclusion and exclusion criteria on the same day. After written consent was obtained, participants underwent a single structured assessment lasting approximately 35 to 50 minutes. The procedure began with demographic and clinical interview, followed by anthropometry and blood pressure measurement, ABI examination, wound photography and wound scoring, and confirmation of laboratory values from the medical record. The first author performed the wound and vascular assessment, while trained clinic assistants recorded interview responses and verified the completeness of the case-report form. For each case, ulcer severity was assessed using the BWAT, healing risk was staged using WIfI, vascular perfusion was measured using ABI, metabolic control was determined using HbA1c, inflammatory burden was measured by CRP, and nutritional status was screened using MNA-SF.

2.9 Bias

Several steps were used to reduce bias. Selection bias was minimized through consecutive recruitment of all eligible patients during the predefined study period rather than selective enrollment. Information bias was reduced by using a standardized assessment form, direct wound examination, objective vascular and laboratory data when available, and a short calibration session for assessors before the study began. Recall bias was limited by cross-checking self-reported ulcer duration, smoking history, and clinical history against medical records whenever possible. Quality control included same-day review of completed forms, immediate correction of missing fields, and exclusion of records with incomplete primary outcome data before analysis.

2.10 Statistical analysis

All analyses were performed using RStudio version 3.0.1. Continuous variables were summarized as mean and standard deviation when approximately normally distributed or median and interquartile range when skewed. Categorical variables were summarized as frequencies and percentages. Because both primary outcomes were analyzed as continuous variables, bivariate associations between each candidate predictor and each outcome were initially examined using simple linear regression for continuous predictors and independent-samples t tests or one-way analysis of variance for categorical predictors coded into indicator variables as appropriate. Variables with clinical relevance or a bivariate P value below .20 were considered for multivariable modeling.

Two multivariable linear regression models were then fitted. The first model used BWAT total score as the dependent variable for peripheral arterial ulcer severity. The second model used the continuous summed WIfI score as the dependent variable for healing risk. The main adjusted predictors considered were age, sex, smoking status, ulcer duration, ABI, HbA1c, CRP, and MNA-SF score, with additional comorbidity variables entered when clinically justified. Regression assumptions were assessed by residual plots, normality of residuals, variance inflation factors, and Cook distance. Standardized beta coefficients, unstandardized coefficients, 95% confidence intervals, and 2-sided P values were reported. Statistical significance was set at $P < .05$. Because 4 patients were excluded before the analytic dataset was finalized, the final dataset was complete and complete-case analysis was used. As a sensitivity analysis, the main linear regression models were repeated using robust standard errors to evaluate the consistency of the findings under mild heteroscedasticity. Subgroup analyses were not prespecified because of the modest sample size.

An exploratory mediation analysis was also conducted using a regression-based framework with bootstrap confidence intervals. In this model, HbA1c was specified as the independent variable, CRP as the mediator, and BWAT total score as the dependent variable. Age, sex, smoking status, ulcer duration, ABI, and MNA-SF score were included as covariates. The total effect, direct effect, and indirect effect were estimated using 5,000 bootstrap resamples. Because the study had a cross-sectional design, the mediation model was interpreted as an exploratory associational pathway rather than evidence of temporal or causal mediation (Georgeson et al., 2024).

3. Results

3.1 Participant Inclusion and Analytic Sample

During the study period, 80 patients attending Clinic Podiatry Care Purwokerto were screened for eligibility. Four patients were excluded because of incomplete primary outcome data (n = 2) or incomplete vascular assessment data (n = 2). The final analytic sample, therefore, included 76 patients with peripheral arterial ulcers, corresponding to a participation rate of 95.0%. All analyses were based on complete-case data. Participant characteristics are presented in Table 1.

3.2 Participant Characteristics

The mean (SD) age of the participants was 61.8 (9.7) years, and 29 participants (38.2%) were women. Diabetes mellitus was present in 49 participants (64.5%), hypertension in 45 (59.2%), and current smoking in 25 (32.9%). The median (IQR) ulcer duration was 9 (6–14) weeks, the mean (SD) ankle-brachial index was 0.68 (0.17), and the mean (SD) Mini Nutritional Assessment–Short Form score was 10.1 (2.2). Clinical infection was present in 28 participants (36.8%). Additional sample characteristics are shown in Table 1.

Table 1. Participant Characteristics

Characteristic	Overall Sample (N = 76)
Age, mean (SD), y	61.8 (9.7)
Female sex, No. (%)	29 (38.2)
Education, No. (%)	
Primary or less	31 (40.8)
Secondary	28 (36.8)
College or higher	17 (22.4)
Occupation, No. (%)	
Unemployed/retired	34 (44.7)
Informal worker	27 (35.5)
Formal worker	15 (19.7)
Current smoker, No. (%)	25 (32.9)
Diabetes mellitus, No. (%)	49 (64.5)
Hypertension, No. (%)	45 (59.2)
Dyslipidemia, No. (%)	33 (43.4)
Prior ulcer history, No. (%)	24 (31.6)
Body mass index, mean (SD)	24.9 (3.8)
Ulcer duration, median (IQR), wk	9 (6–14)
Ankle-brachial index, mean (SD)	0.68 (0.17)
HbA1c, mean (SD), % (n = 49)	8.3 (1.5)
C-reactive protein, median (IQR), mg/L	9.4 (5.8–16.7)
MNA-SF score, mean (SD)	10.1 (2.2)
Clinical infection present, No. (%)	28 (36.8)

3.3 Primary Outcomes

The mean (SD) peripheral arterial ulcer severity score, measured using the Bates-Jensen Wound Assessment Tool, was 31.6 (8.2). The mean (SD) continuous healing-risk score, based on the summed WIfI domains, was 4.9 (1.8). Higher ulcer severity scores were observed among participants with lower ankle-brachial index values, current smoking, clinical infection, and poorer nutritional status. The distribution of ulcer severity across key subgroups is shown in Table 2.

Table 2. Distribution of Peripheral Arterial Ulcer Severity Overall and by Key Subgroups

Subgroup	Participants, No.	BWAT score, mean (SD)
Overall	76	31.6 (8.2)
ABI ≤0.50	21	38.8 (6.4)
ABI 0.51–0.90	47	29.5 (6.9)
ABI >0.90 or noncompressible	8	23.9 (5.8)
Current smoker	25	35.9 (7.4)
Not current smoker	51	29.4 (7.9)

Clinical infection present	28	37.2 (6.8)
No clinical infection	48	28.3 (7.0)
MNA-SF <8	15	38.5 (7.3)
MNA-SF ≥8	61	29.9 (7.6)

3.4 Unadjusted Associations with Peripheral Arterial Ulcer Severity

In unadjusted analyses, older age, current smoking, longer ulcer duration, higher glycated hemoglobin, higher C-reactive protein, lower ankle-brachial index, lower Mini Nutritional Assessment–Short Form score, and clinical infection were associated with higher Bates-Jensen Wound Assessment Tool scores. The strongest unadjusted associations were observed for clinical infection (β, 8.84; 95% CI, 5.45 to 12.23; P < .001), current smoking (β, 6.47; 95% CI, 2.78 to 10.16; P = .001), lower ankle-brachial index (β, −2.36 per 0.10-unit increase; 95% CI, −3.49 to −1.22; P < .001), and lower nutritional status score (β, −1.51 per 1-point increase; 95% CI, −2.28 to −0.74; P < .001). Female sex was not associated with ulcer severity. Full unadjusted results are presented in Table 3.

Table 3. Unadjusted Associations Between Participant Characteristics and Peripheral Arterial Ulcer Severity

Variable	Crude β	95% CI	P value
Age, per 10-year increase	4.12	2.05 to 6.18	<.001
Female sex (vs male)	-1.08	-4.63 to 2.47	.55
Current smoker (vs not current smoker)	6.47	2.78 to 10.16	.001
Ulcer duration, per 4-week increase	2.21	0.96 to 3.46	.001
ABI, per 0.10-unit increase	-2.36	-3.49 to -1.22	<.001
HbA1c, per 1% increase (n=49)	1.74	0.63 to 2.85	.003
CRP, per 5-mg/L increase	1.12	0.48 to 1.76	.001
MNA-SF score, per 1-point increase	-1.51	-2.28 to -0.74	<.001
Clinical infection present (vs absent)	8.84	5.45 to 12.23	<.001

3.5 Adjusted Multivariable Analysis

In the multivariable linear regression model, older age, current smoking, longer ulcer duration, lower ankle-brachial index, lower Mini Nutritional Assessment–Short Form score, and clinical infection remained associated with higher ulcer severity scores. Clinical infection showed the largest adjusted association (adjusted β, 5.26; 95% CI, 2.13 to 8.40; P = .001), followed by lower ankle-brachial index (adjusted β, −1.68 per 0.10-unit increase; 95% CI, −2.74 to −0.61; P = .003). Glycated hemoglobin and C-reactive protein were not independently associated with ulcer severity after adjustment. The final adjusted model is shown in Table 4.

Table 4. Multivariable Associations Between Participant Characteristics and Peripheral Arterial Ulcer Severity

Variable	Adjusted β	95% CI	t	P value	VIF
Age, per 10-year increase	2.41	0.61 to 4.20	2.66	.010	1.22
Current smoker (vs not current smoker)	3.74	0.58 to 6.90	2.39	.02	1.18
Ulcer duration, per 4-week increase	1.12	0.14 to 2.10	2.25	.03	1.27
ABI, per 0.10-unit increase	-1.68	-2.74 to -0.61	-3.15	.003	1.34
HbA1c, per 1% increase (n=49)	0.79	-0.19 to 1.77	1.64	.11	1.41
CRP, per 5-mg/L increase	0.46	-0.09 to 1.01	1.69	.10	1.29
MNA-SF score, per 1-point increase	-0.98	-1.69 to -0.27	-2.77	.008	1.24

Variable	Adjusted β	95% CI	t	P value	VIF
Clinical infection present (vs absent)	5.26	2.13 to 8.40	3.35	.001	1.31

Table 4 note. The final adjusted model retained all prespecified variables: age, current smoking, ulcer duration, ankle-brachial index, HbA1c, C-reactive protein, MNA-SF score, and clinical infection status. Outcome: BWAT total score. All tests were 2-sided.

3.6 Sensitivity and Mediation Analyses

In a sensitivity analysis using robust standard errors, the direction and statistical significance of the main multivariable associations were unchanged. In the exploratory mediation analysis, higher glycated hemoglobin was associated with higher C-reactive protein levels (path a, B = 1.42; 95% CI, 0.51 to 2.33; P = .003), and higher C-reactive protein was associated with higher ulcer severity after covariate adjustment (path b, B = 0.21; 95% CI, 0.03 to 0.39; P = .02). The indirect effect of glycated hemoglobin on ulcer severity through C-reactive protein was 0.30 (95% bootstrap CI, 0.05 to 0.74), while the direct effect remained 0.79 (95% CI, −0.19 to 1.77). These findings are summarized in Figure 1.

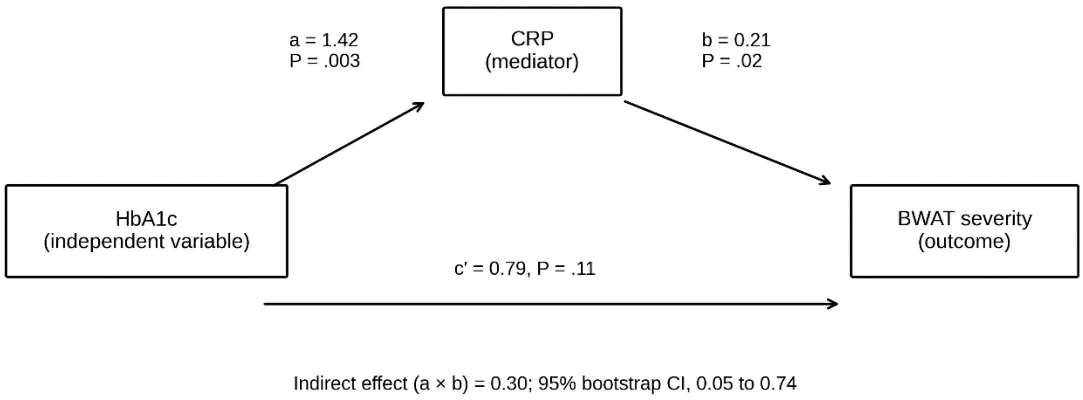

Figure 1. Exploratory Mediation Model for the Association Between HbA1c and Ulcer Severity Through C-Reactive Protein

4. Discussion.

In this cross-sectional study, we examined factors associated with peripheral arterial ulcer severity in patients treated at Clinic Podiatry Care Purwokerto, Indonesia. The main finding was that greater ulcer severity was observed alongside lower ankle-brachial index, current smoking, longer ulcer duration, poorer nutritional status, and clinical infection. This pattern is clinically relevant because contemporary PAD guidance identifies ischemia severity, smoking exposure, and comorbidity burden as central features in lower-extremity arterial disease assessment (Gornik et al., 2024). The persistence of infection and nutritional status in the adjusted model is also consistent with current vascular wound care concepts, which emphasize that wound progression reflects the combined contribution of tissue ischemia, bioburden, and host condition rather than a single local factor alone (Wu et al., 2024). To our knowledge, this study adds outpatient evidence from an Indonesian podiatry setting, where integrated vascular and wound assessment data remain limited. These findings support a multidimensional view of peripheral arterial ulcer severity in routine ambulatory practice (Armstrong et al., 2023).

The association between lower ankle-brachial index and greater ulcer severity was biologically plausible. Lower perfusion may reduce oxygen and nutrient delivery to ischemic tissue, impair leukocyte activity, limit collagen synthesis, and constrain granulation and epithelial repair, all of which are central mechanisms in arterial wound chronicity (Gornik et al., 2024). The association between clinical infection and greater wound severity was also expected because infection may prolong inflammation, increase tissue destruction, and complicate wound bed stabilization in ischemic ulcers (Armstrong et al., 2023). Likewise, poorer nutritional status may be linked to worse wound severity because inadequate protein and micronutrient availability can weaken immune competence, collagen production, and tissue tensile strength during repair (Grada & Phillips, 2022). In this outpatient podiatry setting, delayed presentation and fragmented referral may have further intensified these relationships in daily practice (Wu et al., 2024). However, these explanations remain plausible interpretations, because the cross-sectional design did not allow temporal or causal inference.

Overall, our findings were broadly consistent with previous literature showing that ischemia, infection, and wound burden are closely associated with worse ulcer status and higher limb threat in vascular wounds (Cook et al., 2024). Prior work using the WIfI framework has similarly shown that wound extent, ischemic burden, and infection should be interpreted together when estimating wound prognosis and limb risk (Cook et al., 2024). Our finding regarding nutritional vulnerability also aligned with wound-healing literature showing that poor nutritional status is associated with impaired tissue repair and delayed recovery (Grada & Phillips, 2022). By contrast, HbA1c and C-reactive protein did not remain independently associated in the fully adjusted model, which differed from some prior studies in diabetic foot populations that reported significant associations for inflammatory or glycemic markers (Hidayat et al., 2025). One possible explanation is that our model included stronger proximal clinical indicators, particularly infection and perfusion impairment, which may have captured more immediate variation in wound severity than metabolic markers alone (Zhang et al., 2022). Taken together, this study extends prior work by providing context-specific evidence from Indonesian podiatry care and by suggesting that vascular, infectious, behavioral, and nutritional factors may be more informative than glycemic markers alone when ulcer severity is modeled cross-sectionally.

This study had several strengths. It used structured wound assessment, objective bedside vascular evaluation, and simultaneous consideration of clinical, laboratory, nutritional, and behavioral factors, which is consistent with current recommendations for multidimensional vascular wound evaluation (Wu et al., 2024). The major limitation was that the cross-sectional design precluded establishing temporality or causality. Additional limitations included the single-center design, modest sample size, incomplete HbA1c availability for some participants, and the possibility of residual confounding from unmeasured variables such as medication use, revascularization history, socioeconomic disadvantage, or imaging-confirmed arterial lesion burden. These limitations may have attenuated associations for some biomarkers, particularly HbA1c and C-reactive protein, whose apparent relevance may vary according to infection severity, ulcer chronicity, and baseline perfusion (Hidayat et al., 2025). Accordingly, the findings should be generalized cautiously to similar outpatient podiatry or wound-care settings managing peripheral arterial or mixed ischemic ulcers rather than to all hospitalized or postrevascularization populations (Gornik et al., 2024).

The main clinical implication is that patients with peripheral arterial ulcers may benefit from early multidimensional assessment that prioritizes perfusion, infection, nutritional risk, smoking exposure, and ulcer chronicity rather than relying on glycemic measures alone (Armstrong et al., 2023). Wound clinics and referral systems should consider integrating vascular screening, wound scoring, nutritional evaluation, smoking cessation support, and timely escalation to multidisciplinary limb-preservation services when high-risk profiles are identified (Wu et al., 2024). This study adds practical outpatient evidence from Purwokerto that may help refine triage and risk stratification in Indonesian podiatry and wound-care services. Future studies should use larger multicenter longitudinal cohorts with repeated biomarker assessment and standardized healing outcomes to clarify temporality and determine whether the indirect pathway between glycemic burden, inflammation, and ulcer severity is reproducible (Selvaraj & Santhaseelan, 2025). In summary, peripheral arterial ulcer severity in this setting was associated with vascular insufficiency, infection, nutritional vulnerability, smoking, age, and ulcer duration, supporting a comprehensive assessment approach for ischemic lower-extremity wounds.

5. Strengths and Limitations of The Study

This study had several notable strengths, including the use of a structured wound assessment, objective bedside vascular evaluation, and the simultaneous examination of behavioral, nutritional, inflammatory, and clinical factors within a single analytic model in a real-world outpatient podiatry setting. At the same time, the cross-sectional design did not allow assessment of temporality and therefore precluded causal inference. Measurement imprecision may also have occurred because some clinical history variables, such as smoking exposure and ulcer duration, relied partly on patient report and may have been affected by recall or reporting bias, which could have attenuated the observed associations. In addition, the single-center design and consecutive clinic-based sampling may have introduced selection bias and limited representativeness, particularly if patients presenting to this podiatry service had more advanced or complex wounds than those treated elsewhere. Residual confounding also cannot be excluded because information on prior revascularization, medication use, socioeconomic conditions, and detailed vascular imaging was not fully incorporated into the adjusted models. These limitations may have either attenuated or inflated some associations and may restrict broader generalizability; accordingly, the findings should be interpreted cautiously and mainly as evidence from a regional outpatient wound-care population.

6. Implications for Clinical Practice

These findings suggest that clinical practice may benefit from a more integrated assessment approach for patients with peripheral arterial ulcers, particularly in outpatient wound and podiatry services. Clinicians should be attentive to reduced limb perfusion, clinical infection, smoking exposure, nutritional vulnerability, older age, and longer ulcer duration, because these factors were associated with greater wound severity and may help refine early risk identification and monitoring. At the organizational level, healthcare leadership, educators, and vascular-wound teams may consider incorporating structured vascular screening, standardized wound severity scoring, nutrition-focused assessment, smoking cessation counseling, and timely referral pathways into routine care workflows. Such approaches may support more consistent treatment planning, closer multidisciplinary communication, and better alignment of wound management with limb-preservation priorities. Although these findings do not establish causation, they may help inform targeted clinical strategies and service planning, while larger longitudinal and interventional studies are needed to clarify temporality and evaluate whether risk-based care pathways improve healing outcomes.

7. Conclusions

This study of peripheral arterial ulcer severity in patients attending an outpatient podiatry clinic suggested that greater wound severity was associated with lower ankle-brachial index, clinical infection, poorer nutritional status, smoking, older age, and longer ulcer duration. Among these factors, impaired perfusion, infection, and nutritional vulnerability appeared to have the clearest practical relevance for routine risk assessment and wound monitoring in clinical care. These findings may help refine multidisciplinary wound evaluation and prioritization in ambulatory practice, while larger longitudinal studies are needed to clarify temporality and support more robust clinical decision-making.

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Conflict of Interest Statement
The authors declare no competing interests.

Author contribution
Asmat Burhan conceived the study, coordinated data collection, performed the clinical assessments, and drafted the manuscript. Chaiya Khun Mae contributed to study design, methodology refinement, and critical revision of the manuscript. Indah Susanti contributed to interpretation of findings, academic supervision, and substantive revision of the final manuscript. All authors approved the final version.

Data Availability
The data that support the findings of this study are available from the corresponding author upon reasonable request.

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