

Mapping the Evidence on Arterial Ulcers in Adults and Older Adults: A Scoping Review**

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ABSTRACT

Objective: To map the literature regarding evidence on the development and treatment of arterial ulcers in adults and older adults across various healthcare settings, including the influence of comorbidities on healing and the closure techniques employed. **Method:** This was a scoping review guided by the following question: What evidence is available in the literature regarding the development and treatment of arterial ulcers in adults and older adults across different healthcare settings, including the influence of comorbidities on healing and the closure techniques employed? Data management was performed using the RAYYAN® online software. The review was registered on the Open Science Framework. **Results:** The sample comprised 28 articles, with older men being predominantly affected and presenting multiple comorbidities, with peripheral arterial disease being the main etiology. The ulcers were small, deep, well-demarcated, and painful, and primarily presented with coldness to the touch and/or pallor and weak pedal pulses, with necrotic tissue and minimal exudate in the wound bed. The main treatment was revascularization and/or endovascular interventions, with mean healing times ranging from 3 to 11 months. **Conclusion:** Evidence on this topic remains scarce, particularly in Brazil; therefore, further research is recommended to support the optimal management of arterial ulcers.

KEYWORDS: Skin Ulcer. Peripheral Arterial Disease. Wound Healing. Evidence-Based Practice.

Mapeamento das evidências sobre úlceras arteriais em adultos e idosos: revisão de escopo**

RESUMO

Objetivo: Mapear a literatura quanto às evidências sobre o desenvolvimento e tratamento de úlceras arteriais em adultos e idosos nos diversos contextos assistenciais, incluindo a influência das comorbidades na cicatrização e as técnicas de fechamento empregadas. **Método:** Trata-se de uma revisão de escopo conduzida por meio da pergunta: Quais as evidências disponíveis na literatura sobre o desenvolvimento e tratamento de úlceras arteriais em adultos e idosos nos diferentes contextos assistenciais, incluindo a influência das comorbidades na cicatrização e as técnicas de fechamento empregadas? A operacionalização dos dados se deu por meio do *software online RAYYAN®*. Registrado na plataforma *Open Science Framework*. **Resultados:** Contemplaram a amostra 28 artigos, em que os idosos do sexo masculino figuram como majoritariamente

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afetados, com múltiplas comorbidades, cuja etiologia principal foi a doença arterial periférica. As úlceras eram pequenas, profundas, bem delimitadas, dolorosas e apresentavam principalmente frieza ao toque e/ou palidez e pulsos pediosos fracos, com tecido necrótico e exsudato mínimo no leito da ferida. O tratamento principal foi a revascularização e/ou intervenções endovasculares, com o tempo médio de cicatrização variável entre 3 e 11 meses. **Conclusão:** A temática ainda é escassa, especialmente no Brasil, por isso se sugerem novas pesquisas para o manejo ideal das úlceras arteriais.

DESCRIPTORES: Úlcera cutânea. Doença arterial periférica. Cicatrização. Prática clínica baseada em evidências.

Mapeo de la evidencia sobre úlceras arteriales en adultos y personas mayores: revisión de alcance**

RESUMEN

Objetivo: Mapear la literatura en relación con la evidencia disponible sobre el desarrollo y el tratamiento de las úlceras arteriales en adultos y personas mayores en distintos ámbitos asistenciales, incluida la influencia de las comorbilidades en la cicatrización y las técnicas de cierre empleadas. **Método:** Se realizó una revisión de alcance orientada por la siguiente pregunta: ¿Qué evidencia se encuentra disponible en la literatura sobre el desarrollo y el tratamiento de las úlceras arteriales en adultos y personas mayores en diferentes ámbitos asistenciales, incluida la influencia de las comorbilidades en la cicatrización y las técnicas de cierre empleadas? La gestión de los datos se realizó mediante el programa informático en línea RAYYAN®. El protocolo se registró en la plataforma Open Science Framework. **Resultados:** Se incluyeron 28 artículos. Los varones de edad avanzada fueron los más afectados y presentaban múltiples comorbilidades, mientras que la enfermedad arterial periférica fue la principal etiología identificada. Las úlceras eran pequeñas, profundas, bien delimitadas y dolorosas, y se caracterizaban principalmente por frialdad al tacto o palidez, pulsos pediosos débiles, tejido necrótico y una cantidad mínima de exudado en el lecho de la herida. Las principales opciones terapéuticas fueron la revascularización y las intervenciones endovasculares, y el tiempo medio de cicatrización osciló entre 3 y 11 meses. **Conclusión:** La evidencia sobre este tema sigue siendo escasa, especialmente en Brasil, por lo que se recomienda realizar nuevas investigaciones que contribuyan a mejorar el manejo de las úlceras arteriales.

DESCRIPTORES: Úlcera cutánea. Enfermedad arterial periférica. Cicatrización de heridas. Práctica clínica basada en la evidencia.

INTRODUCTION

Ulcers are open wounds that can develop in various locations throughout the body and with different levels of depth¹. These wounds can be classified as venous or arterial¹. Arterial ulcers, the focus of this study, also known as ischemic ulcers, arise from arterial obstruction, as the blood is unable to adequately perfuse the tissues and oxygenate the cells, resulting in cell death and the possible development of these lesions².

The reported global prevalence of adults living with leg ulcers is 1% to 2%, and may reach 3% among patients over 65 years of age¹. At the national level, as a comparison, the annual incidence is also high, with approximately three to five new cases per 1,000 inhabitants¹. Furthermore, given the growing number of older adults in the Brazilian population, with data from the Brazilian Institute of Geography and Statistics (IBGE) showing a 56% increase in the number of older adults in 2022³, the prevalence of arterial ulcers may be even higher.

The problem posed by arterial ulcers is not limited to their chronicity but also includes the high recurrence rate of these lesions, which negatively affects the well-being and quality of life of affected individuals while increasing the demand on and costs to healthcare systems¹. Due to the location of the lesions, the intensity of pain, and/or the need for specific treatment,

individuals may need to take leave from their occupational activities, resulting in socioeconomic losses for themselves and their families, in addition to negatively affecting their self-image⁴.

For healthcare services, arterial ulcers are highly costly because they involve issues associated with prolonged and, in some cases, recurrent treatment, specific dressings for each type of ulceration, and the need for an interdisciplinary team capable of appropriately managing this condition⁵. In developed countries, such as the United States and the United Kingdom, the costs of treating arterial ulcers can exceed billions of dollars each year, including healthcare professionals' salaries, hospital stays, home visits by primary care teams, and wound care supplies, among other expenses^{6,7}.

The need for actions aimed at prevention is noteworthy, particularly among populations at higher risk of developing arterial ulcers, given that this condition constitutes a public health problem and a global health challenge^{4,8,9}.

Although this is a relevant topic, particularly because it requires professionals with expertise in technical and scientific knowledge to promote evidence-based practice that supports clinical decision-making aimed at preventing arterial ulcers, the literature remains scarce, especially regarding the clinical characteristics and factors associated with the development and healing of arterial ulcers. This scarcity limits healthcare professionals' access to relevant information that could support the adoption of prevention and treatment strategies capable of promoting recovery and improving individuals' quality of life. Therefore, this study may contribute to advancing knowledge by synthesizing the available evidence on the development and treatment of arterial ulcers in adults and older adults, identifying gaps in the literature, and providing support for improving clinical practice, developing care protocols, and planning future research, particularly in the Brazilian context.

OBJECTIVES

To map the literature regarding evidence on the development and treatment of arterial ulcers in adults and older adults across different healthcare settings, including the influence of comorbidities on healing and the closure techniques employed.

METHODS

This is a scoping review, an exploratory and literature-mapping synthesis of evidence. The protocol for this study was based on the guidelines provided in the JBI Manual for Evidence Synthesis¹⁰.

To formulate the research question (What evidence is available in the literature regarding the development and treatment of arterial ulcers in adults and older adults across different healthcare settings, including the influence of comorbidities on healing and the closure techniques employed?), the PCC mnemonic (P: population, C: concept, and C: context) was used. For this review, the following elements were adopted: P: adults and older adults; C: development and treatment of arterial ulcers, the influence of comorbidities on healing, and closure techniques; and C: open (any healthcare setting related to arterial ulcers).

Regarding the eligibility criteria adopted, studies published within the past 10 years were included (due to the volume of publications and the constant changes observed in clinical practice in recent years) (period); full-text scientific articles available free of charge, with a quantitative approach; official materials; and guidelines (study types), regardless of the country of origin and/or language of publication (language). It should be noted that the reviewers who collected and extracted the data were proficient in English. In addition, an automated translation tool was used as a support measure to minimize interpretation errors. Of the 28 selected studies, 27 were published in English and one in Portuguese.

Studies involving adults and older adults (aged over 18 years) with arterial ulcers (population) that addressed the development and/or treatment of arterial ulcers, including their clinical and structural characteristics (concept), in any healthcare setting related to arterial ulcers (primary care, hospital, outpatient, or home care) (open context) were included. Qualitative studies, study protocols without reported results, studies addressing any type of lesion other than arterial ulcers, letters to the editor, websites, blogs, and abstracts presented at conferences were excluded.

Following an adaptation of the recommendations of the JBI Manual for Evidence Synthesis¹⁰, data selection was conducted in three stages:

1. Exploratory search (PubMed; Virtual Health Library);
2. Comprehensive search of databases using identified keywords;
3. Review of the reference lists of all selected studies.

The search strategies were accessed through the Journals Portal of the Coordination for the Improvement of Higher Education Personnel (CAPES), using institutional login credentials through the Federated Academic Community (CAFe). For the comprehensive search, a combination of terms included in the Medical Subject Headings (MeSH) was used: Arterial Ulcer, Peripheral Arterial Disease (clinical condition); Adult, Aged (population); Wound Healing; Wound Infection; Wound Closure Techniques; Wounds; Cell Proliferation; Regeneration; Stem Cells; Inflammation; Leg Ulcer; Skin; Therapeutic; Nursing Care; Enterostomal Therapy (concept) in the search strategies for PubMed, Embase, Web of Science, and Scopus. In the Virtual Health Library (VHL), the following terms from the Health Sciences Descriptors (DeCS) were used: Arterial Ulcer, Peripheral Arterial Disease (clinical condition); Adult, Aged (population); Healing; Wound Healing; Wound Infection; Wound Closure Techniques; Wounds; Cell Proliferation; Regeneration; Stem Cells; Inflammation; Leg Ulcer; Skin; Therapeutic Procedure; Nursing Care; Enterostomal Therapy (concept). The search was refined using filters aligned with the eligibility criteria, including a time frame limited to the past 10 years, studies involving humans (adults and older adults), and full-text availability.

To enhance the retrieval of relevant articles, keywords were cross-searched using the Boolean operators AND and OR, applying the same combination across all search platforms. Both primary descriptors and alternative terms provided by the DeCS and MeSH platforms were included. It should be noted that the alternative term Arterial Ulcer was added by the authors because it represents the focus of this study. However, this term is not included in the health sciences descriptor platforms. The search strategy adopted in this study is presented in Chart 1.

To facilitate reference management, RAYYAN®, an online software platform that supports the conduct of reviews, was used to export data from the databases and organize article information to facilitate the selection process, including identification, title, year of publication, indexing database, journal, abstract, and full-text file. The software features an artificial intelligence-based tool for identifying and removing duplicate references, designed to optimize the management of retrieved studies. Duplicate studies were removed before title and abstract screening; the authors' names, publication title, and DOI (Digital Object Identifier) were used as comparison criteria.

The stages were performed independently by two researchers, and disagreements were discussed until a final consensus was reached. Data collection was conducted between May and August 2025.

Data extraction was performed by two independent reviewers using an instrument developed by the researchers and adapted from the *JBI Manual for Evidence Synthesis* (Appendix 10.1)¹⁰. The instrument was pilot-tested on a sample of three included studies and adjusted according to the needs identified. Information was extracted on the identification and methodological characteristics of the studies (author, year, country, publication type, language, journal, objective, study design, healthcare setting, and sample), population characteristics (age, sex, race/ethnicity, and comorbidities), development and clinical characteristics of arterial ulcers, healing process, association between comorbidities and healing, clinical and surgical treatments, wound closure techniques, main findings related to the research questions, conclusions, limitations, and knowledge gaps.

The data were descriptively mapped using frequency counts (absolute and relative) and median values. The results were presented based on categories that emerged from the research question. The findings were presented in figures and tables. Based on the results, a conceptual map was developed with the assistance of a generative artificial intelligence (AI) tool. The map was reviewed, checked, and validated by the researchers.

The study protocol was registered on the Open Science Framework (OSF) at <https://doi.org/10.17605/OSF.IO/8CR6Z> and remained unchanged throughout its conduct. Because this was a scoping review conducted using publicly available

Chart 1. Combined search strategy. Maringá (PR), Brazil, 2025.

Databases	No. of combinations	Search strategies
PubMed, Scopus and Embase	Combination 1	(((Adult) OR (Aged)) OR (Wound Healing)) OR (Wound Closure Techniques)) AND (Arterial Ulcer)
	Combination 2	((((Adult) OR (Aged)) AND (Wound Infection)) AND (Cell Proliferation)) OR (Regeneration)) AND (Arterial Ulcer)
	Combination 3	(((Adult) OR (Aged)) AND (Wound Closure Techniques)) OR (Stem Cells)) AND (Arterial Ulcer)
	Combination 4	(((Adult) OR (Aged)) AND (Inflammation)) OR (Wound Infection)) AND (Arterial Ulcer)
	Combination 5	((((Adult) OR (Aged)) AND (Peripheral Arterial Disease)) AND (Leg Ulcer)) OR (Arterial Ulcer))
	Combination 6	((((Adult) OR (Aged)) AND (Arterial Ulcer)) OR (Leg Ulcer)) AND (Nursing Care)) OR (Enterostomal Therapy)
	Combination 7	((((((((Adult) OR (Aged)) AND (Wound Healing)) OR (Wound Infection)) OR (Wounds)) OR (Cell Proliferation)) OR (Regeneration)) OR (Stem Cells)) OR (Inflammation)) AND (Leg Ulcer)) OR (Arterial Ulcer)
	Combination 8	((((((((Adult) OR (Aged)) AND (Wound Healing)) OR (Wound Infection)) OR (Wounds)) OR (Cell Proliferation)) OR (Regeneration)) OR (Stem Cells)) OR (Inflammation)) AND (Leg Ulcer)) OR (Arterial Ulcer)) AND (Nursing Care)
	Combination 9	(((Adult) OR (Aged)) AND (Peripheral Arterial Disease)) AND (Leg Ulcer)
Web of Science	Combination 1	(((ALL=(Adult)) OR ALL=(Aged)) AND ALL=(Wound Healing)) OR ALL=(Wound Closure Techniques)) AND ALL=(Arterial Ulcer)
	Combination 2	((((ALL=(Adult)) OR ALL=(Aged)) AND ALL=(Wound Infection)) AND ALL=(Cell Proliferation)) OR ALL=(Regeneration)) AND ALL=(Arterial Ulcer)
	Combination 3	(((ALL=(Adult)) OR ALL=(Aged)) AND ALL=(Wound Closure Techniques)) OR ALL=(Stem Cells)) AND ALL=(Arterial Ulcer)
	Combination 4	(((ALL=(Adult)) OR ALL=(Aged)) AND ALL=(Inflammation)) OR ALL=(Wound Infection)) AND ALL=(Arterial Ulcer)
	Combination 5	(((ALL=(Adult)) OR ALL=(Aged)) AND ALL=(Peripheral Arterial Disease)) AND ALL=(Leg Ulcer)) OR ALL=(Arterial Ulcer)
	Combination 6	((((ALL=(Adult)) OR ALL=(Aged)) AND ALL=(Arterial Ulcer)) OR ALL=(Leg Ulcer)) AND ALL=(Nursing Care)) OR ALL=(Enterostomal Therapy)
	Combination 7	((((((((ALL=(Adult)) OR ALL=(Aged)) AND ALL=(Wound Healing)) OR ALL=(Wound Infection)) OR ALL=(Wounds)) OR ALL=(Cell Proliferation)) OR ALL=(Regeneration)) OR ALL=(Stem Cells)) OR ALL=(Inflammation)) AND ALL=(Leg Ulcer)) OR ALL=(Arterial Ulcer)
	Combination 8	((((((((ALL=(Adult)) OR ALL=(Aged)) AND ALL=(Wound Healing)) OR ALL=(Wound Infection)) OR ALL=(Wounds)) OR ALL=(Cell Proliferation)) OR ALL=(Regeneration)) OR ALL=(Stem Cells)) OR ALL=(Inflammation)) AND ALL=(Leg Ulcer)) OR ALL=(Arterial Ulcer)) AND ALL=(Nursing Care)
	Combination 9	(((ALL=(Adult)) OR ALL=(Aged)) AND ALL=(Peripheral Arterial Disease)) AND ALL=(Leg Ulcer)
Virtual Health Library	Combination 1	(Adulto) OR (Idoso) AND (Cicatrização dos Ferimentos) OR (Técnicas de Fechamento de Feridas) AND (Úlcera Arterial)
	Combination 2	(Adulto) OR (Idoso) AND (Infecção dos Ferimentos) AND (Proliferação celular) OR (Regeneração) AND (Úlcera Arterial)
	Combination 3	(Adulto) OR (Idoso) AND (Técnicas de Fechamento de Feridas) OR (Células-Tronco) AND (Úlcera Arterial)
	Combination 4	(Adulto) OR (Idoso) AND (Inflamação) OR (Infecção dos Ferimentos) AND (Úlcera arterial)
	Combination 5	(Adulto) OR (Idoso) AND (Doença Arterial Periférica) AND (Úlcera da Perna) OR (Úlcera Arterial)
	Combination 6	(Adulto) OR (Idoso) AND (Úlcera Arterial) OR (Úlcera da Perna) AND (Cuidados de Enfermagem) OR (Estomaterapia)
	Combination 7	(Adulto) OR (Idoso) AND (Cicatrização de Feridas) OR (Infecção dos Ferimentos) OR (Feridas) OR (Proliferação Celular) OR (Regeneração) OR (Células-Tronco) OR (Inflamação) AND (Úlcera da Perna) OR (Úlcera Arterial)
	Combination 8	(Adulto) OR (Idoso) AND (Cicatrização de Feridas) OR (Infecção dos Ferimentos) OR (Feridas) OR (Proliferação Celular) OR (Regeneração) OR (Células-Tronco) OR (Inflamação) AND (Úlcera da Perna) OR (Úlcera Arterial) AND (Cuidados de Enfermagem)
	Combination 9	(Adulto) OR (Idoso) AND (Doença Arterial Periférica) AND (Úlcera da Perna)

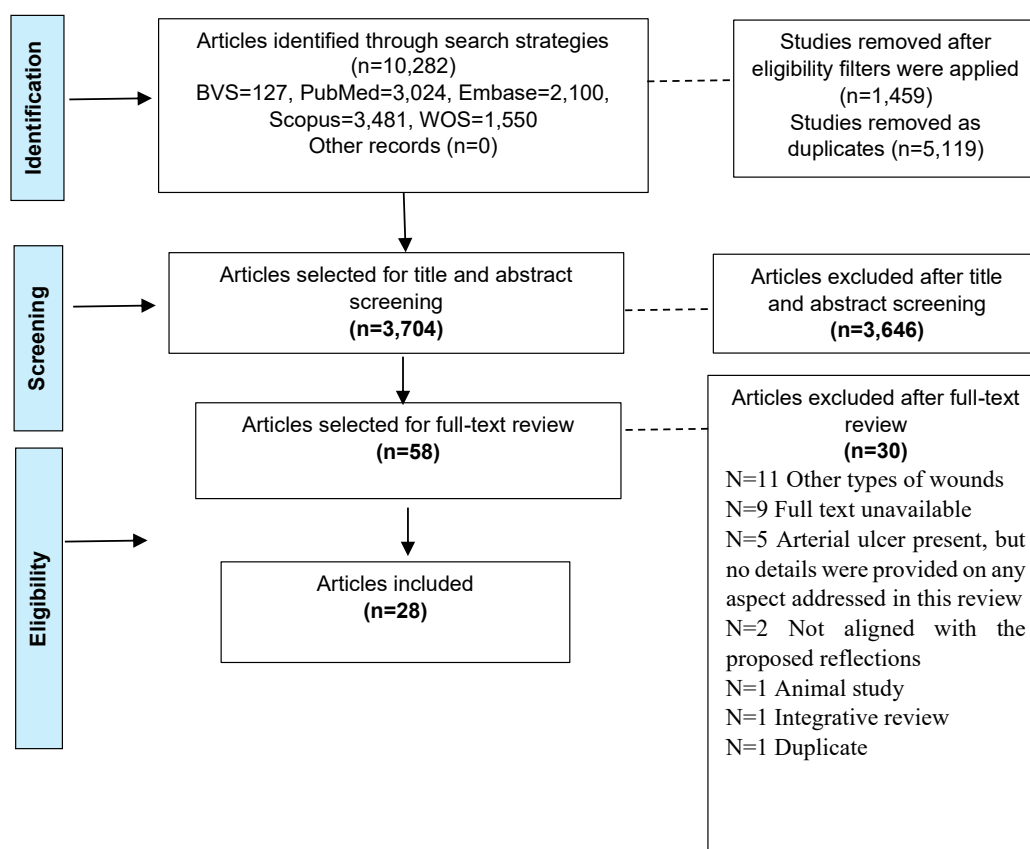
Source: Prepared by the authors, 2025.

data, it was not submitted for review by a research ethics committee involving human participants; nevertheless, all ethical principles established in Resolution No. 466/2012 were followed.

In accordance with international scientific integrity guidelines, the use of AI-based tools at specific technical stages of this study is hereby declared. During the reference management phase, RAYYAN® software was used to automatically identify duplicate articles, with final removal manually validated by the researchers. Subsequently, the language models Gemini and ChatGPT were used to support proofreading, syntactic refinement, and textual cohesion of the manuscript. The use of AI to generate the conceptual map is also reiterated. The authors further affirm that no stage of critical analysis, data interpretation, or intellectual content writing was delegated to automated tools and, therefore, assume full responsibility for the final content presented.

RESULTS

Among the 10,282 articles identified in the databases, 28 were included in this review. The flowchart for study selection is presented in Figure 1¹¹ below.



VHL: Virtual Health Library; WOS: Web of Science.

Source: Prepared based on the recommendations of Tricco et al.¹¹.

Figure 1. Flowchart of study selection. Maringá (PR), Brazil, 2025.

Regarding the methodological approaches used in the studies, 10 were retrospective cohort studies, two were retrospective multicenter studies, and one was a multicenter cohort study; five were cross-sectional studies; one was a comparative study and one was an observational study; one was a pilot study; three were case reports; two were randomized clinical trials and one was a non-randomized clinical trial; and one was a lower-extremity wound differentiation guideline. Most studies were conducted in the Northern Hemisphere, in countries such as the United States of America, Singapore, and Japan, indicating that countries with greater financial resources have conducted research on various healing techniques for this type of wound (Table 1)¹²⁻³⁹.

Table 1. Characteristics of studies on the development, healing process, and treatment of arterial ulcers in adults and older adults. Maringá (PR), Brazil. (n=28).

Reference	Title	Year of publication	Country	Objective	Language of publication
Kuikko et al. ¹²	Characteristics of chronic ulcer patients by gender and ulcer aetiology from a multidisciplinary wound centre	2024	Finland	Analyze the specific characteristics of patients with chronic ulcers regarding gender and ulcer etiology through a cohort of patients treated at a multidisciplinary wound care center.	English
Moraes et al. ¹³	Biocellulose-based hydrogel dressing as a strategy for the management of chronic arterial wounds	2024	Brazil	Evaluate a biocellulose-based hydrogel as a strategy for managing chronic arterial wounds, assessing its safety and potential benefits.	English
Pasek et al. ¹⁴	Application of topical hyperbaric oxygen therapy and medical active dressings in the treatment of arterial leg ulcers—a pilot study	2023	Poland	Compare the efficacy of combined treatment, including advanced medical dressings and topical hyperbaric oxygen therapy, versus medical dressings used as monotherapy in the treatment of arterial leg ulcers.	English
Meng et al. ¹⁵	Major limb amputation and mortality in patients with neuro-ischaemic lower extremity wounds managed in a tertiary hospital: focus on differences among patients with diabetes, peripheral arterial disease and both	2022	Singapore	Characterize the main clinical outcomes of patients with lower-extremity wounds in Singapore with DM, PAD, or DM-PAD.	English
Stillman et al. ¹⁶	An arterial insufficiency ulcer in an individual with cervical spinal cord injury and hypotension	2020	USA	Case report of a woman with chronic cervical spinal cord injury and resting hypotension who presented with a nonhealing arterial ulcer of the ankle.	English
Goh et al. ¹⁷	Incidence of chronic wounds in Singapore, a multiethnic Asian country, between 2000 and 2017: a retrospective cohort study using a nationwide claims database	2020	Singapore	Estimate trends in the incidence rates of chronic wounds and their four most common categories in the general population of Singapore using a national administrative claims database.	English
Maia et al. ¹⁸	Bacterial cellulose biopolymer film and gel dressing in the treatment of ischemic wounds after lower limb revascularization	2019	Brazil	Evaluate the use of FGBC biopolymer film in the treatment of ischemic wounds following lower-extremity revascularization.	Portuguese
Salm et al. ¹⁹	Arterial leg ulcers-bacterial patterns, antimicrobial resistance and clinical characteristics: a retrospective single-centre cohort, 2012–2021	2023	Germany	Provide information on the microbiological and antimicrobial resistance patterns of specific pathogens in patients with arterial leg ulcers.	English
Linn et al. ²⁰	Heal or no heel: outcomes of ischaemic heel ulcers following lower limb revascularization from a multi-ethnic Asian cohort in Singapore	2020	Singapore	Review the outcomes of patients who underwent revascularization for ischemic heel ulcers and investigate factors contributing to poor prognosis and impaired wound healing.	English
Zhu et al. ²¹	Health-related quality of life and chronic wound characteristics among patients with chronic wounds treated in primary care: a cross-sectional study in Singapore	2022	Singapore	Explore health-related quality of life and its associations with patients' sociodemographic and wound characteristics in a multiethnic primary care population.	English

It continues...

Table 1. Continuation.

Reference	Title	Year of publication	Country	Objective	Language of publication
Bohelay et al. ²²	Lower-limb ulcers in systemic sclerosis: a multicentre retrospective case-control study	2018	France	Describe the main causes and outcomes of lower-extremity ulcers in patients with systemic sclerosis and assess the factors associated with ischemic causes.	English
Mohapatra et al. ²³	Bypass versus endovascular intervention for healing ischemic foot wounds secondary to tibial arterial disease	2018	USA	Compare pedal bypass and endovascular tibial intervention in terms of clinical and patency outcomes in a contemporary cohort of patients with tibial artery disease and ischemic tissue loss.	English
Nakama et al. ²⁴	Clinical outcomes of pedal artery angioplasty for patients with ischemic wounds: Results From the Multicenter RENDEZVOUS Registry	2017	Japan	Investigate the clinical outcomes of pedal artery angioplasty in patients with critical limb ischemia.	English
Jockenhöfer et al. ²⁵	Aetiology, comorbidities and cofactors of chronic leg ulcers: retrospective evaluation of 1000 patients from 10 specialised dermatological wound care centers in Germany	2016	Germany	Analyze the etiology of chronic leg ulcers, as well as comorbidities and cofactors, in 1,000 patients from 10 specialized dermatological wound care centers in various regions of Germany.	English
Cangel et al. ²⁶	Comparison of larval therapy and vacuum-assisted closure therapy after revascularization in peripheral artery disease patients with ischemic wounds.	2022	Türkiye	Compare the efficacy of vacuum-assisted closure therapy and larval debridement therapy in patients with peripheral arterial disease and an ischemic ulcer of a lower extremity who underwent peripheral revascularization.	English
Kayama et al. ²⁷	A pilot study investigating the use of regional oxygen saturation as a predictor of ischemic wound healing outcome after endovascular treatment in patients with chronic limb-threatening ischemia	2021	Japan	Determine the prognostic value of regional tissue oxygen saturation for ulcer healing after endovascular treatment of peripheral arterial disease.	English
Acevedo ²⁸	Successful treatment of painful chronic wounds with amniotic and umbilical cord tissue: a case series	2020	USA	Report the safe use of umbilical cord tissue to promote wound healing and pain relief in three cases involving chronic ischemic wounds.	English
Szewczyk et al. ²⁹	Quality of life in patients with leg ulcers or skin lesions – a pilot study	2015	Poland	Compare the quality of life of patients with leg ulcers of venous and arterial etiology with that of patients with lower-extremity skin lesions caused by chronic venous insufficiency.	English
Karn ³⁰	To determine the clinicopathological characteristics of ulcers on the lower limb and developing effective management strategies.	2024	India	Determine the clinicopathological characteristics of lower-extremity ulcers and develop effective treatment strategies.	English
Mohanta et al. ³¹	A comprehensive study of clinical features and management of ulcers of the lower limb.	2019	India	Study the causal factors and clinical characteristics of various types of lower-extremity ulcers.	English

It continues...

Table 1. Continuation.

Reference	Title	Year of publication	Country	Objective	Language of publication
Nag et al. ³²	Clinico-etiological evaluation of chronic leg ulcer in a tertiary care center of eastern India	2020	India	Determine the clinical and etiological patterns of patients with chronic leg ulcers.	English
Kehagias et al. ³³	Feasibility of ischemic leg ulcer healing using percutaneous techniques: a real-life study.	2019	Greece	Evaluate the technical and clinical efficacy of percutaneous transluminal angioplasty in the treatment of ischemic foot ulcers.	English
Furuyama et al. ³⁴	Prognostic factors of ulcer healing and amputation-free survival in patients with critical limb ischemia.	2018	Japan	Determine the predictors of poor healing outcomes for ischemic ulcers after optimal arterial revascularization and assess the efficacy of cilostazol therapy, a selective phosphodiesterase 3 inhibitor.	English
Sanchez and Partsch ³⁵	Healing of an arterial leg ulcer by compression bandaging: a case report.	2017	Austria	Demonstrate that arterial ulcer healing can also be achieved with compression therapy, even in the absence of venous insufficiency.	English
Kaufman et al. ³⁶	Topical oxygen therapy stimulates healing in difficult, chronic wounds: a tertiary centre experience.	2018	Israel	Examine the efficacy and safety of continuous topical oxygen diffusion in a real-world setting.	English
Gabel et al. ³⁷	A conservative approach to select patients with ischemic wounds is safe and effective in the setting of deferred revascularization.	2020	USA	Evaluate wound healing, limb salvage, and patient survival in individuals with ischemic wounds who underwent revascularization when surgical intervention was preceded by a trial of conservative wound therapy.	English
Star ³⁸	Differentiating lower extremity wounds: arterial, venous, neurotrophic.	2018	USA	Distinguish among the three most common types of lower-extremity wounds to guide successful treatment and prevent the significant morbidity and mortality associated with amputation.	English
Cwajda-Białasik et al. ³⁹	Influence of ulceration etiology on the global quality of life and its specific dimensions, including the control of pain, in patients with lower limb vascular insufficiency	2017	Poland	Compare quality of life and its specific dimensions in patients with lower-extremity ulcerations of various etiologies.	English

ID: identification; USA: United States of America; SCI: spinal cord injury; LE: lower extremities; DM: diabetes mellitus; PAD: peripheral arterial disease; DM-PAD: diabetes mellitus-peripheral arterial disease; FGBC: gel-associated bacterial cellulose.

Source: Prepared by the authors, 2025.

Participant Characteristics

The number of participants ranged from one to 11,733 (median: 100). A predominance of male participants was reported in 20 studies (71%). The median participant age was 67 years, and White individuals predominated. Regarding wound etiology, peripheral arterial disease/peripheral arterial occlusive disease (PAD/PAOD)^{12,13,18-20,23,25-28,35,37} was predominant, followed by atherosclerosis^{29,31,38,39}, critical ischemia^{24,33,34,39}, causes involving microcirculatory or macrocirculatory ischemia²², others resulting from the combination of diabetes mellitus (DM) and PAD¹⁵, and arterial ulcers of unspecified origin^{14,16,17,21,30,32,36}.

Presence of Comorbidities Associated with the Development of Arterial Ulcers

The presence of comorbidities was found to potentially negatively influence the development and healing of arterial ulcers. The most notable comorbidities included systemic arterial hypertension^{12,13,15,18-21,23-25,27,28,33-35}, DM^{12,13,17-21,23-28,33-35,37}, dyslipidemia^{12,13,15,18-20,23-25,27,33,34}, cardiac diseases, including heart failure, acute myocardial infarction, and

coronary artery disease^{13,15,17,18,20-23,26,27,33,34,37}, pulmonary diseases, such as asthma and chronic obstructive pulmonary disease^{12,26,35}, smoking^{13,18,19,24,27,28,31-33,37}, peripheral vascular disease^{17,21}, obesity^{25,26}, metabolic syndrome²⁵, atherosclerosis²⁶, and stroke^{13,15}.

Renal insufficiency (chronic kidney disease or end-stage renal disease) was also reported in a large proportion of the studies^{12,15,17,19-21,23,24,26,27,33,34} and is recognized as one of the factors associated with PAD; therefore, renal impairment may also be related to the development of arterial ulcers. In addition, another comorbidity reported in isolation was spinal cord injury related to hypotension. However, the study did not specify whether this was the cause of arterial ulcer development.

Characteristics of Arterial Ulcers

The sites where arterial ulcers developed varied and included the feet^{21-23,31,33,34,36} and forefoot^{13,24,37,38}, with particular involvement of the toes^{24,26,27,32,38}, lower extremities^{21,25,28,32,35}, and heels^{13,18,20,24,26}. Some studies described the wounds in detail and characterized them as small and deep ulcers^{14,16,24,31,32,35}, well-demarcated^{18,33,35,38}, with coldness to the touch and/or pallor^{16,28,31,35,38}, predominantly absent or weak pedal pulses^{16,28,30,35,38}, an ankle-brachial index (ABI) <0.9 (suggestive of PAD)^{14,32,38}, shiny perilesional skin^{14,31,32} and edema^{14,16,35}, with hair loss around the wound^{31,38} and loss of sensation³⁰. Regarding the tissues found in the wound bed, necrotic tissue was predominant^{14,24,31,35,38}, followed by granulation tissue^{18,33} and fibrin¹⁴, accompanied in some cases by exudate (all in small amounts)^{14,18,31,38} and malodor¹⁴.

Wound staging was performed using the Rutherford^{20,24,34} and Fontaine²⁶ classifications. The former is associated with clinical symptoms and objective findings of the disease and is divided into six categories; the wounds analyzed in the studies were categorized as Rutherford 5 (minor tissue loss). In the Fontaine classification, only clinical symptoms are assessed, across stages I to IV, ranging from asymptomatic disease to ischemic ulcer or gangrene, respectively. The wounds investigated were classified as Fontaine III and IV. Only one article reported the wound dimensions²⁸, measuring 1.0 × 1.2 × 0.1 cm³, confirming its small size.

Regarding pain, the studies frequently reported severe pain^{21,31,32,35,38,39}. However, there were also reports of no pain³⁸ or mild pain¹³. In some studies, pain complaints were assessed in relation to treatment and were found to decrease^{14,35} or cease after the application of a specific treatment method^{13,18,26,28}.

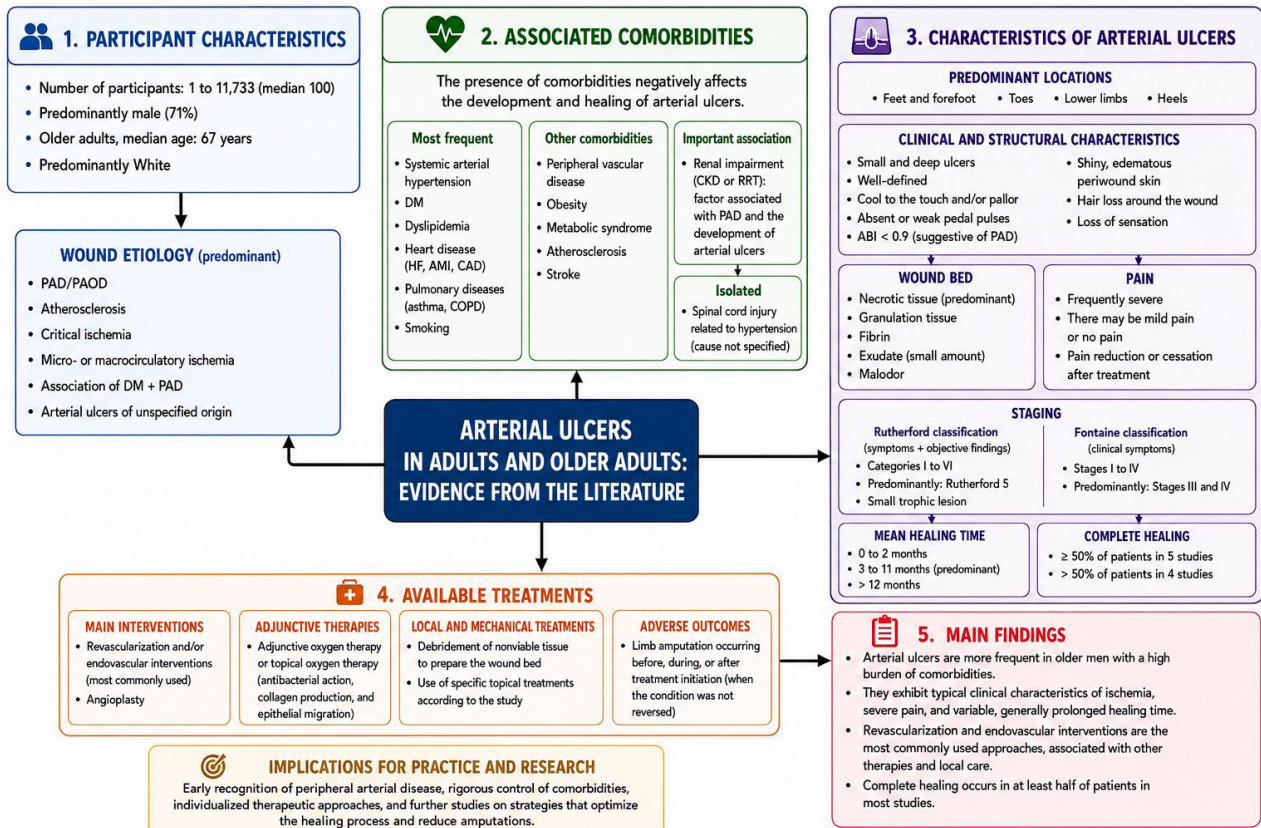
The mean healing time varied. The studies showed that most arterial ulcers tended to heal within 3 to 11 months^{12,18,20,33-35}, while others took more than 12 months²²⁻²⁴, and some healed within 0 to 2 months^{13,28}. Among the studies that reported the specific number of patients whose wounds achieved complete closure, at least 50% achieved successful healing in five cases^{13,18,23,26,36}, while in four studies, more than half of the analyzed population achieved a positive response to the treatment used^{20,26,33,37}.

Available Treatments for Arterial Ulcers

Several treatments have been proposed to promote healing or reduce the area of arterial wounds, with revascularization and/or endovascular interventions being the most commonly used^{15,20,22,23,27,34,37}. Angioplasty has also been shown to be a therapeutic alternative^{24,31,33}. Less invasive methods have been tested, such as the use of oxygen as an adjunctive therapy^{14,20} or as the primary treatment through topical oxygen therapy, which promotes cellular mechanisms that support healing, including antibacterial activity, collagen production, and epithelial migration³⁶.

As a mechanical approach, debridement of nonviable tissue was also used to enable better visualization of the viable wound bed and facilitate the application of primary treatment methods^{15,16,20,24,28}. It is worth noting that several studies employed specific treatments in their respective populations^{13,14,16,18-20,26,28,35}. In some studies, when the clinical condition did not improve, amputation of the affected limb was necessary; this occurred before, during, or after the initiation of treatment^{15,22,31,37}.

The synthesis of the results is presented in the conceptual map (Figure 2).



PAD: peripheral arterial disease; PAOD: peripheral arterial occlusive disease; DM: diabetes mellitus; HF: heart failure; AMI: acute myocardial infarction; CAD: coronary artery disease; COPD: chronic obstructive pulmonary disease; CKD: chronic kidney disease; ESRD: end-stage renal disease.

Source: Prepared by the authors with the assistance of a generative artificial intelligence tool, based on the results of this scoping review.

Figure 2. Conceptual map of the evidence on the development and treatment of arterial ulcers in adults and older adults. Maringá (PR), Brazil, 2025.

DISCUSSION

Based on the results, arterial ulcers were found to be more prevalent among older men with multiple comorbidities, with PAD/PAOD being the main condition associated with the development of these wounds. PAD is a condition that affects the arteries, usually those of the lower extremities, causing narrowing of these vessels and, consequently, reduced blood flow⁴⁰. It may be associated with comorbidities such as DM and hypertension, and although it can occur independently of these conditions, the findings of this study corroborate the literature, demonstrating that these individuals are at greater cardiovascular risk⁴¹.

Another condition associated with arterial ulcers is chronic kidney disease (CKD). A U.S. study that evaluated individuals living with PAD identified a higher risk of CKD or end-stage renal disease, regardless of other comorbidities, since multiple arterial stenoses may affect the renal artery, altering blood flow to the kidneys and causing ischemic nephropathy⁴². However, it is important to emphasize that, as with the studies analyzed, the literature also indicates that this association and its complications remain poorly characterized. Nevertheless, CKD has increasingly been recognized as a risk factor for the development of arterial ulcers⁴².

Regarding the characteristics of arterial ulcers, the articles highlighted the use of the Rutherford and Fontaine classification systems, which are used to stage PAD and address the development of ulcerations. Although these systems are recognized worldwide, they are outdated methods that have become increasingly limited, particularly because of advances in treatment techniques, which may hinder the appropriate classification of lesions⁴³.

New classification systems are being used, such as Wound, Ischemia, and foot Infection (WIFI), developed by the Society for Vascular Surgery in the United States, which addresses three domains: wound, which classifies its size, depth, and

severity; ischemia, for which the Ankle-Brachial Index (ABI) is the metric used to classify this domain; and foot infection, which determines whether an infection is present and its severity. All domains are graded from 0 to 3, with grade 3 always representing the most complex and severe scenario. These criteria can predict the risk of limb amputation and are more comprehensive than other classification systems⁴⁴.

The main treatments described in the studies were revascularization and/or endovascular intervention. Considering that surgical treatments involve more invasive approaches and are associated with higher morbidity and mortality, patients must be assessed individually regarding their risks and benefits. The goal of these treatments is amputation-free survival, that is, preservation of the affected limb, thereby promoting wound healing and improving claudication⁴⁵.

A meta-analysis found that patients who underwent endovascular procedures had a lower likelihood of amputation (OR 0.80; 95% CI, 0.68–0.93, $p=0.005$) after 30 days, one year, and three years compared with those who required open surgery⁴⁶. Another systematic review with meta-analysis evaluating the association between mortality and amputation in open versus endovascular surgery found that open interventions were associated with the highest risks, including death, compared with less invasive interventions⁴⁷.

Revascularization and/or endovascular intervention are costly treatments. Within the Brazilian Unified Health System (SUS), studies have shown that revascularization is a recurrent, costly, and prolonged treatment. In an epidemiological analysis conducted between 2008 and 2019, approximately 129,000 revascularization procedures were performed through the SUS, representing a total expenditure of approximately US\$238 million. Endovascular procedures were the most costly, whereas open procedures were associated with the highest mortality⁴⁸.

A study conducted in Brazil between 2010 and 2020 highlighted the urgent nature of both open and endovascular revascularization procedures. During the period analyzed, 83,218 patients were hospitalized for these procedures, representing expenditures of R\$334 million on surgery and hospitalization, with a mean length of stay of 10.2 days for open surgery and 5.3 days for endovascular interventions⁴⁹.

In addition to the primary treatment for arterial ulcers, which consists of restoring tissue perfusion, pain management is also essential. This scoping review demonstrated that most patients reported pain; moreover, cases of intermittent claudication are common and may also affect quality of life. In a cross-sectional study conducted in the United States, the use of opioids before and after revascularization procedures was found to be routine, with hydrocodone, oxycodone, tramadol, and codeine being the most commonly used⁵⁰.

Another study obtained similar results, reporting high analgesic consumption following a diagnosis of PAD and emphasizing that higher medication use was associated with a greater number of comorbidities⁵¹. It should be emphasized that successful treatment requires addressing the unpleasant symptoms associated with arterial ulcers, making a holistic approach to the patient essential, incorporating nonpharmacological measures to manage pain and other symptoms.

Regarding the topography and characteristics of arterial ulcers, the studies demonstrated a predominance of lesions in the lower extremities due to reduced blood flow, particularly in the arteries supplying these regions. The foot was generally the most commonly affected area^{52,53}. Other features, such as small, deep, and well-demarcated ulcers, weak or absent pedal pulses, shiny perilesional skin, and an ABI <0.9 , are widely recognized characteristics of arterial ulcers and help differentiate them from other types of ulcers. In addition, the appearance of the wound bed is characteristic, with necrotic tissue and minimal or absent exudate being frequently observed⁵⁴.

Although the healing process was one of the focuses of this scoping review, it was not adequately addressed in the studies included in the sample, particularly because they consisted primarily of descriptive studies. Nevertheless, the literature highlights multiple factors that can delay the healing process, such as advanced age, the presence of comorbidities, the high cost of the methods used to restore tissue perfusion, which may negatively affect treatment adherence, and insufficient knowledge among the population regarding appropriate therapy, potentially leading to inappropriate therapeutic interventions⁵³.

Study Limitations

Although the importance of including gray literature, such as Google Scholar or ProQuest, in scoping reviews is recognized, it was not possible to search these databases due to operational barriers, which may represent an important limitation affecting the scope of the results. Other important limitations should also be noted, including substantial heterogeneity among the studies, the use of broad descriptors, the restriction to quantitative studies, with the exclusion of relevant qualitative evidence, such as patient experiences, treatment adherence, and care-related aspects, and the difficulty in fully addressing some research questions due to the scarcity of evidence on the healing process of arterial ulcers. Finally, requiring studies to be freely available does not constitute a methodological eligibility criterion and may introduce selection bias by restricting the inclusion of potentially relevant evidence. However, regarding this latter point, it should be emphasized that the search strategies were accessed through the CAPES Journals Portal, which expands access to the full text of studies, thereby reducing losses resulting from subscription restrictions.

There was also a concentration of research in high-income countries, a scarcity of multicenter studies, and limited characterization of outcomes related to the healing process, making assessment difficult. In addition, there was little standardization in the clinical description of ulcers, assessment methods, and patient follow-up.

From this perspective, it should be emphasized that, although the initial sample size was large (10,282 articles), only a small number of studies met the eligibility criteria, representing a limitation of this study, particularly with regard to studies conducted in Brazil, since the Brazilian population has distinct characteristics that should be considered when determining treatment, such as extensive racial admixture and the large number of people who rely exclusively on the Brazilian Unified Health System (SUS).

However, this study included other robust databases that, combined with the broad range of descriptors, enabled the mapping of the literature produced on the topic and the synthesis of scientific evidence to support clinical care.

Recommendations

This review encompassed an investigation of the literature using a variety of methodologies. The development of prospective multicenter studies and randomized controlled clinical trials with high methodological rigor is recommended to assess the comparative effectiveness of therapeutic approaches, such as revascularization and other advanced topical therapies.

Further research in developing countries is needed. Studies conducted in Brazil on arterial ulcers are particularly recommended, especially those employing robust methodologies and more demographically diverse samples, including analyses stratified by gender and ethnicity, to generate scientific evidence that can inform treatment, make it more accessible and timely, and promote survival with quality of life and well-being.

Given the high prevalence of comorbidities, particularly those amenable to management in primary care, future studies should develop a predictive risk model to support individualized care for patients at risk of developing severe disease.

Finally, a scarcity of precise quantitative data was identified regarding the standardization of lesion assessment and measurement, as well as fragmentation in the use of staging scales. Future research should adopt rigorous standards for wound description and measurement, with detailed documentation of wound-bed tissue composition.

CONCLUSION

Through this review, it was possible to map the evidence on the development and treatment of arterial ulcers across various healthcare settings, including the influence of comorbidities on healing and the closure techniques employed. The results demonstrated that arterial ulcers predominantly affected older men with multiple comorbidities, with peripheral arterial disease being the main precursor to wound development. These lesions primarily developed in the lower extremities, particularly the feet, and were small in size, with regular edges, the presence of necrotic tissue, and little exudate. The mean healing time ranged from 3 to 11 months. According to the studies, the most commonly used treatment was revascularization.

Although this study conducted a comprehensive search of databases, a scarcity of research addressing this topic was observed, particularly regarding the wound healing process. Therefore, further studies focusing on arterial ulcers, particularly those conducted in Brazil, are recommended to support the development of protocols for the optimal management of these wounds, aiming to achieve the best cost-benefit ratio while accounting for the characteristics of this population and the services provided through the Brazilian Unified Health System.

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