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Research paper

A systematic review of racial/ethnic disparities in pharmacotherapy and surgical treatment outcomes in peripheral arterial disease among African American/non-Hispanic Black, non-Hispanic White and Hispanic patients

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ABSTRACT

Background: Lower extremity peripheral arterial disease (PAD) is associated with significant morbidity and mortality in racial/ethnic diverse populations. However, limited data exist on treatment outcome disparities in racial/ethnic diverse populations, particularly in AA/NHB populations.
Objective: The aim of this systematic review is to analyze disparities in the outcomes of PAD treatments, particularly pharmacotherapy and surgery, among racial/ethnic groups in the US.
Methods: A comprehensive search of original investigations pertaining to PAD treatments between 2015 and 2021 was performed. Quality assessment of the studies was also completed.
Results: Fourteen studies were included. Thirteen studies reported differences in treatment outcomes for surgical intervention, and one study reported differences for concurrent surgical and pharmacotherapy. NHB and Hispanic/Latinx ethnicities were associated with decreased overall and perioperative mortality in four studies. Six studies noted increased amputation risk among racial/ethnic diverse populations. Only one study noted significant survival benefit by race/ethnicity. Three studies noted increased risk of major adverse limb events and postoperative complications. One study noted increased limb patency after intervention in racial/ethnic cohorts. Overall, all studies reported high methodological quality with adequate assessment of outcomes and follow-up of cohort.
Conclusion: In this analysis, the predominant intervention reported is surgical. Overall, racial/ethnic populations are less likely to experience PAD-associated mortality but are more likely to experience adverse events. Further studies are necessary to include all racial/ethnic diverse populations in assessing PAD therapeutic intervention outcomes. Moreover, targeted public health efforts are necessary to increase PAD educational awareness, community-driven risk modification, and patient-centered care planning.

1. Introduction

Lower extremity peripheral artery disease (PAD), which describes atherosclerotic obstruction from the aortoiliac to the pedal arteries, is the third leading cause of atherosclerotic cardiovascular disease (ASCVD) morbidity and mortality after myocardial infarction (MI) and stroke [1]. Moreover, PAD patients with chronic comorbidities and numerous risk factors are more likely to experience elevated risk of decreased walking capacity, poor cognitive function, major adverse limb events (MALE), major adverse cardiovascular events (MACE), and mortality [1].

Racial/ethnic disparities in PAD are similar to those observed in

Abbreviations: AA, African American; ABI, ankle brachial index; ACC, American College of Cardiology; AHA, American Heart Association; ASCVD, atherosclerotic cardiovascular disease; AI, American Indian; AN, Alaskan Native; CLI, critical limb ischemia; CVD, cardiovascular disease; DM, diabetes mellitus; IVL, intravascular lithotripsy; Lp(a), lipoprotein (a); MACE, major adverse cardiovascular events; MALE, major adverse limb events; MAVE, major adverse vascular events; NHB, non-Hispanic Black; NHW, non-Hispanic White; NOS, Newcastle-Ottawa Scale; PAD, peripheral arterial disease; PVI, peripheral vascular intervention; SET, supervised exercise therapy; US, United States.

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overall ASCVD: African American (AA)/non-Hispanic Black (NHB) and Hispanic/Latinx adults, along with other racial/ethnic diverse populations, have an increased risk of PAD and adverse outcomes compared to non-Hispanic white (NHW) adults in the United States (US) across all age groups from 40 to ≥80 [2–4]. Although race is a social construct, due to social determinants of health (SDOH), racial/ethnic populations carry disproportionately higher risk factor burden, receive suboptimal medical management of comorbidities, present to their clinicians with severe disease outcomes, and experience significant health complications [2].

While racial/ethnic disparities exist in PAD, there is a limited understanding of racial/ethnic disparities in treatment outcomes. Therefore, it is important to understand the various treatment-associated outcomes experienced in these population cohorts. A recent statement by the American Heart Association [1] detailed PAD diagnosis, management, and prognosis, and more importantly, it emphasized the importance of understanding treatment responses and implementation gaps among racially/ethnic populations. Therefore, the purpose of this systematic review is to synthesize information on morbidity and mortality outcomes of specific PAD treatment modalities within US racial/ethnic diverse populations.

2. Materials and methods

This systematic review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [5].

2.1. Eligibility criteria

This systematic review included studies investigating racial/ethnic disparities in PAD-related outcomes (e.g., mortality, survival, amputation, adverse events) among patients receiving varying treatment modalities including surgery, pharmacotherapy, or lifestyle intervention. Only primary research articles completed in the US, including both observational and interventional study designs, and published between 2015 and 2021 were included. Participants included adults receiving at least one PAD treatment. For PAD outcomes, studies needed to report differences between racial/ethnic groups. Differences could be reported as percentages of each racial/ethnic group experiencing the outcome, or measures of association between race and disease-related outcome. Articles that did not present racial/ethnic disparities in treatment outcomes were excluded. Comprehensive reviews, case reports, society guidelines, conference abstracts, commentaries, and dissertations.

2.2. Information sources and search strategy

Articles were identified through searches in MEDLINE (PubMed) and Embase with English language restrictions. All databases were searched from 2015 to December 2021 to ensure inclusion of recently published articles. In addition to database searching, a manual search of reference lists was also completed to ensure selection of all relevant articles. The search strategy was created by a health sciences librarian and included terms pertaining to PAD, treatment interventions, and racial-ethnic groups. The following Medical Subject Headings and keywords appropriate to each database were used: “antiplatelet therapies”, “lipid lowering therapies”, “antihypertensive therapies”, “risk factor management”, “revascularization”, “endovascularization”, and “amputation”. The comprehensive search strategy is provided in the supplementary documents.

2.3. Study selection

Titles and abstracts of all retrieved articles were screened using Covidence systematic review software by two independent reviewers (SN, TR). Titles and abstracts that met inclusion criteria were assessed in full text. Full text articles that met inclusion criteria were included in this systematic review. Disagreements or discrepancies in the screening process were resolved by consensus voting.

2.4. Risk of bias assessment

The Newcastle-Ottawa Scale (NOS) was utilized to perform quality assessment for observational studies [6].

2.5. Data extraction

A standard data extraction form was used to collect all information. Data were extracted by two independent reviewers using Excel. Information on the following variables was extracted from each study: study characteristics (year of publication, country of study, study design, study dates, primary aim); participant characteristics (number of participants, sex, race/ethnicity, comorbidities), interventions (surgery, pharmacotherapy, lifestyle intervention), outcomes (morbidity, mortality, risk of hospitalization, amputation), key conclusions of study authors, and study limitations.

2.6. Data synthesis

Tabulated and narrative synthesis of results summarizes the racial/ethnic disparities in PAD outcomes among patients receiving various modalities of treatment. Synthesis was structured around PAD-related outcomes pertaining to mortality, survival, amputations, adverse events, and limb patency.

3. Results

3.1. Study selection

Overall, 4842 records were identified through database searching, with an additional 204 records identified through manual searching of reference lists. After removal of duplicates, 4646 articles were screened and 4218 were deemed irrelevant. In the 428 full-text articles assessed for eligibility, 14 studies were ultimately included. Study selection details and full-text exclusion reasons are depicted in Fig. 1. The results noted in Table 2 from this systematic review will aim to use contemporary terminology when referring to the various racial/ethnic diverse populations.

3.2. Characteristics of included studies

All fourteen studies were published in peer reviewed journals and were completed using retrospective analyses (n = 14). Sample sizes ranged from 341 to 15,937,763 with a median sample size of 3848. Most studies (n = 13) investigated outcomes after surgical treatment, and one study investigated outcomes among patients undergoing surgical treatment and using statin therapy concurrently. No studies investigated racial/ethnic disparities in outcomes following lifestyle intervention. Mean age of study participants ranged from 63.4 to 76, with majority of studies having a mean age of participants over 65 (n = 13). Percentage of female participants ranged from 2.1 % to 57 %, while percentage of male participants ranged from 43 % to 100 %%; however, outcomes were not stratified by sex in all studies. Characteristics of included studies are presented in Table 1.

3.3. Mortality

Eight studies reported on treatment differences in mortality [7–14]. One study reported on perioperative mortality in addition to all-cause mortality [13]. Four studies found significant racial/ethnic differences in mortality. Arhuidese et al., in measuring for loss of survival over time, found significantly lower mortality in AA/NHB and Hispanic/Latinx

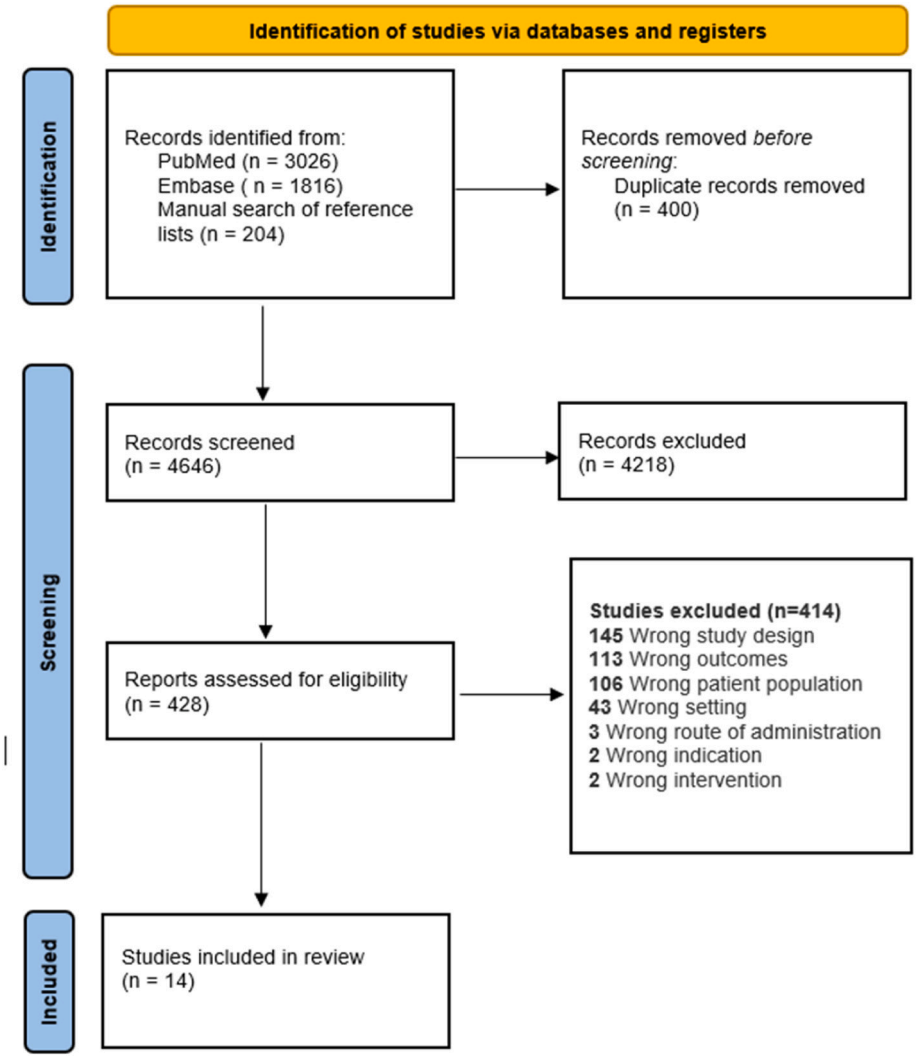

Fig. 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) search elaborating inclusion and exclusion criteria. PubMed = Public/Publisher MEDLINE; Embase = excerpta medica database.

patients following infra-inguinal bypass surgery as compared to NHW patients [14]. AA/NHB race was associated with lower occurrence of overall mortality following infra-inguinal bypass and peripheral vascular intervention (PVI), and supra-inguinal PVI, but not following supra-inguinal bypass or amputation [9]. For perioperative mortality, Brothers et al. found AA/NHB race had a similarly significant protective effect following supra-inguinal bypass and infra-inguinal PVI [9]. Loja et al. found protective effects of both AA/NHB and Hispanic/Latinx race on all-cause mortality within 30 days of first-time lower extremity arterial revascularization [10]. Likewise, Siracuse et al., found a significant protective effect of racial/ethnic status on mortality following endovascular intervention [12]. The remaining studies did not find significant associations.

3.4. Survival

Only one of three studies noted significant differences between racial/ethnic groups on survival [14–16]. Arhuidese et al. found significant differences in survival rates between NHW, AA/NHB, and Hispanic/Latinx patients four years after infra-inguinal bypass surgery, with the highest rate among Hispanic/Latinx patients (32.8 %), followed by AA/NHB patients (29.8 %) [14]. However, Newhall et al. and Rivero et al., found similar rates of overall survival, amputation-free survival, MACE-free survival, or MALE-free survival between Black and other patients undergoing revascularization procedures [15,16].

3.5. Amputations

Seven studies reported on treatment differences in lower extremity amputations [7–10,13,17,18]. While Alasaad et al. [7] noted a similar prevalence of major and minor lower extremity amputation with no statistically significant difference by race/ethnicity status, Newhall et al. [15] noted a significantly increased proportion of major amputations in AA/NHB patients. Three other studies demonstrated that AA/NHB patients were at higher risk of lower extremity amputation [8,13,17]. Hispanic and AA/NHB patients undergoing surgical or revascularization therapy who were prescribed statin therapy experienced higher risk for lower extremity amputation [18]. AA/NHB and Hispanic/Latinx patients with recent history of lower extremity revascularization were likely to experience major amputation within 30 and 365 days, and AA/NHB patients were more likely than Hispanic/Latinx patients to experience major amputation within 30 days [10]. Yang et al., similar to Loja et al., observed increased amputation odds risk in Hispanic/Latinx patients despite representing a smaller proportion of amputation-receiving patients [13].

Table 1
Demographic information of reported studies.

Study	Study dates	Study design	Sample Size	Mean age (SD)	Gender	Race/ethnicity	Treatment
Alasaad et al. [7]	2007–2012	Retrospective analysis	696	Black: 70 (11) White: 72 (11)	Black M: 43 % Black F: 57 % White M: 60.7 % White F: 39.3 %	Black: 37.8 % White: 62.2 %	Surgery
Arhuidese et al. [14]	2007–2011	Retrospective analysis	9305	Black: 65.3 (11.1) White: 69.3 (10.9) Hispanic: 65.5 (10.7)	Black M: 51.7 % Black F: 48.3 % White M: 66.1 % White F:33.9 % Hispanic M: 64.4 % Hispanic F: 35.6 %	Black: 36 % White: 56 % Hispanic: 8 %	Surgery
Arya et al. [8]	2003–2014	Cohort analysis	155,647	66.7 (9.9)	M: 97.9 % F: 2.1 %	Black: 16.1 % White: 82.6 % Other: 1.3 %	Surgery
Brothers et al. [9]	2003–2015	Retrospective registry analysis	104,936	Supra African American: 63.4 (10.9) Supra White American: 63.9 (10.9) Infra African American: 63.8 (11.4) Infra White American: 67.3 (11.2)	M: 65.8 % F: 34.2 %	African American: 14.8 % White American: 85.2 %	Surgery
Hess et al. [19]	2009–2014	Retrospective analysis	381,415	69 (range 61–77)	M: 58.3 % F: 41.7 %	Black: 12.8 % White: 72.9 % Other: 14.3 %	Surgery
Loja et al. [10]	2005–2009	Retrospective analysis	25,635	71.5 (range 35–105)	M: 55.6 % F: 44.4 %	Black: 7.7 % Non-Hispanic White: 68 % Hispanic: 17.2 % Other: 4.5 % Asian/Native Hawaiians: 2.5 %	Surgery
Mehaffey et al. [17]	2011–2014	Retrospective analysis	3848	Infrainguinal endovascular intervention 70 (12) Lower extremity bypass 68 (11)	M: Infrainguinal 57.2 % F: Infrainguinal 42.8 % M: Lower extremity bypass 58.4 % F: Lower extremity bypass 41.6 %	White infrainguinal 78.1 % Non-White infrainguinal 21.9 % White lower extremity bypass 76.6 % Non-White lower extremity bypass 23.4 %	Surgery
Newhall et al. [15]	2007–2011	RCS	15,937,763	76	–	Black: 11.7 % Non-Black: 88.3 %	Surgery
Pandit et al. [11]	2012–2014	Retrospective analysis	4218	Frail: 73 (4) Nonfrail: 73 (9)	Frail M: 64 % Frail F: 36 % Nonfrail M: 65.4 % Nonfrail F: 34.6 %	Frail African American: 29.5 % Nonfrail African American: 24.5 % Frail White: 60 % Nonfrail White: 62.8 % Frail Hispanic: 10.9 % Nonfrail Hispanic: 8.2 %	Surgery
Parmar et al. [18]	2009–2010	Retrospective analysis	488	–	M: 56 % F: 44 %	White: 61 % Non-White: 39 %	Pharmacotherapy
Qato et al. [20]	2013–2018	Retrospective analysis	341	67.8 (11.8)	M: 59.8 % F: 40.2 %	African American: 14.7 % White: 82.1 % Other: 3.23 % Hispanic: 5 % Non-Hispanic: 95 %	Surgery
Rivero et al. [16]	2003–2012	RCS	834	African American: 67.2 (10.6) Caucasian: 69.1 (10.8)	M: 100 %	African American: 12.8 % Caucasian: 87.2 %	Surgery
Siracuse et al. [12]	2010–2017	Retrospective cohort	1014	NHB: 67.2 (10.6) NHW: 69.1 (10.8)	M: 59 % F: 41 %	White: 84.6 % Non-White: 15.4 %	Surgery
Yang et al. [13]	2013	RCS	2381	–	M: 68.1 % F: 31.9 %	Non-Hispanic African American: 20.5 % Non-Hispanic White: 72.7 % Hispanic: 6.76 %	Surgery

3.6. Adverse events

Five studies reported on MACE, MALE, MAVE, and other notable adverse events [7,10,11,17,19]. AA/NHB and Hispanic/Latinx statuses were associated with increased risk for 30-day complications following lower extremity amputations, and AA/NHB ethnicity was associated with increased one-year risk of inpatient hospitalization after all PAD revascularization procedures [11,19]. However, one analysis noted that after popliteal and infra-popliteal peripheral arterial interventions, AA/NHB ethnicity was associated with decreased MAVE risk [7]. Although

Table 2
Outcomes specific data per reported study in the systematic review.

Study	Intervention	Study group (n)	Follow up	Outcomes	Racial/ethnic differences in outcomes	Associations between race/ethnicity and outcomes (95 % CI)
Alasaad et al. [7]	Popliteal and infra-popliteal peripheral arterial interventions	Black = 263 White = 433	Mean: 36 ± 20 months	Major limb amputation	4.2 % Black; 4.4 % White (p = 0.88)	
				All ipsilateral limb major or minor amputations	11.8 % Black; 12 % White (p = 0.93)	
				Need for repeat revascularization or bypass surgery of the ipsilateral limb	20.5 % Black; 27.3 % White (p = 0.046)	White: ref Black: HR = 0.64 (0.46, 0.89); p = 0.007
				All-cause mortality	28.9 % Black; 32.1 % White (p = 0.375)	
				MAVE	–	White: ref Black: HR = 0.7 (0.56, 0.89); p = 0.003
Arhuidese et al. [14]	Infrainguinal bypass surgery (IBS)	Black = 3354 White = 5188 Hispanic = 763		Primary patency	23.7 % White; 20.9 % Black; 25.6 % Hispanic (p < 0.001)	White: ref Hispanic: NS Black: aHR = 1.14 (1.05, 1.24); p = 0.001
				Primary assisted patency	29.4 % White; 24.5 % Black; 32.1 % Hispanic (p < 0.001)	White: ref Hispanic: NS Black: aHR = 1.16 (1.07, 1.27); p = 0.001
				Secondary patency	40.4 % White; 32.9 % Black; 40.3 % Hispanic (p < 0.001)	White: ref Hispanic: NS Black: aHR = 1.30 (1.18, 1.42); p < 0.001
				Limb salvage	45.3 % White; 42.0 % Black; 40.1 % Hispanic (p < 0.001)	White: ref Hispanic: NS Black: aHR = 1.27 (1.15, 1.40); p < 0.001
				Survival over time	15.3 % White; 29.8 % Black; 32.8 % Hispanic (p < 0.001)	White: ref Hispanic: aHR = 0.67 (0.59, 0.75); p < 0.001 Black: aHR = 0.65 (0.60, 0.71); p < 0.001
Arya et al. [8]	Lower extremity amputation	Black = 25,059 White = 128,564	Median: 5.9 years	Incident amputation	10.7 % Black; 5.3 % White	White: ref Black: aHR = 1.37 (1.30 to 1.45)
				Mortality	38.3 % Black; 40.2 % White	
Brothers et al. [9]	INFRA bypass	African American = 3223 White American = 21,018	Median: 18 (IQR 8–33) months	Overall mortality	10.9 % AA; 19.2 % White (p < 0.001)	White: ref AA: OR = 0.67 (0.59 to 0.77); p < 0.0001
				Perioperative mortality	0.9 % AA; 1.42 % White (p < 0.060)	White: ref AA: NS
	SUPRA bypass	African American = 725 White = 7303		Overall mortality	13.8 % AA; 13.0 % White (p = 0.061)	White: ref AA: NS
				Perioperative mortality	2.5 % AA; 3.3 % White (p = 0.30)	White: ref AA: OR = 0.31 (0.14, 0.64); p = 0.001
	InfraPVI	African American = 8285 White = 39,763		Overall mortality	12.4 % AA; 13.6 % White (p = 0.0042)	White: ref AA: OR = 0.0.68 (0.63, 0.74), p < 0.0001
				Perioperative mortality	0.7 % AA; 0.7 % White (p = 0.46)	White: ref AA: OR = 0.73 (0.53 to 0.99), p = 0.04
	SupraPVI	African American = 2066 White = 19,124		Overall mortality	10.7 % AA; 10.2 % White (p = 0.43)	White: ref AA: OR = 0.74 (0.63, 0.88); p < 0.0004
				Perioperative mortality	1.4 % AA; 0.9 % White (p = 0.085)	White: ref AA: NS
	AMP	African American = 1235 White = 2188		Overall mortality	18.4 % AA; 18.7 % White (p = 0.86)	White: ref AA: NS
				Perioperative mortality	3.2 % AA; 3.6 % White (p = 0.60)	White: ref AA: NS
Hess et al. [19]	Peripheral artery revascularization	Black = 48,780 White = 278,084 Other = 54,551	1 year	1 year inpatient hospitalization for MALE	Black vs. White 14.8 % Black; 10.2 % White; 9.5 % Other	White: ref Black: OR = 1.27 (1.24, 1.31); p < 0.0001
Loja et al. [10]	First-time lower extremity arterial revascularization procedures	Non-Hispanic White = 17,433 Black = 1979 Hispanic = 4417 Asian/Native Hawaiian =	Short term: 30 days	Myocardial infarction within 30 days	0.6 % NHW; 0.7 % Black; 0.8 % Hispanic	–
				Major amputation within 30 days	1.7 % NHW; 6.2 % Black; 5.3 % Hispanic	NHW: ref Black: OR = 1.99 (1.56, 2.55), p < 0.0001

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Table 2 (*continued*)

Study	Intervention	Study group (n)	Follow up	Outcomes	Racial/ethnic differences in outcomes	Associations between race/ethnicity and outcomes (95 % CI)
		1163 Other = 643				Hispanic: OR = 1.50 (1.23 to 1.83), p < 0.0001
				All-cause mortality within 30 days	1.6 % NHW; 1.1 % Black; 2.0 % Hispanic	NHW: ref Black: OR = 0.43 (0.27, 0.67); p = 0.0002 Hispanic: OR = 0.86 (0.66, 1.13); p = 0.28
			Long term: 1 year	Major amputation within 365 days	4.1 % NHW; 13.8 % Black; 14.1 % Hispanic	NHW: ref Black: OR = 1.85 (1.54, 2.12); p < 0.0001 Hispanic: OR = 1.89 (1.66, 2.16); p < 0.0001
				Reintervention within 365 days	32.9 % NHW; 36.6 % Black; 36.0 % Hispanic	NHW: ref Black: OR = 1.17 (1.06, 1.30); p = 0.0002 Hispanic: OR = 1.08 (1.00, 1.16); p = 0.04
				All-cause mortality within 365 days	9.8 % NHW; 12.5 % Black; 12.9 % Hispanic	NHW: ref Black: NS Hispanic: NS
Mehaffey et al. [17]	Lower extremity bypass (LEB), infra-inguinal endovascular intervention (IEI)	White IEI 1497 Non-White 427 IEI White LEB 1465 Non-White LEB 459	30 days	MALE within 30 days	–	White: ref Asian: OR = 0.96 (0.37, 2.49); p = 0.93 Black: OR = 1.21 (0.94, 1.56); p = 0.14
				MACE within 30 days	–	White: ref Asian: OR = 0.31 (0.04–2.31); p = 0.23 Black: OR = 0.52 (0.33–0.81); p = 0.01
				Major amputation	–	White: ref Asian: 0.82 (0.19–3.47); p = 0.78 Black: 1.63 (1.18–2.25); p = 0.003
Newhall et al. [15]	Revascularization procedures	Black = 1,861,061 Non-Black = 14,076,702	Maximum: 24 months following index procedure	Amputation free survival	68.4 % Black; 74.5 % non-Black	–
				Major amputation	5.5 per 1000 Black; 1.9 per 1000 non-Black (p < 0.001)	–
Pandit et al. [11]	Lower extremity amputation	Frail White = 733 African American = 360 Hispanic = 133	Maximum: 3 years	30-day complications	–	White: ref AA: OR = 3.2 (1.90, 4.4); p = 0.01 Non-Hispanic: ref Hispanic: OR = 2.6 (1.9–3.1); p = 0.04
				Mortality	–	White: ref AA: NS Non-Hispanic: ref Hispanic: NS
				30-day readmission	–	White: ref AA: OR = 2.9 (1.8, 3.6), p = 0.03 Non-Hispanic: ref Hispanic: OR = 1.4 (1.10, 2.7); p = 0.025
Parmar et al. [18]	Statin dose prescribed (among patients undergoing surgical or endovascular intervention)	Non-White = 190 White = 298	Median: 2 years	Lower extremity major amputation	–	White: ref Non-white race: HR = 2.1 (1.0, 4.4)
Qato et al. [20]	Peripheral endovascular intervention isolated to the PFA	Race Caucasian = 282 African American = 50 Other = 11 Ethnicity Hispanic = 17 Non-Hispanic = 324	Mean: 13 ± 4.6 months	Primary patency	–	White: ref AA: HR = 2.33 (0.71, 7.62) Others: HR = 2.22 (0.10, 50.55) p = 0.36
				Improvement in symptoms	–	Claudication to asymptomatic vs. unchanged White: ref AA: OR = 0.24 (0.07, 0.80) Others: OR = 0.33 (0.03, 3.40)

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Table 2 (*continued*)

Study	Intervention	Study group (n)	Follow up	Outcomes	Racial/ethnic differences in outcomes	Associations between race/ethnicity and outcomes (95 % CI)
						Claudication to IRP/TL vs. unchanged White: ref AA: OR = 0.64 (0.07, 5.88) Others: 2.94 (0.25, 34.1) IRP to asymptomatic vs. unchanged White: ref AA: OR = 1.26 (0.53, 3.0) Others: OR = 1.21 (0.23, 6.40) IRP/TL to claudication vs. unchanged White: AA: OR = 0.91 (0.21, 3.86) Others: N/A
Rivero et al. [16]	Revascularization or primary amputation	Caucasian (CAU) = 727 African American (AA) = 107	Mean: 38.5 ± 28.9 months	Primary patency Assisted primary patency Secondary patency Limb salvage Overall survival Amputation-free survival MACE-free survival MALE-free survival	65 % AA; 69 % White (p = 0.954) AA vs. white65 % AA; 72 % White (p = 0.751) 83 % AA; 77 % White (p = 0.767) 73 % AA; 83 % White (p = 0.048) 51 % AA; 51 % White (p = 0.771) 34 % AA; 32 % White (p = 0.520) 43 % AA; 46 % White (p = 0.978) 72 % AA; 76 % White (p = 0.189)	
Siracuse et al. [12]	Peripheral endovascular intervention	Caucasian (White) = 858 Non-white = 156	Mean: 745.1 ± 555.6 days	Mortality	–	Ref: White Non-White: HR = 0.48 (0.23, 0.96); p = 0.039
Yang et al. [13]	Open lower extremity bypass	Non-Hispanic White = 1732 Non-Hispanic African American = 488 Hispanic = 161		Mortality	2 % NHW; 2 % NHAA; 2 % Hispanic (p = 0.908)	NHW: ref NH AA: OR = 0.86 (0.43, 1.74) Hispanic: OR = 1.05 (0.37, 2.97)
				Lower extremity amputation	3 % NHW; 8 % NHAA; 4 % Hispanic (p < 0.0001)	NHW: ref NH AA: aOR = 2.80 (1.76, 4.56); p < 0.001 Hispanic: aOR = 1.32 (0.54, 3.18)

AA/NHB ethnicity was associated with increased MALE risk within 30 days of lower extremity bypass surgery and infra-inguinal endovascular interventions, AA/NHB ethnicity was protective for MACE within 30 days of the same interventions [17]. However, there were no notable racial/ethnic differences in 30 day myocardial infarction rates in Loja and colleagues' analysis [10].

3.7. Patency

Three studies reported on differences in limb patency outcomes [14,16,20]. Although Arhuidese et al. noted higher primary and secondary patency percentages after infra-inguinal surgery in Hispanic/Latinx patients and lower percentages, Rivero et al. noted similar percentages in both AA/NHB and NHW patients [14,16]. AA/NHB ethnicity was positively associated with patency rates in Arhuidese et al., but the significance was not observed in Qato et al. [14,20] In addition, AA/NHB ethnicity was a significant predictor of secondary bypass surgery patency, but this was not noted in other studies.

3.8. Risk of bias in studies

The overall methodological quality ranged from 7 to 9, with the median score of 8. The results are provided in Table 3. All 14 studies (100 %) provided adequate explanation for derivation of cohorts and comparison groups, and assessment of outcomes. However, only ten studies (66 %) provided information of adequacy of cohort follow-up. All studies demonstrated adequate representation of exposed cohort, ascertainment of exposure, assessment of outcome, and follow-up.

4. Discussion

Fourteen studies from the systematic review provided racial/ethnic

Table 3
Quality of assessment for reported studies using Newcastle-Ottawa Scale.

Author	Representativeness of the exposed cohort	Selection of nonexposed cohorts	Ascertainment of exposure	Demonstration that outcome of interest not present at the start of the study	Comparability of cohorts on the basis of design or analysis	Assessment of outcome	Was follow-up long enough for outcomes to occur	Adequacy of follow-up of cohorts
Siracuse et al. [12]	1	0	1	1	2	1	1	1
Qato et al. [20]	1	1	1	1	1	1	1	1
Arya et al. [8]	1	0	1	1	2	1	1	1
Alasaad et al. [7]	1	1	1	1	1	1	1	1
Yang et al. [13]	1	0	1	1	2	1	1	1
Newhall et al. [15]	1	1	1	1	2	1	1	0
Brothers et al. [9]	1	0	1	1	2	1	1	1
Rivero et al. [16]	1	0	1	1	2	1	1	0
Loja et al. [10]	1	1	1	1	2	1	1	1
Arhuidese et al. [14]	1	1	1	1	2	1	1	1
Pandit et al. [11]	1	1	1	1	2	1	1	1
Parmar et al. [18]	1	1	1	1	2	1	1	0
Hess et al. [19]	1	1	1	1	2	1	1	0
Mehaffey et al. [17]	1	1	1	1	2	1	1	1

differences in pharmacotherapy and surgical treatment outcomes, with 93 % of the studies reporting surgical outcomes. This review demonstrated that racial/ethnic groups were less likely to experience mortality but remained at high-risk adverse limb and cardiovascular events (Fig. 2). This finding is consistent with a recent analysis by Kalbaugh et al. [21] which noted that AA/NHB and Hispanic/Latinx patients with claudication or CLI experienced increased cumulative incidence of MALE and amputations post-revascularization but were at reduced risk for one-year mortality.

A greater number of the reported studies in this analysis provided outcome differences following surgical interventions, which is consistent with the overarching pattern that US racial/ethnic differences in PAD treatment outcomes are well-documented in surgical compared to lifestyle and pharmacotherapy interventions [2]. Although the AHA/ACC Class I and Class IIa guidelines as well as the Society for Vascular Surgery (SVS) guidelines suggest non-operative statin, antihypertensive, and antiplatelet therapy for initial management [22–24], racial/ethnic diverse populations were more likely to receive surgical interventions due to delayed care and presentation. In addition, they also received suboptimal medication management of comorbidities, which decreased their likelihood of receiving revascularization and increased their likelihood for amputation as treatment [2].

SDOH may explain the decreased pharmacotherapy and increased surgical intervention patterns observed in racial/ethnic groups. Structural racism has contributed to decreased PAD awareness and access to medical care among AA/NHB and Hispanic/Latinx patients. Access to safe exercise spaces, under-diagnosis, atypical symptom presentation, and low education attainment increase barriers to recognizing early onset signs of PAD, including claudication, walking impairment, and ulceration, hence exacerbating the surgical intervention and amputation

Fig. 2. Risk status of outcomes by racial/ethnic groups.

burden [16,25–27,51,52]. Furthermore, NHB patients are likely to experience suboptimal prescription of lipid-lowering statins, antiplatelet, and antihypertensive medications, even though extensive evidence demonstrate impactful risk control and amputation reduction with medication therapy [28–30]. Additionally, major medication therapy clinical trials, such as CAPRIE, EUCLID, VOYAGER [31] and FOURIER [32], have demonstrated risk reduction, mortality benefit, and beneficial treatment outcomes with pharmacotherapy treatments; however, NHB, Hispanic/Latinx and other racial/ethnic groups are not well-represented in these clinical trials and limits for meaningful subgroup analyses. Among patients with diabetes, NHB patients are less likely to achieve adequate glycemic control due to suboptimal antidiabetic medication management but are significantly more likely to experience lower extremity foot ulceration and amputations. Finally, AA/NHB and Hispanic/Latinx patients receiving surgical interventions and amputations are more likely to experience debilitating comorbidities at baseline, subsequent hospitalizations, suboptimal limb salvage outcomes, increased post-operative complications, and perioperative mortality [9,33–37]. While there are associations of SDOH and SES negatively impacting treatment outcomes in racial/ethnic diverse populations compared to non-Hispanic White patients, no studies included in this analysis reported on treatment outcome differences according to social or structural factors. Therefore, future studies should include the impact of specific SDOH and structural factors on PAD treatment outcomes within racial/ethnic diverse populations.

Lifestyle interventions, in addition to surgical and pharmacotherapy treatments, which include risk factor reduction, chronic disease management, and behavioral modifications serves a multimodal purpose in PAD disease management [1]. Although lifestyle intervention studies were included in the search, they were ultimately excluded due to lack of reporting treatment differences and survival outcomes among racial/ethnic populations. These studies primarily commented on subjective symptom improvement and quality of life measures. Nevertheless, evidence from previous studies demonstrates that lifestyle interventions can offer significant symptom change and risk management.

Supervised exercise therapy (SET) can meaningfully enhance walking abilities while also improving pain and quality of life, but they are under recommended by clinicians due to cost-associated barriers. Home-based walking interventions are classified within AHA/ACC Class IIa recommendations, but there is limited efficacy evidence on improving walking and ischemic limb symptoms. In order to better assess leg outcomes and improve walking status, future randomized community-based studies are required, especially among racially/ethnically diverse communities [1]. Furthermore, qualitative research studying approaches to augment physician recommendation and participant interest in SET therapy are necessary, especially since the Centers for Medicare and Medicaid Services has approved coverage of 36 sessions of SET for symptomatic PAD patients over 12 weeks, with authorization and strict supervision from interdisciplinary health care team [38,39]. With regards to smoking cessation, an AHA/ACC class I [40] recommendation for symptomatic PAD treatment, only 16 % of patients in a prior study were referred by physicians to smoking cessation counseling even though 72 % of patients with smoking history at baseline continued smoking long-term [41]. Moreover, AA/NHB patients are equally likely to engage in smoking cessation, but SDOH have negatively influenced smoking abstinence patterns between AA/NHB and NHW patients [42,43].

There exists a paradoxical finding that while racial/ethnic groups experience decreased mortality risk, there is an elevated risk for adverse events, including MALE. One reason for this paradox may be related to racial/ethnic PAD patients initially presenting with significant atherosclerosis and significant symptoms of tissue loss and resting pain, possibly contributed by underdiagnosis and barriers to early recognition [13]. In addition, racial/ethnic patients may present with more significant comorbidities and risk factors that can increase the need for urgent surgical evaluation or amputations and can subsequently increase risk of post-intervention complications. With regards to adverse events post-intervention, racial/ethnic populations experience graft thrombosis or repeat amputations due to disparities in health care access to effectively manage long-term sequelae of CVD comorbidities and risk factors, thus further negatively contributing to PAD treatment outcomes [13]. Despite the reasoning, future studies are necessary to understand the significant difference in mortality compared to adverse events in racial/ethnic diverse populations treated for PAD.

While disparities in treatment outcomes exist for AA/NHB and Hispanic/Latinx populations, similar quality and quantity of data does not exist in American Indian (AI)/Alaska Native (AN) adults, Asian/Pacific Islander, and other racial/ethnic groups. In this analysis, only five studies (33 %) reported demographics data on other race/ethnicities and one study (6.6 %) reported on Asian race/ethnicity; two studies (13.33 %) reported outcomes on Asians and other ethnicities. Asian-Americans/Native Hawaiians, American Indians (AI)/Alaskan Natives (AN), and other race/ethnicities were significantly underrepresented in this review, even though PAD prevalence in these communities is also gradually increasing in adults age > 60 [4]. Therefore, future studies need to detail overall survival, mortality, and risk of adverse events to different treatment modalities in Asian-Americans/Native Hawaiians, AI/AN, and other underrepresented race/ethnicities. In addition, a few studies in this analysis categorized racial/ethnic diverse populations to the non-white category and provided minimal information on the constituents categorized in this subgroup. While this review uses culturally conscious terminology, future studies and guidelines need to standardize representation of different racial/ethnic populations given the disparate lifetime PAD risk, treatment outcomes, and mortality [2,44].

Limitations were noted in this study. First, only studies conducted in the US were identified and analyzed in this review. Majority of the studies in the comprehensive search were completed outside of the US and ultimately excluded. Most clinical trials evaluating PAD treatment interventions were performed in European cohorts or global multicenter trials and therefore did not provide comprehensive subgroup demographics and analyses of race/ethnicity specific outcomes. Second, among studies completed in the US, most did not include a significantly large racially/ethnically participant cohort and therefore may misrepresent the true outcome differences for the studied treatment modalities. Third, findings from this review are only limited to data from retrospective analyses and are consistent with a recent statement that PAD guidelines are being driven from retrospective cohort analyses or subgroup analyses from major ASCVD clinical trials [1]. Fourth, although general sex-differences exist in PAD [56], there is limited data available in this analysis on sex and race/ethnicity-stratified outcomes for surgery and pharmacotherapy.

Despite numerous gaps, there are critical avenues for improvement in understanding PAD in racially/ethnically groups. These avenues include designing accessible home-based exercise therapies, identifying outcomes gaps in open versus endovascular interventions, conducting community-based studies on lower extremity outcomes, and including diverse US racial/ethnic populations to examine outcomes in all PAD studies [1]. A recent review of novel endovascular procedures has demonstrated that atherectomy, a debulking procedure that removes arterial plaques, and Intravascular lithotripsy (IVL) improved primary limb patency in patients with claudication and CLI. However, future randomized clinical studies are necessary in large samples to better demonstrate longitudinal impacts on symptom change and calcification management [45].

Moreover, community-based studies examining walking performance in racially/ethnically diverse communities have observed that AA/NHB patients receiving patient-centered assessment and counseling experienced an increase in mean walking distance at 12 months [46]. However, more studies are necessary to ascertain if demographic or clinical factors better predict response to walking and exercise therapy [47]. Alternative approaches to exercise interventions, such as arm and leg ergometry, have also demonstrated the ability to improve overall

walking distance and cardiovascular fitness from baseline to the completion of trials [48]. Given that there exist avenues for public health interventions to bolster early disease recognition and management in racial/ethnic communities, these community-based interventions can be integrated with robust community education modules. Integrated health education approaches can provide communities with tools to increase PAD awareness, identify signs and symptoms, evaluate for and manage risk factors, address barriers to care, and connect communities with appropriate healthcare resources. These approaches may help to prevent severe PAD progression prior to receiving appropriate medical care.

Another approach to addressing racial/ethnic disparities in PAD treatment outcomes is to focus on comprehensive wound care. Recently, there has been an emergence of comprehensive wound care clinics that have facilitated follow-up care after PAD revascularization or surgical interventions. Research from outpatient wound care clinics have demonstrated a significant increase in surgical debridement, revascularizations, and limb preservation, with probable mechanisms being attributed to expanded community presence and increased physician collaboration [53]. In addition, comprehensive wound care clinics have demonstrated significant ability to decrease major amputations and increased wound healing but had no difference on all-cause mortality [53,54]. With regards to wound care, an aggressive wound care regimen paired with nerve block and skin grafting along with daily dressing change with disinfection and irrigation, occasional surgical debridement, and negative pressure wound therapy yielded significant differences in freedom from amputation and overall healing [55].

Finally, certain ASCVD biomarkers, such as lipoprotein(a) [Lp(a)], should be examined more thoroughly since Lp(a) is a strong independent predictor of PAD risk [49]. Currently, there are no approved Lp(a) lowering drugs that exist, but one hepatocyte-directed antisense oligonucleotide, APO(a)-L_{Rx}, has shown promising results Lp(a) reduction in established CVD and needs to be further studied for PAD treatment [50].

5. Conclusion

Overall, disparities exist between racially/ethnically diverse populations with PAD as it pertains to pharmacotherapy and surgical outcomes. This study provides a synthesis of all studies analyzing differences in treatment-based survival and adverse events in racial/ethnic diverse populations. A larger proportion of the studies in this review reported racial/ethnic disparities in PAD treatment and these patient subgroups experience adverse events; however, racial/ethnic diverse populations are less likely to experience increased mortality risk. Therefore, targeted research studies are necessary to better understand early PAD management, reduction of adverse events, implementing community-driven interventions for symptom reduction. The results of this study carry important implications for public health and medical interventions to reconcile racial/ethnic disparities in PAD treatment outcomes.

CRediT authorship contribution statement

Saihariharan Nedunchezhian: Conceptualization, Methodology, Data curation, Writing-Original draft, Writing-Review and editing
Tina Reddy: Methodology, Data curation, Writing-Original draft, Writing-Review and editing
Madeline Wegener: Writing-Original draft, Writing-Review and editing
Samantha O'Connell: Validation, Data curation, Writing-Original draft, Writing-Review and editing
Dr. Keith C. Ferdinand: Writing-Original draft, Writing-Review and editing, Supervision.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Dr. Ferdinand is a consultant for Amgen, Novartis, Pfizer, Medtronic, Boehringer-Ingelheim, and Janssen.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ahjo.2022.100179.

References

[1] M.H. Criqui, K. Matsushita, V. Aboyans, et al., Lower extremity peripheral artery disease: contemporary epidemiology, management gaps, and future directions: a scientific statement from the American Heart Association [published correction appears in Circulation. 2021 Aug 31;144(9):e193], Circulation 144 (9) (2021) e171–e191, https://doi.org/10.1161/CIR.0000000000001005.
[2] E.L. Hackler 3rd, N.M. Hamburg, K.T. White Solaru, Racial and ethnic disparities in peripheral artery disease, Circ. Res. 128 (12) (2021) 1913–1926, https://doi.org/10.1161/CIRCRESAHA.121.318243.
[3] K. Matsushita, Y. Sang, H. Ning, et al., Lifetime risk of lower-extremity peripheral artery disease defined by ankle-brachial index in the United States, J. Am. Heart Assoc. 8 (18) (2019), e012177, https://doi.org/10.1161/JAHA.119.012177.
[4] C.W. Tsao, A.W. Aday, Z.I. Almarzooq, et al., Heart disease and stroke statistics-2022 update: a report from the American Heart Association [published online ahead of print, 2022 Jan 26], Circulation (2022), https://doi.org/10.1161/CIR.0000000000001052.
[5] A. Liberati, D.G. Altman, J. Tetzlaff, et al., The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration, PLoS Med. 6 (2009) e1000100–e1000134.
[6] M. Oremus, C. Oremus, G.B. Hall, M.C. McKinnon, ECT, team CSR: interrater and test–retest reliability of quality assessments by novice student raters using the jadad and Newcastle-Ottawa scales, BMJ Open 2 (2012), e001368.
[7] M. Alasaad, A. Zaitoun, S. Szpunar, et al., Association of race with long-term outcomes in patients undergoing popliteal and infra-popliteal percutaneous peripheral arterial interventions, Cardiovasc. Revasc. Med. 20 (8) (2019) 649–653, https://doi.org/10.1016/j.carrev.2018.10.014.
[8] S. Arya, Z. Binney, A. Khakharia, et al., Race and socioeconomic status independently affect risk of major amputation in peripheral artery disease, J. Am. Heart Assoc. 7 (2) (2018), https://doi.org/10.1161/jaha.117.007425.
[9] T.E. Brothers, J. Zhang, P.D. Mauldin, et al., Better survival for African and Hispanic/Latino Americans after infrainguinal revascularization in the Society for Vascular Surgery Vascular Quality initiative, J. Vasc. Surg. 65 (4) (2017) 1062–1073, https://doi.org/10.1016/j.jvs.2016.10.105.
[10] M.N. Loja, A. Brunson, C.-S. Li, et al., Racial disparities in outcomes of endovascular procedures for peripheral arterial disease: an evaluation of California hospitals, 2005–2009, Ann. Vasc. Surg. 29 (5) (2015) 950–959, https://doi.org/10.1016/j.avsg.2015.01.006.
[11] V. Pandit, P. Nelson, K. Kempe, et al., Racial and ethnic disparities in lower extremity amputation: assessing the role of frailty in older adults, Surgery 168 (6) (2020) 1075–1078, https://doi.org/10.1016/j.surg.2020.07.015.
[12] J.J. Siracuse, K. Van Orden, J.A. Kalish, et al., Endovascular treatment of the common femoral artery in the vascular quality initiative, J. Vasc. Surg. 65 (4) (2017) 1039–1046, https://doi.org/10.1016/j.jvs.2016.10.078.
[13] Y. Yang, E.B. Lehman, F. Aziz, African americans are at a higher risk for limb loss but not mortality after lower extremity bypass surgery, Ann. Vasc. Surg. 58 (2019) 63–77, https://doi.org/10.1016/j.avsg.2019.01.004.
[14] I. Arhuidese, S. Wang, S. Locham, M. Faateh, B. Nejim, M. Malas, Racial disparities after infrainguinal bypass surgery in hemodialysis patients, J. Vasc. Surg. 66 (4) (2017) 1163–1174, https://doi.org/10.1016/j.jvs.2017.04.044.
[15] K. Newhall, E. Spangler, N. Dzebisashvili, D.C. Goodman, P. Goodney, Amputation rates for patients with diabetes and peripheral arterial disease: The effects of race and Region, Ann. Vasc. Surg. 30 (2016).
[16] M. Rivero, N.D. Nader, R. Blochle, L.M. Harris, M.L. Dryjski, H.H. Dosluoglu, Poorer limb salvage in african american men with chronic limb ischemia is due to advanced clinical stage and higher anatomic complexity at presentation, J. Vasc. Surg. 63 (5) (2016) 1318–1324, https://doi.org/10.1016/j.jvs.2015.11.052.
[17] J.H. Mehaffey, R.B. Hawkins, A. Fashandi, et al., Lower extremity bypass for critical limb ischemia decreases major adverse limb events with equivalent cardiac risk compared with endovascular intervention, J. Vasc. Surg. 66 (4) (2017), https://doi.org/10.1016/j.jvs.2017.04.036.
[18] G.M. Parmar, Z. Novak, E. Spangler, et al., Statin use improves limb salvage after intervention for peripheral arterial disease, J. Vasc. Surg. 70 (2) (2019) 539–546, https://doi.org/10.1016/j.jvs.2018.07.089.
[19] C.N. Hess, R.K. Rogers, T.Y. Wang, et al., Major adverse limb events and 1-year outcomes after peripheral artery revascularization, J. Am. Coll. Cardiol. 72 (9) (2018) 999–1011, https://doi.org/10.1016/j.jacc.2018.06.041.

[20] K. Qato, N. Nguyen, V. Bouris, et al., Outcomes of endovascular management of isolated profunda femoris artery occlusive disease, Ann. Vasc. Surg. 72 (2021) 244–252, https://doi.org/10.1016/j.avsg.2020.08.138.
[21] C.A. Kalbaugh, B. Witrick, L.B. Sivaraj, et al., Non-hispanic black and hispanic patients have worse outcomes than white patients within similar stages of peripheral artery disease, J. Am. Heart Assoc. 11 (1) (2022), e023396, https://doi.org/10.1161/JAHA.121.023396.
[22] P.A. Soden, S.L. Zettervall, K.E. Shean, A.G. Vouyouka, P.P. Goodney, J.L. Mills, J. W. Hallett, M.L. Schermerhorn, Society for Vascular Surgery Vascular Quality Initiative. Regional variation in outcomes for lower extremity vascular disease in the vascular quality initiative, J.Vasc. Surg. 66 (810–818) (2017), https://doi.org/10.1016/j.jvs.2017.01.061.
[23] M.S. Conte, F.B. Pomposelli, Society for Vascular Surgery practice guidelines for atherosclerotic occlusive disease of the lower extremities management of asymptomatic disease and claudication. Introduction, J. Vasc. Surg. 61 (3 suppl) (2015) 1S, https://doi.org/10.1016/j.jvs.2014.12.006.
[24] M.D. Gerhard-Herman, H.L. Gornik, C. Barrett, N.R. Barshes, M.A. Corriere, D. E. Drachman, L.A. Fleisher, F.G. Fowkes, N.M. Hamburg, S. Kinlay, et al., 2016 AHA/ACC guideline on the management of patients with lower extremity peripheral artery disease: a report of the American College of Cardiology/American Heart Association task force on clinical practice guidelines, Circulation 135 (2017) e726–e779, https://doi.org/10.1161/CIR.0000000000000471.
[25] E.P. Havranek, M.S. Mujahid, D.A. Barr, I.V. Blair, M.S. Cohen, S. Cruz-Flores, G. Davey-Smith, C.R. Dennison-Himmelfarb, M.S. Lauer, D.W. Lockwood, et al., American Heart Association Council on Quality of Care and Outcomes Research, Council on Epidemiology and Prevention, Council on Cardiovascular and Stroke Nursing, Council on Lifestyle and Cardiometabolic Health, and Stroke Council. Social determinants of risk and outcomes for cardiovascular disease: a scientific statement from the American Heart Association, Circulation 132 (2015) 873–898, https://doi.org/10.1161/CIR.0000000000000228.
[26] A.J. Henry, N.D. Hevelone, M. Belkin, L.L. Nguyen, Socioeconomic and hospital-related predictors of amputation for critical limb ischemia, J. Vasc. Surg. 53 (2011) 330–339, https://doi.org/10.1016/j.jvs.2010.08.077, e1.
[27] A.T. Hirsch, T.P. Murphy, M.B. Lovell, G. Twillman, D. Treat-Jacobson, E. M. Harwood, E.R. Mohler, M.A. Creager, R.W. Hobson, R.M. Robertson, et al., Peripheral arterial disease coalition. Gaps in public knowledge of peripheral arterial disease: the first national PAD public awareness survey, Circulation 116 (2007) 2086–2094, https://doi.org/10.1161/CIRCULATIONAHA.107.725101.
[28] M.P. Dorsch, C.A. Lester, Y. Ding, M. Joseph, R.D. Brook, Effects of race on statin prescribing for primary prevention with high atherosclerotic cardiovascular disease risk in a large healthcare system, J. Am. Heart Assoc. 8 (2019), e014709, https://doi.org/10.1161/JAHA.119.014709.
[29] T.A. Meadows, D.L. Bhatt, A.T. Hirsch, M.A. Creager, R.M. Califf, E.M. Ohman, C. P. Cannon, K.A. Eagle, M.J. Alberts, S. Goto, et al., REACH registry investigators. Ethnic differences in the prevalence and treatment of cardiovascular risk factors in US outpatients with peripheral arterial disease: insights from the reduction of atherothrombosis for continued health (REACH) registry, Am. Heart J. 158 (1038–1045) (2009), https://doi.org/10.1016/j.ahj.2009.09.014.
[30] R.L. Pande, T.S. Perlstein, J.A. Beckman, M.A. Creager, Secondary prevention and mortality in peripheral artery disease: National Health and nutrition examination study, 1999 to 2004, Circulation 124 (2011) 17–23, https://doi.org/10.1161/CIRCULATIONAHA.110.003954.
[31] E.S. Debus, M.R. Nehler, N. Govsyeyev, et al., Effect of rivaroxaban and aspirin in patients with peripheral artery disease undergoing surgical revascularization: insights from the VOYAGER PAD trial, Circulation 144 (14) (2021) 1104–1116, https://doi.org/10.1161/CIRCULATIONAHA.121.054835.
[32] M.S. Sabatine, R.P. Giugliano, A.C. Keech, et al., Evolocumab and clinical outcomes in patients with cardiovascular disease, N. Engl. J. Med. 376 (18) (2017) 1713–1722, https://doi.org/10.1056/NEJMoa1615664.
[33] K.H. Holman, P.K. Henke, J.B. Dimick, J.D. Birkmeyer, Racial disparities in the use of revascularization before leg amputation in medicare patients, J.Vasc. Surg. 54 (420–426) (2011) 426.e1, https://doi.org/10.1016/j.jvs.2011.02.035.
[34] K. Newhall, E. Spangler, N. Dzebisashvili, D.C. Goodman, P. Goodney, Amputation rates for patients with diabetes and peripheral arterial disease: the effects of race and region, Ann. Vasc. Surg. 30 (2016) 292–298, https://doi.org/10.1016/j.avsg.2015.07.040, e1.
[35] S. Selvarajah, J.H. Black, A.H. Haider, C.J. Abularrage, Racial disparity in early graft failure after infrainguinal bypass, J. Surg. Res. 190 (335–343) (2014), https://doi.org/10.1016/j.jss.2014.04.029.
[36] B. Nejim, R.J. Beaulieu, H. Alshaikh, M. Hamouda, J. Canner, M.B. Malas, A unique all-payer rate-setting system controls the cost but not the racial disparity in lower extremity revascularization procedures, Ann. Vasc. Surg. 52 (116–125) (2018), https://doi.org/10.1016/j.avsg.2018.03.013.
[37] J.A. Rizzo, J. Chen, C. Laurich, A. Santos, B.J. Martinsen, M.P. Ryan, H. Kotlarz, C. Gunnarsson, Racial disparities in PAD-related amputation rates among native Americans and non-Hispanic whites: an HCUP analysis, J. Health Care Poor Underserved 29 (2018) 782–800, https://doi.org/10.1353/hpu.2018.0058.
[38] T.S. Jensen, J. Chin, L. Ashby, J. Schafer, D. Dolan, National Coverage Determination for Supervised Exercise Therapy (SET) for Symptomatic Peripheral Artery Disease (PAD), Centers for Medicare & Medicaid Services, 2017.
[39] A. Dua, R. Gologorsky, D. Savage, et al., National assessment of availability, awareness, and utilization of supervised exercise therapy for peripheral artery disease patients with intermittent claudication, J. Vasc. Surg. 71 (5) (2020) 1702–1707, https://doi.org/10.1016/j.jvs.2019.08.238.
[40] M.D. Gerhard-Herman, H.L. Gornik, C. Barrett, et al., 2016 AHA/ACC guideline on the management of patients with lower extremity peripheral artery disease: a report of the american College of Cardiology/American Heart Association task force on clinical practice guidelines, Circulation 135 (12) (2017) e726–e779, https://doi.org/10.1161/CIR.0000000000000471.
[41] K.K. Patel, P.G. Jones, E.F. Ellerbeck, D.M. Buchanan, P.S. Chan, C.M. Pacheco, G. Moneta, J.A. Spertus, K.G. Smolderen, Underutilization of evidence-based smoking cessation support strategies despite high smoking addiction burden in peripheral artery disease specialty care: insights from the International PORTRAIT Registry, J. Am. Heart Assoc. 7 (2018), e010076, https://doi.org/10.1161/JAHA.118.010076.
[42] J.A. Kulak, M.E. Cornelius, G.T. Fong, G.A. Giovino, Differences in quit attempts and cigarette smoking abstinence between Whites and African Americans in the United States: literature review and results from the international tobacco control US survey, Nicotine Tob. Res. 18 (suppl 1) (2016) S79–S87, https://doi.org/10.1093/ntr/ntv228.
[43] N.L. Nollen, M.S. Mayo, L. Sanderson Cox, N.L. Benowitz, R.F. Tyndale, E. F. Ellerbeck, T.S. Scheuermann, J.S. Ahluwalia, Factors that explain differences in abstinence between black and white smokers: a prospective intervention study, J. Natl. Cancer Inst. 111 (1078–1087) (2019), https://doi.org/10.1093/jnci/djz001.
[44] A. Flanagin, T. Frey, S.L. Christiansen, AMA manual of style committee. Updated guidance on the reporting of race and ethnicity in medical and science journals, JAMA 326 (7) (2021) 621–627, https://doi.org/10.1001/jama.2021.13304.
[45] K.M. Sanders, P.A. Schneider, M.S. Conte, J.C. Iannuzzi, Endovascular treatment of high-risk peripheral vascular occlusive lesions: a review of current evidence and emerging applications of intravascular lithotripsy, atherectomy, and paclitaxel-coated devices, Semin. Vasc. Surg. 34 (4) (2021) 172–187, https://doi.org/10.1053/j.semvascsurg.2021.10.009.
[46] T.C. Collins, L. Lu, J.S. Ahluwalia, et al., Efficacy of community-based exercise therapy among African American patients with peripheral artery disease, JAMA Netw. Open 2 (2) (2019), https://doi.org/10.1001/jamanetworkopen.2018.7959.
[47] K. Patel, T.S. Polonsky, M.R. Kibbe, et al., Clinical characteristics and response to supervised exercise therapy of people with lower extremity peripheral artery disease, J. Vasc. Surg. 73 (2) (2021) 608–625, https://doi.org/10.1016/j.jvs.2020.04.498.
[48] T.S. Polonsky, M.M. McDermott, Lower extremity peripheral artery disease without chronic limb-threatening ischemia: a review, JAMA 325 (21) (2021) 2188–2198, https://doi.org/10.1001/jama.2021.2126.
[49] C.E. Kosmas, D. Silverio, A. Sourlas, et al., Role of lipoprotein (a) in peripheral arterial disease, Ann. Transl. Med. 7 (Suppl 6) (2019) S242, https://doi.org/10.21037/atm.2019.08.77.
[50] S. Tsimikas, E. Karwatowska-Prokopczuk, I. Gouni-Berthold, et al., Lipoprotein(a) reduction in persons with cardiovascular disease, N. Engl. J. Med. 382 (3) (2020) 244–255, https://doi.org/10.1056/NEJMoa1905239.
[51] L. Chen, D. Zhang, L. Shi, C.A. Kalbaugh, Disparities in peripheral artery disease hospitalizations identified among understudied race-ethnicity groups, Front. Cardiovasc. Med. 24 (8) (2021), 692236, https://doi.org/10.3389/fcvm.2021.692236. PMID: 34109228; PMCID: PMC8180581.
[52] D.K. Chew, L.L. Nguyen, C.D. Owens, M.S. Conte, A.D. Whittemore, E. C. Gravereaux, M.T. Menard, M Belkin, Comparative analysis of autogenous infrainguinal bypass grafts in African Americans and Caucasians: the association of race with graft function and limb salvage, J. Vasc. Surg. 42 (4) (2005) 695–701, https://doi.org/10.1016/j.jvs.2005.06.012.
[53] M.A. Eid, K.S. Mehta, P.P. Goodney, Epidemiology of peripheral artery disease, Semin. Vasc. Surg. 34 (1) (2021) 38–46, https://doi.org/10.1053/j.semvascsurg.2021.02.005.
[54] A.M. Flores, M.W. Mell, R.L. Dalman, V. Chandra, Benefit of multidisciplinary wound care center on the volume and outcomes of a vascular surgery practice, J. Vasc. Surg. 70 (5) (2019) 1612–1619, https://doi.org/10.1016/j.jvs.2019.01.087.
[55] S. Mii, K. Tanaka, R. Kyuragi, et al., Aggressive wound care by a multidisciplinary team improves wound healing after infrainguinal bypass in patients with critical limb ischemia, Ann. Vasc. Surg. 41 (2017) 196–204, https://doi.org/10.1016/j.avsg.2016.09.024.
[56] S. Kim, A.A. Pendleton, K.L. McGinigle, Women's vascular health: peripheral artery disease in female patients, Semin. Vasc. Surg. 35 (2) (2022) 155–161, https://doi.org/10.1053/j.semvascsurg.2022.04.006.