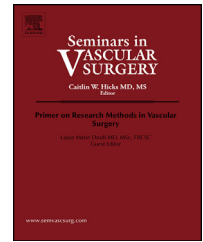


Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/semvascsurg

Review article

A review of disparities in peripheral artery disease and diabetes-related amputations during the COVID-19 pandemic

Laura Pride^{a,1}, Mahmood Kabeil^{b,1}, Olamide Alabi^c, Samantha D. Minc^d,
Foluso A. Fakorede^e, Lyssa N. Ochoa^f, A. Sharee Wright^g,
Max V. Wohlauer^{b,*}

^a Augusta University/University of Georgia Medical Partnership, Athens, GA

^b Division of Vascular Surgery, University of Colorado Anschutz Medical Campus, Aurora, CO

^c Division of Vascular Surgery and Endovascular Therapy, Emory University School of Medicine, Atlanta, GA

^d Division of Vascular and Endovascular Surgery, Department of Cardiovascular and Thoracic Surgery, School of Medicine, Department of Occupational Health and Environmental Sciences, School of Public Health, West Virginia University, Morgantown, WV

^e Cardiovascular Solutions of Central Mississippi, Cleveland, MS

^f San Antonio Vascular and Endovascular Clinic, San Antonio, TX

^g Division of Vascular Surgery, Medical University of South Carolina, Charleston, SC

ARTICLE INFO

Article history:

Available online xxx

ABSTRACT

The COVID-19 pandemic has profoundly affected health care delivery. In addition to the significant morbidity and mortality associated with acute illness from COVID-19, the indirect impact has been far-reaching, including substantial disruptions in chronic disease care. As a result of pandemic disruptions in health care, vulnerable and minority populations have faced health inequalities. The aim of this review was to investigate how the COVID-19 pandemic has impacted vulnerable populations with limb-threatening peripheral artery disease and diabetic foot infections.

© 2022 Elsevier Inc. All rights reserved.

1. Introduction

As of October of 2022, more than 1 million people have died from COVID-19 (SARS-CoV-2) across the United States [1]. In addition to the substantial morbidity and mortality associated with acute illness from COVID-19, the indi-

rect impact has been far-reaching, with significant disruptions in chronic disease care, including diabetes and peripheral artery disease (PAD). Racial and ethnic minority communities have been underserved by our health care systems and experience higher prevalence and severity of chronic disease, with greater associated morbidity [2,3]. The COVID-19 pandemic has intensified these existing racial

* Corresponding author.

E-mail address: max.wohlauer@cuanschutz.edu (M.V. Wohlauer).

¹ These authors contributed equally to this work as co-first authors.

<https://doi.org/10.1053/j.semvascsurg.2022.12.002>

0895-7967/\$ – see front matter © 2022 Elsevier Inc. All rights reserved.

Please cite this article as: Laura Pride, Mahmood Kabeil, Olamide Alabi et al., A review of disparities in peripheral artery disease and diabetes-related amputations during the COVID-19 pandemic, *Seminars in Vascular Surgery*, <https://doi.org/10.1053/j.semvascsurg.2022.12.002>

disparities, as evidenced by higher rates of infection, hospitalization, and death rates among non-White individuals [4]. According to early US reports during the pandemic, COVID-19 disproportionately affected Black populations with higher mortality rates, a concerning pattern seen across the country [5].

PAD is a common, complex, chronic condition with a broad spectrum of severity for which management has suffered in the wake of COVID-19, with resultant increases in amputation rates and mortality. Chronic limb-threatening ischemia (CLTI) describes PAD with lower limb rest pain, gangrene, or a lower limb ulcer that has been present for more than 2 weeks [6]. Diabetes is prevalent in the United States, affecting more than 10% of the United States population [7]. The presence of diabetes is independently associated with mortality from cardiovascular disease [8]. In addition, patients with poorly controlled diabetes are more likely to have ischemic vascular changes, which accelerates the disease process and increases risk of amputation [9]. Despite efforts to lower the number of amputations in the United States, rates have remained stable in patients with diabetes and PAD [10].

A well-described example of disparate health outcomes is the disproportionately higher rate of lower extremity amputation experienced by Black, Hispanic and Latino, American Indian and Alaskan Natives, and indigenous communities with PAD, as well as diabetes, despite accounting for confounding factors like socioeconomic status, comorbidities, and advanced disease [3,9,11,12]. In addition, American Indian and Alaskan Native populations have a lower rate of revascularization procedures, despite their increased risk of amputation compared with other racial and ethnic minority groups [12].

To date, there are few published reports on the impact of COVID-19 on PAD and diabetes management and resultant amputation rates among vulnerable communities. In this review, we seek to better understand contributing factors leading to the increase in overall amputation rates and describe possible approaches to mitigate the uneven burden of disease experienced by these populations.

2. Methods

The following databases were queried: PubMed (pubmed.gov November 2019 to search date), Embase (embase.com November 2019 to search date), and Web of Science (webofscience.com November 2019 to search date) using search terms discussed and agreed upon by all co-authors, including “COVID-19,” “SARS-CoV-2,” “peripheral arterial disease,” “chronic limb-threatening ischemia,” “peripheral vascular diseases,” “diabetic foot,” “rural population,” “rural health services,” “rurality,” “remote,” “geographic minority,” and “amputation.” The authors developed the search strategies, which are outlined in Table 1, in collaboration with a librarian.

Filtering for references from November 2019 to October 2022, full-length publications with original data were included. All retrieved records were de-duplicated and organized using the Covidence platform (Veritas Health Innovation Ltd), a web-based collaboration software platform that streamlines the production of systematic and other literature reviews [13]. The initial search resulted in 374 references. Two

co-authors (L.P., M.K.) worked on screening all of the retrieved articles, and a senior co-author (M.V.W.) resolved conflicts. After de-duplication, 374 total unique citations underwent a two-stages screening process. After screening titles and abstracts for relevance, 31 articles were included for a full-text review. Four articles were added from cross-referencing and 10 articles were excluded (survey or questionnaire data, case reports and case series, correspondences, literature reviews, research letters, or editorials reports, or amputation rate not reported).

The Covidence platform [13] was also used to calculate inter-rater reliability, which showed 82% proportionate agreement and 29% Cohen’s kappa coefficient for the abstract screening. For the full-text selection, proportionate agreement was 93.5% (near-perfect agreement), and Cohen’s kappa coefficient was 83% (substantial agreement). This systematic review follows the recommendations from the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement. A Preferred Reporting Items for Systematic Reviews and Meta-Analyses diagram of this process is shown in Figure 1, and the publications outlined in Table 2.

In total, 25 articles were included in this review: 14 studies reported on the impact of COVID-19 on PAD amputation rates and 11 reported on the impact on diabetic foot care and diabetes-related amputations during the pandemic. The search was expanded internationally due to the paucity of data on the subject in the United States. Five studies were conducted in Italy, three in the United States, two in Turkey, two in the United Kingdom, two in the Netherlands, one in Jordan, one in Brazil, one in Canada, one in China, one in Germany, one in Indonesia, one in Israel, one in Mexico, one in Poland, one in Switzerland, and one in the United States and Canada. The screening was conducted using Covidence (a web-based collaboration software platform that streamlines the production of systematic and other literature reviews) [13].

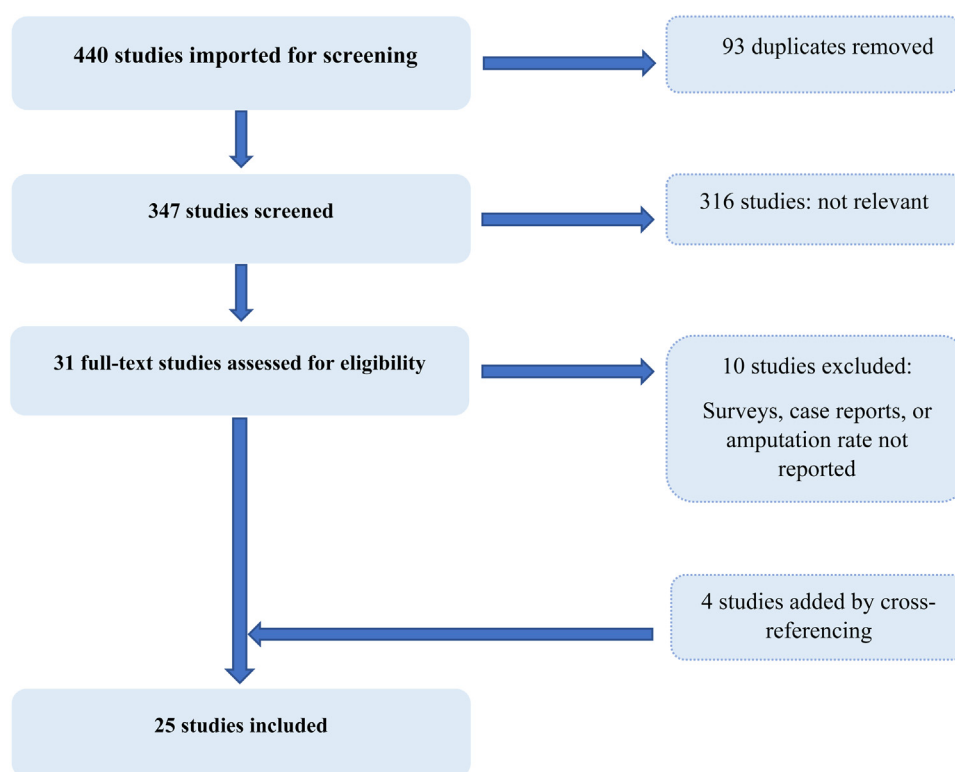
3. Results

3.1. Disruptions in chronic disease management

COVID-19 disrupted the management of chronic disease around the world. Redistribution of care and resources for pandemic relief efforts, suspension of screening and annual health maintenance visits, and diverting staff to areas of acute need compromised primary care [39,40]. Risk factors for severe disease and poor outcomes with COVID-19 are known to include several chronic health conditions, such as diabetes, hypertension, and autoimmune conditions, as well as cardiovascular and chronic respiratory disease, outlining the importance of optimizing management during the pandemic. As a result of stay-at-home orders implemented early in the pandemic, outpatient visits of all types were reduced across the United States. Cortez et al. [41] performed a cross-sectional analysis of changes in outpatient practices across the United States between using nationally representative audit data from the National Disease and Therapeutic Index. When examining ambulatory care visits within this dataset, the authors found major declines in total preventive care visits (in-person and virtual) between quarters 2 and 4 of 2020 (–21.6%

Table 1 – Search strategies.

Variable	COVID-19	Peripheral arterial disease	Rural	Amputation	Racial and ethnic groups
Search terms	COVID-19 Coronavirus disease 2019 2019 novel coronavirus SARS-CoV-2	Peripheral arterial disease Chronic limb-threatening ischemia Peripheral vascular diseases Diabetic foot	Rural population Rural health care Rural area Remote area Minority group	Amputation	Population Groups Ethnic, racial and religious groups
Combined search strings	(COVID-19) AND (Peripheral Arterial Disease) AND (Amputation) (COVID-19) AND (Peripheral Arterial Disease) AND (Rural) (COVID-19) AND (Peripheral Arterial Disease) AND (Racial and ethnic groups)				

**Fig. 1 – A Preferred Reporting Items for Systematic Reviews and Meta-Analyses diagram of the search method.**

and –47.3%, respectively) compared with those from the 2 years prior, despite substantial increases in telemedicine visits during this period. When stratifying between the type of visit during quarter 2 and 4 of 2020, they also found overall decreases in primary (–16.6% and –22.3%, respectively), specialty (–9.4% and –21.8%, respectively), and surgical (–11.4% and –38.1%, respectively) care visits compared with visits during 2018 and 2019 [41].

Diabetes is a significant risk factor for severe COVID-19 illness. A study by Wright et al. [40] used rates of low-density lipoprotein and hemoglobin A1c testing, as well as new prescriptions for statins and metformin as surrogates for primary care activity within two large health care institutions in the Eastern United States. They found that between February and

March of 2020, laboratory testing and new prescriptions fell by 81% to 90% and by 52% to 60%, respectively [40]. Similarly, a large population-based cohort study in Ontario, Canada, including records from nearly 1.5 million patients, revealed a 28% decrease in outpatient diabetes-related visits, with an associated 41% drop in hemoglobin A1c measurements compared with the year prior [30].

The alterations in chronic care delivery have unevenly affected low-income, rural, and minority populations [42]. Chronic conditions known to be risk factors for severe COVID-19 illness are overrepresented in minority populations, contributing to the disproportionate impact of COVID-19 on these communities [43,44]. According to Centers for Disease Control and Prevention data, since December 2020, the highest cumu-

Table 2 – Study design.

First author, year	Country	Type of study
Schmidt, 2020 [14]	United States	Longitudinal study, EMR review, single-center
Liu, 2020 [15]	China	Retrospective cohort study, EMR review
Casciato, 2020 [16]	Ohio, United States	Retrospective cohort study, single-center
Caruso, 2020 [17]	Italy	Retrospective cohort study, single-center
Mascia, 2020 [18]	Italy	Prospective cohort study, single-center
Lancaster, 2020 [19]	California, United States	Retrospective cohort study, single-center
Musajee, 2022 [20]	United Kingdom	Retrospective cohort study, single-center
Piazza, 2021 [21]	Italy	Retrospective cohort study, single-center
Scheurig-Muenkler, 2022 [22]	Germany	Retrospective cohort study, multi-center
Aljarrah, 2021 [23]	Jordan	Retrospective cohort study, chart review
Lou, 2021 [24]	United States and Canada	Retrospective cohort study, VQI registry
Schuijvens, 2020 [25]	Netherlands	Retrospective study, single-center
Stabile, 2021 [26]	Italy	Cross-sectional study, multi-center
Trunfio, 2021 [27]	Switzerland	Retrospective cohort study, single-center
Yunir, 2022 [28]	Indonesia	Retrospective cohort study, single-center
Lozano-Corona, 2022 [29]	Mexico	Retrospective cohort study, single-center
de Mestral, 2022 [30]	Canada	Population-based cohort study
Ergişi, 2022 [31]	Turkey	Retrospective cohort study, single-center
Kendirici, 2022 [32]	Turkey	Retrospective cohort study, chart review
Rubin, 2023 [33]	Israel	Retrospective cohort study, single-center
Kleibert, 2022 [34]	Poland	Retrospective cohort study, multi-center
Exelmans, 2022 [35]	Netherlands	Retrospective cohort study, chart review
Guarinello, 2022 [36]	Brazil	Retrospective cohort study, registry data
Zayed, 2022 [37]	United Kingdom	Prospective cohort study, single-center
Veraldi, 2022 [38]	Italy	Retrospective cohort study, single-center

Abbreviations: EMR, electronic medical record; VQI, Vascular Quality Initiative.

lative COVID-19 death rates per 100,000 persons in the United States have occurred in rural counties compared with urban ones. Several pre-existing deficits in the infrastructure of rural health care contribute to disparities seen among rural communities during COVID-19. Consequences of these disparities included less guidance regarding public health measures to reduce infection and delays in accessing care for appropriate testing and treatment of COVID-19 infection [43].

3.2. Alterations in surgical care

During the initial surge of COVID-19 cases in March of 2020, recommendations were made by the Centers for Medicare and Medicaid Services (CMS) to discontinue all nonemergent medical services. Additional recommendations were released by several governing medical and surgical organizations, including the American College of Surgeons, the American Medical Association, and the Society for Vascular Surgery to help guide the triage of patients during the COVID-19 surge. As a result of these guidelines, substantial decreases in surgical volume across specialties were observed in the following months, with an estimated cancellation or delay of 28 million nonurgent surgeries globally [45]. In addition to surgical delays, alterations in guidelines for surgical management may have had unintended effects. The American College of Surgeons released a tiered triage system for patients with PAD, recommending that procedures be postponed in patients with PAD and rest pain or tissue loss, when possible [46]. A subsequent decrease in total vascular surgical volume and an increase in the proportion of patients presenting with more severe PAD requiring urgent surgery has been described in several studies [19–21,23,25–27,36,38]. Not surprisingly,

many also noted a consequent increase in amputation rates [19,21–23,25–27,35–38].

3.3. PAD or CLTI-related amputations

In our search, 14 studies specifically reported on the impact of COVID-19 on amputation rates in patients with PAD. Four of these studies found a significant increase in amputations during the COVID-19 period [25,26,36,38]. Lancaster et al. [19] described a 74% decrease in surgical volume within the University of California San Francisco medical system in the first 3 weeks after the COVID-19 stay-at-home orders. The study found a significant increase in the ratio of major to minor lower extremity amputations from 0.3 to 0.7 ($P = .003$) and nearly triple the major amputations occurring during the initial COVID-19 surge compared with the prepandemic period [19]. Eight additional publications reported a nonsignificant trend toward higher amputation rates in patients with PAD during the COVID-19 pandemic [18,19,21–23,27,35,37]. An analysis of the Vascular Quality Initiative compared lower extremity revascularization and amputation rates performed across the United States and Canada between January 1, 2019 and June 30, 2020. Compared with presurge months, overall surgical volume fell by 35.2% (95% CI, 31.9% to 38.4%; $P < .001$) during the surge, and by 19.8% (95% CI, 16.8% to 22.9%; $P < .001$) in the post-surge period. Also noted was a significant reduction in the rate of amputations performed (–17.8%; 95% CI, –29.2% to –6.5%). The authors noted higher proportions of above knee amputations and lower proportions of below knee amputations performed during the COVID-19 surge compared with before or after the surge (above knee amputations 34.2% during v 32.5% and 31.4% before and after, respectively; below

knee amputations 39.0% during ν 42.5% and 41.1% before and after, respectively; $P = .031$) [24].

A single-center study in Italy evaluated all patients admitted to the vascular surgery department during the first 7 weeks of the pandemic surge found a significant increase in the volume of urgent and emergent surgeries and patients admitted with decompensated PAD compared with the same time frame in 2019, as well as a nonsignificant decrease in amputation rates [18]. A single-center, retrospective study in Brazil examined 1,043 vascular surgery admissions from March 2019 to March 2021. The authors found a significant increase in patients presenting with Rutherford class 4–6 CLTI ($P < .001$) during the first year of the pandemic compared with the previous year. A significant increase in lower limb amputations (35 ν 112; $P < .001$) in the pandemic period compared with prepandemic was also described [36]. A similar study in Italy analyzed PAD admissions across 20 hospitals during the 5 weeks before the first COVID-19 pandemic surge compared with the 5 weeks after. The authors observed a reduced rate of PAD-related hospitalizations, with a greater proportion of patients presenting with CLTI (Fontaine stage 3 and 4). In addition, inpatient amputations increased in the weeks after the onset of COVID-19 (29.3% ν 13.4%; $P < .001$) [26]. Another single-center retrospective study from the United Kingdom found a 77% decrease in all vascular interventions when comparing the first 6 weeks of the initial COVID-19 surge with the same time interval the year prior. However, they did not find a significant difference in amputation rates [20].

Only 2 of the 14 publications regarding amputations in patients with PAD during the COVID-19 era included race or ethnicity in their analyses. The first study, a prospective cohort study using national registry data (Vascular Quality Initiative) evaluated 57,181 patients who underwent either lower extremity revascularization or amputation before, during, and after the first COVID-19 surge (March 1 through April 30, 2020). They reported that the proportion of White patients decreased (73.6% during surge ν 75.4% before and 75.4% after surge; $P = .03$) during the surge. Patients presenting during the surge were more likely to be non-White, have diabetes, and present with more advanced PAD, CLTI, or acute limb ischemia [24]. The second study by Lancaster et al. [19] reported that although major amputations at their center tripled during the pandemic, there was no significant difference in the distribution of race among patients who had amputations during the first surge of COVID-19 compared with prepandemic. However, no quantitative demographic data were reported in the study. Small sample size from a single center limits the generalizability of this study, and because data on race and ethnicity were not reported, their influence on amputation rates either before or during the pandemic remains unclear [19].

3.4. Diabetes-related amputations

At the onset of the pandemic, high-risk patient populations were urged to avoid medical facilities to minimize the risk of COVID-19 infection, including patients with diabetes. However, diabetic foot complications require regular clinic visits for close wound surveillance, offloading, and other tailored treatments. The disruption in regular access to wound care caused by the pandemic and patients' perception of safety

caused significant delays in managing diabetes and related foot complications.

Our review of the literature found 11 publications regarding diabetes-related amputations during COVID-19, most of which reported increased rates of amputations during the pandemic period. Two studies showed an increase in diabetes-related amputations during the COVID-19 pandemic in the United States. A single-center study from Ohio compared 150 patients that received admission or consultation by the foot and ankle surgery service during the first 5 months of the COVID-19 pandemic with 120 control patients in the 3 preceding months. The study found a higher severity of infection (14.97% ν 9.57% prepandemic), higher any-level-amputation rate (odds ratio [OR], 10.8; 95% CI, 6.5–17.8; $P < .0001$), higher major amputation rates (OR, 12.5; 95% CI 4.2–37.7; $P < .001$), and higher rates of emergency surgery (6.00% ν 0.83% prepandemic; $P = .046$) [16]. Schmidt et al. [14] performed a single-center study implementing a rigorous triage protocol in Michigan in >90% of patients for diabetic foot complications in the preceding year. From March to May of 2020, there was an 81.9% decrease in in-person visits, a 34.8% decrease in new-patient referrals, and an increase in the proportion of consults resulting in minor amputation compared with a historic cohort from the year before (20.3% in 2019 ν 24.2% in 2020) [14].

The deleterious effects of disruptions in care delivery to patients with active diabetic foot ulcers (DFUs) due to COVID-19 were also reported from around the world. A single-center study from China evaluated during the pandemic period and found that patients with DFUs experienced higher rates of severe infections (52.3% ν 20.7% prepandemic; $P < .001$), longer intervals between ulcer onset and medical visits (median of 75 days ν 45 days prepandemic; $P = .001$), longer time from outpatient assessment to hospital admission (3 days ν 7 days prepandemic; $P < .001$), and a trend toward higher overall amputation rates and mortality [15]. Analysis of patients at a tertiary care center in Naples, Italy, found that patients presenting with DFUs during the initial COVID-19 surge had a more than a three-fold increased risk of undergoing amputation ($P = .009$) compared with the 5 months preceding the onset of COVID-19 [17]. Single-center studies from Turkey, Mexico, Indonesia, and Poland also reported significant increases in severe foot infections and amputation rates [28,29,32,34].

A dramatic decrease in surveillance likely influenced amputation rates among patients with diabetes during the pandemic. In June 2020, the WHO reported that 76 of 155 countries either partially or entirely disrupted services related to diabetes and diabetes-related complications in response to the pandemic [43]. In the United States, many wound centers were closed after misclassifying them as nonessential services. A study using electronic health record data from a national wound care management company analyzed charts of first-visit patients presenting with chronic wounds between January 2019 and June 2020. A total of 84,094 wounds were included in 2019 and 68,131 in 2020, approximately 40% of which were diabetic ulcers in both cohorts. Analysis revealed that in-person visits per wound decreased by 12% in 2020 compared with 2019 (10.79 from 12.31; $P < .001$), with a 40% drop in monthly case volume in April 2020 compared with April 2019 (8,656 ν 14,089 wounds) [47].

Additional studies found no significant difference in diabetes-related amputations. A population-based study on patients with diabetes in Ontario, Canada, using national health record data, found no significant difference in diabetes-related amputations between January 2020 and February 2021. The authors hypothesized that this was a result of lessened mobility due to stay-at-home ordinances implemented during the pandemic, leading to a decrease in the repetitive microtrauma of walking [30]. Two small, single-center publications also found no significant differences in amputation rates during COVID-19. The first study is limited by small sample size (19 patients in one of the studies) and unknown lost-to-follow up rates. The other reported a higher percentage of patients with stroke and renal failure in the prepandemic control group, as well as longer duration follow-up compared with the pandemic group, which may have skewed results [31,33].

None of the 11 publications on diabetes-related amputations during COVID-19 included a subgroup analysis of amputation rates based on race or ethnicity, and only 1 included race and ethnicity in the baseline population demographic characteristics [16]. Of the publications that did not include race, all but one is based outside of the United States. In addition, many of these studies are based on small sample sizes from brief time intervals, likely a result of a push for timely dissemination of information after the onset of the global pandemic.

4. Discussion

Although health inequities have long existed, the COVID-19 pandemic brought them to the forefront of our collective consciousness, with preventive care and chronic disease management neglected due to surges in infection rates and stay-at-home orders, the pandemic also unveiled and exacerbated existing disparities in health care delivery and outcomes across the United States. Chronically disenfranchised and vulnerable populations have fared worse with both COVID-19-related illness and sequelae and non-COVID-19-related health outcomes. This is likely a result of the compounding effect the pandemic has had on chronic disease and social determinants of health.

Nearly all chronic medical conditions are risk factors for worse COVID-19 illness and are more prevalent in racial and ethnic minority populations, as well as socioeconomically disadvantaged populations. These populations are more likely to be employed as essential workers, are less able to work remotely and socially isolate, and are more likely to live in densely populated areas with more crowded living conditions. Those living in rural areas have reduced access to testing and care, which can lead to delays in presentation with more severe illness. Lack of representation and implicit biases among health care workers also creates a barrier of stigma and substandard care of racial and ethnic minority populations [43,44].

The most illuminating finding of our review, however, is the paucity of published data about the impact of COVID-19 on PAD and diabetes-related amputation rates among ethnic, racial, and geographic minority communities. This is partic-

ularly striking, given the known increased rates of amputation experienced by these populations before the pandemic. A study published in 2011 found that being Black, Hispanic, or American Indian or Alaskan Native is strongly associated with a higher risk of amputation compared with being White. Geographic location also influenced risk for amputation, as living in a rural area was associated with higher amputation rates compared with urban areas [48].

Despite the lack of available data regarding amputation rates in vulnerable populations during the pandemic, marked disparities have been described in closely related cardiovascular disease (CVD) outcomes. Wadhwa et al. [49] analyzed death certificate data from the National Center for Health Statistics from March through August of 2020 and compared with those of the same months the previous year. Their analysis revealed an increase in non-COVID-19-related heart disease and cerebrovascular disease deaths during the pandemic period that disproportionately impacted racial and ethnic minority populations. Compared with White people, the relative increase in mortality was significantly greater in Black, Hispanic, and Asian people [49].

A similar study by Janus et al. [50] examined the demographic features of nearly 3.6 million CVD deaths in 2018 to 2021. They found consistent patterns of higher CVD mortality in Black individuals that increased to a greater degree than White individuals during the pandemic period. On subgroup analysis of deaths from 2020 to 2021, they found excess CVD mortality nearly three times greater in Black individuals compared with White counterparts. This disparity was consistent across CVD subtype, including myocardial infarction, stroke, and heart failure. Most striking was the excess CVD deaths in Black individuals, which was more than five times that of White individuals seen during the first COVID-19 surge in April to May of 2020 [50].

Our review highlights the void in the current literature regarding the impact of COVID-19 on amputation rates in vulnerable populations. The articles included in the review were all retrospective studies, most of which were reporting data only from the first year of the pandemic, and several focusing specifically on the initial surge. Many of the publications were single-institution studies with small sample sizes, likely the result of an attempt to expeditiously disseminate information among the medical community in the face of a novel pandemic. Current, more inclusive publications with larger sample sizes are still needed to fully glean the true impact of the pandemic.

4.1. Closing the gap

Efforts to address health disparities and alterations in access to care created by the pandemic are ongoing at both individual and population levels. We include two examples to illustrate how providers in high-risk communities managed patients during the pandemic: the San Antonio Vascular and Endovascular Clinic (SAVE) clinic (San Antonio, TX) and West Virginia University (WVU) Medicine (Morgantown, WV), as well as an overview of current legislative initiatives. The case studies demonstrate strategies to maintain access to health care, despite stay-at-home orders and clinic closures, and illustrate the difficulties involved with providing care in a

system that has been chronically under-resourced before the pandemic.

4.2. SAVE clinic and community-based clinic case study

The SAVE clinic is a community-based private vascular surgery practice with multiple locations specifically targeted to underserved, majority-minority areas in and around San Antonio, TX. Interdisciplinary care patients with PAD in communities with disparate private health care entities require extraordinary efforts under the best circumstances. Without a major hospital's dedicated financial and staffing resources supporting the efforts, the burden of design, implementation, and coordination of anything resembling a program falls directly on the individually participating physicians and podiatrists and their respective small business resources. Before the COVID-19 pandemic, SAVE established multidisciplinary PAD care pathways by networking with other practitioners engaged in limb salvage efforts and identifying implementation strategies that fit each practitioner's constraints. Variables include method of communication on referrals (ie, fax, text, electronic medical record, and Health Insurance Portability and Accountability Act-compliant app), protocols for wound care (frequency of redressing, sharing of wound photos, and overarching wound care responsibilities), and revascularization expectations (before and after podiatric surgery or wound grafting), among others.

With the onset of the pandemic and associated disruptions to care described at length in this article, alternative solutions were required for each variable. Even as "essential services" continued to be operational, many private practice medical offices of all specialties and primary care either reduced hours, reduced in-person contact, or went entirely "virtual." During the initial stages of the pandemic, SAVE immediately began stratifying patients based on clinical urgency, and patients with PAD were among the most urgent. Existing patients and new referrals could visit any of seven SAVE office locations with maximum safety protocols to minimize potential spread of COVID-19. Alternatively, patients could be seen in their own vehicles in the parking lot of any SAVE office, in which case staff donned gowns, gloves, and masks and performed visits, including any necessary wound care.

Virtual visits were attempted for patients with PAD who were either unwilling, incapable, or otherwise unable to be seen in person. SAVE quickly encountered several barriers to virtual visits, including situations when patients' monthly cellular data plans were completely exhausted by live video calls. SAVE responded to these challenges and developed an alternative approach: patients who were agreeable took photos of their feet and/or wounds and texted them to Health Insurance Portability and Accountability Act-compliant software, which would then allow a regular phone call to be productive.

The multidisciplinary approaches described above were modified depending on the availability and circumstances of collaborating practices. For example, when collaborating practices were experiencing reductions in clinic availability, SAVE practitioners contacted such collaborators by phone to discuss clinical urgency and make next-step decisions. These efforts resulted in patients receiving interventional services, such as

source-control minor amputations, intravenous antibiotics, or revascularizations, while minimizing the number of in-person contacts.

SAVE did not reduce clinic or surgical availability during any stage of the pandemic. Despite this effort to maintain accessibility, in April of 2020, SAVE experienced a 19% decrease in procedure volume and a 53% decrease in new patient consultations compared with the preceding 12-month averages. Prepandemic volumes were surpassed in August and October 2020, for procedure volume and new patient consultations, respectively. Although SAVE is in an urban center, WVU Medicine highlights the challenges faced by rural populations during the pandemic.

4.3. WVU rural case study

Even before the COVID-19 pandemic, rural populations faced health care disparities.

West Virginia serves as an example of the impact of COVID-19 in a highly rural area that was medically underserved and under-resourced before the onset of the pandemic. The lack of testing and tracking capabilities present in rural hospitals and public health departments at baseline caused a significant under-representation in reporting the impact of COVID-19 in rural areas. In addition, there were record numbers of health care staffing shortages, critical access hospital closures, and a depletion of infrastructure in rural areas during the pandemic, which was likely a major contributor to poorer outcomes in rural populations [51]. A recent study published in the *Journal of Rural Health* identified higher hospitalization rates, inpatient mortality, and adverse outcomes due to COVID-19 infection in rural populations compared with urban ones, even when adjusting for demographic differences and comorbidities [52]. Given these issues, there has likely been a significant increase in diabetic foot-related complications in rural populations, however, it is also likely that rural areas have not had the resources or capacity to document this.

Despite these issues, a number of strategies were used to deliver uninterrupted care to patients with PAD at WVU Medicine during the pandemic. For example, in-person appointments for vascular surgery and wound care were maintained, with the option for telemedicine based on patient preference. We quickly identified, however, that telemedicine had limited use in the WV PAD population, due to barriers including the lack of reliable internet access and an older population that was less comfortable with technology. This served to strengthen the decision from the vascular and wound care divisions to remain open. Unfortunately, the orthopedic department, which houses podiatry, invoked a total shut down, causing some difficulties in providing multidisciplinary outpatient care. In this instance, the wound care center expanded their capabilities to address the gaps caused by lack of podiatric appointments—an approach that rural providers are well versed in at baseline (ie, the ability to wear many hats and perform beyond one's usual job description) due to chronic specialist shortages even in nonpandemic scenarios. On the inpatient side, the vascular division advocated for maintaining care for patients with PAD throughout the pandemic, a decision supported by the administration. Unfortunately, due to the hospital closures and staffing shortages, as well as a signif-

icant lack of centers across the state with the ability to provide intensive care at baseline, WVU was overwhelmed with critically ill COVID-19 and non-COVID-19 patients. This limited the ability to accept patients in transfer from across the state, including those with PAD-related needs. As a result, overall amputations across the state may have increased, despite the rates of amputation remaining steady at WVU's main hospital throughout the pandemic. However, further studies are needed to investigate this hypothesis.

4.4. Emerging political action in response to COVID-19

In addition to frontline efforts being used to address the exacerbation of health disparities in vulnerable populations during the pandemic, many PAD advocates are engaged in political action. Several organizations (CardioVascular Coalition, Association of Black Cardiologists, Society for Coronary Angiography and Interventions, Society of Interventional Radiology, Society for Vascular Surgery, and American Podiatric Medical Association) were involved in a recent response to the CMS Amputation Avoidance request for information seeking public input on advancing health equity among stakeholders serving and located in underserved communities. Racial and ethnic minority populations are at disproportionate risk of losing legs and lives—a reality that must be actively addressed through intentional, sustained, and compassionate policy action. Supporting federal policy changes to prevent unnecessary amputations in the United States were sparse and siloed before the COVID-19 pandemic.

As a direct response to the COVID-19 pandemic, policy changes to advance equity and opportunity were enacted, including Executive Order 13985. In alignment with Executive Order 13985, the Advancing Racial Equity and Support for Underserved Communities Through the Federal Government, the CMS Strategic Plan Pillar: Health Equity and the CMS Framework for Health Equity (2022–2032) elicited feedback and perspectives related to challenges and opportunities for CMS to embed health equity and the elusive social determinants of health into efforts encouraging innovation, reducing burden, and creating efficiencies across the health care system when it comes to the development of a process measure, as well as a composite measure, for the inclusion in the Merit-based Incentive Payment System, designed to reduce lower extremity limb amputations among diabetics [53,54]. In regard to PAD-diabetes-related limb preservation, this was new territory for CMS, and the collective response was impactful. The American Heart Association (PAD National Action Plan), the American Diabetes Association (Health Equity Bill of Rights), and Vascular Cures (Health Equity Initiative) are all examples of organizations that were not only involved in the CMS request for information, but have collaborated with multisocietal executive leadership to center their advocacy efforts to advance equitable care and research and to improve awareness, diagnosis, and treatment of PAD.

During the 117th Congress, for the first time, the Amputation Reduction and Compassion Act was incorporated into the Health Equity and Accountability Act of 2022 [55]. The Amputation Reduction and Compassion Act was a response to the new bill and aims to end racial disparities in amputations [56] and has garnered more than 20 bipartisan co-sponsors

and represents the lone legislative vehicle for coverage of PAD tests without cost-sharing under Medicare, Medicaid, and private health insurance for certain at-risk individuals, and requires the development of certain educational programs and Medicare quality measures to reduce amputations relating to such disease.

5. Conclusions and future implications

Nationally and internationally, there is a lack of comprehensive data on testing rates, confirmed cases, and mortality related to COVID-19. Minority and vulnerable groups are not adequately represented in the available data regarding their amputation rates during the COVID-19 pandemic. Further retrospective studies are required to document the health care disparity in racial, ethnic, and geographical minority and other vulnerable groups during the COVID-19 pandemic. It remains a priority of multiple stakeholders to examine the wide-ranging impact of racial and minority groups' disparities, preventable amputations, and preventable deaths in our health care system.

Acknowledgments

The authors would like to express gratitude to Ben Harnke, MLIS, Strauss Health Sciences Library, University of Colorado, Anschutz Medical Campus, for his contribution to this project.

REFERENCES

- [1] COVID Data Tracker. Centers for Disease Control and Prevention. Accessed October 3, 2022. <https://covid.cdc.gov/covid-data-tracker>.
- [2] Haw JS, Shah M, Turbow S, et al. Diabetes complications in racial and ethnic minority populations in the USA. *Curr Diab Rep* 2021;21(1):2.
- [3] Traven SA, Synovec JD, Walton ZJ, et al. Notable racial and ethnic disparities persist in lower extremity amputations for critical limb ischemia and infection. *J Am Acad Orthop Surg* 2020;28:885–92.
- [4] Holmes L Jr, Enwere M, Williams J, et al. Black-white risk differentials in COVID-19 (SARS-COV2) transmission, mortality and case fatality in the United States: translational epidemiologic perspective and challenges. *Int J Environ Res Public Health* 2020;17(12):4322.
- [5] Kirksey L, Tucker DL, Jr Taylor E, et al. Pandemic superimposed on epidemic: COVID-19 disparities in Black Americans. *J Natl Med Assoc* 2021;113:39–42.
- [6] Conte MS, Bradbury AW, Kolh P, et al. Global vascular guidelines on the management of chronic limb-threatening ischemia. *J Vasc Surg* 2019;69(suppl):3S–125S e40.
- [7] By the Numbers: Diabetes in America-Source: National Diabetes Statistics Report, 2022. Centers for Disease Control and Prevention. Accessed October 22, 2022. <https://www.cdc.gov/diabetes/health-equity/diabetes-by-the-numbers.html>.
- [8] Raghavan S, Vassy JL, Ho YL, et al. Diabetes mellitus-related all-cause and cardiovascular mortality in a national cohort of adults. *J Am Heart Assoc* 2019;8(4):e011295.
- [9] McGinagle KL, Minc SD. Disparities in amputation in patients with peripheral arterial disease. *Surgery* 2021;169:1290–4.

- [10] Barnes JA, Eid MA, Creager MA, et al. Epidemiology and risk of amputation in patients with diabetes mellitus and peripheral artery disease. *Arterioscler Thromb Vasc Biol* 2020;40:1808–17.
- [11] Holman KH, Henke PK, Dimick JB, et al. Racial disparities in the use of revascularization before leg amputation in Medicare patients. *J Vasc Surg* 2011;54(420–6) 6.e1.
- [12] Tan TW, Shih CD, KC Concha-Moore, et al. Disparities in outcomes of patients admitted with diabetic foot infections. *PLoS One* 2019;14(2):e0211481.
- [13] Covidence systematic review software. Accessed October 17, 2022. Veritas Health Innovation. www.covidence.org.
- [14] Schmidt BM, Munson ME, Rothenberg GM, et al. Strategies to reduce severe diabetic foot infections and complications during epidemics (STRIDE). *J Diabetes Complications* 2020;34(11):107691.
- [15] Liu C, You J, Zhu W, et al. The COVID-19 outbreak negatively affects the delivery of care for patients with diabetic foot ulcers. *Diabetes Care* 2020;43(10):e125–6.
- [16] Casciato DJ, Yancovitz S, Thompson J, et al. Diabetes-related major and minor amputation risk increased during the COVID-19 pandemic [published online ahead of print November 3,]. *J Am Podiatr Med Assoc* 2020. doi:10.7547/20-224.
- [17] Caruso P, Longo M, Signoriello S, et al. Diabetic foot problems during the COVID-19 pandemic in a tertiary care center: the emergency among the emergencies. *Diabetes Care* 2020;43(10):e123–4.
- [18] Mascia D, Kahlberg A, Melloni A, et al. Single-center vascular hub experience after 7 weeks of COVID-19 Pandemic in Lombardy (Italy). *Ann Vasc Surg* 2020;69:90–9.
- [19] Lancaster EM, Wu B, Iannuzzi J, et al. Impact of the coronavirus disease 2019 pandemic on an academic vascular practice and a multidisciplinary limb preservation program. *J Vasc Surg* 2020;72:1850–5.
- [20] Musajee M, Biasi L, Thulasidasan N, et al. The impact of the COVID-19 pandemic on the workload, case mix and hospital resources at a tertiary vascular unit. *Ann Vasc Surg* 2022;80:104–12.
- [21] Piazza M, Xodo A, Squizzato F, et al. The challenge of maintaining necessary vascular and endovascular services at a referral center in Northern Italy during the COVID-19 outbreak. *Vascular* 2021;29:477–85.
- [22] Scheurig-Muenkler C, Schwarz F, Kroencke TJ, et al. Impact of the COVID-19 pandemic on in-patient treatment of peripheral artery disease in Germany during the first pandemic wave. *J Clin Med* 2022;11(7):2008.
- [23] Aljarrah Q, Allouh M, Hallak A, et al. Impact of the COVID-19 pandemic on the management of chronic limb-threatening ischemia in Northern Jordan: case series and literature review. *Int J Surg Case Rep* 2021;80:105631.
- [24] Lou JY, Kennedy KF, Menard MT, et al. North American lower-extremity revascularization and amputation during COVID-19: observations from the Vascular Quality Initiative. *Vasc Med* 2021;26:613–23.
- [25] Schuivens PME, Buijs M, Boonman-de Winter L, et al. Impact of the COVID-19 lockdown strategy on vascular surgery practice: more major amputations than usual. *Ann Vasc Surg* 2020;69:74–9.
- [26] Stabile E, Piccolo R, Franzese M, et al. A cross-sectional study evaluating hospitalization rates for chronic limb-threatening ischemia during the COVID-19 outbreak in Campania, Italy. *Vasc Med* 2021;26:174–9.
- [27] Trunfo R, Deslarzes-Dubuis C, Buso G, et al. The effects of COVID-19 pandemic on patients with lower extremity peripheral arterial disease: a near miss disaster. *Ann Vasc Surg* 2021;77:71–8.
- [28] Yunir E, Tarigan TJE, Iswati E, et al. Characteristics of diabetic foot ulcer patients pre- and during COVID-19 pandemic: lessons learnt from a national referral hospital in Indonesia. *J Prim Care Community Health* 2022;13:21501319221089767.
- [29] Lozano-Corona R, Reyes-Monroy JA, Lara-Gonzalez V, et al. Revascularization prevents amputation among patients with diabetic foot during the COVID-19 era [published online ahead of print March 21,]. *Vascular* 2022. doi:10.1177/17085381221079108.
- [30] de Mestral C, Gomez D, Wilton AS, et al. A population-based analysis of diabetes-related care measures, foot complications, and amputation during the COVID-19 pandemic in Ontario, Canada. *JAMA Netw Open* 2022;5(1):e2142354.
- [31] Ergişi Y, Ozdemir E, Altun O, et al. Indirect impact of the COVID-19 pandemic on diabetes-related lower extremity amputations: a regional study. *Jt Dis Relat Surg* 2022;33:203–7.
- [32] Kendirci M, Sahiner IT, Sezikli I, et al. Effects of the COVID-19 pandemic on the management of diabetic foot ulcers: experiences from a dedicated diabetic foot care center. *Wounds* 2022;34:146–50.
- [33] Rubin G, Feldman G, Dimri I, et al. Effects of the COVID-19 pandemic on the outcome and mortality of patients with diabetic foot ulcer. *Int Wound J* 2023;20:63–8.
- [34] Kleibert M, Mrozikiewicz-Rakowska B, Bak PM, et al. Breakdown of diabetic foot ulcer care during the first year of the pandemic in Poland: a retrospective national cohort study. *Int J Environ Res Public Health* 2022;19(7):3827.
- [35] Exelmans W, Knaapen L, Boonman-de Winter L, et al. Treating peripheral arterial occlusive disease and acute limb ischemia during a COVID-19 pandemic in 2020. *Ann Vasc Surg* 2022;84:1–5.
- [36] Guarinello GG, D'Amico RC, Miranda ANM, et al. Impact of COVID-19 on the surgical profile of vascular surgery patients at a tertiary hospital in Curitiba, Brazil. *J Vasc Bras* 2022;21:e20220027.
- [37] Zayed H, Musajee M, Thulasidasan N, et al. Impact of COVID-19 pandemic on the outcomes in patients with critical limb threatening ischaemia and diabetic foot infection. *Ann Surg* 2022;275:1037–42.
- [38] Veraldi GF, Mezzetto L, Perilli V, et al. Clinical and economic impact of COVID-19 in vascular surgery at a tertiary university "hub" hospital of Italy. *Ann Vasc Surg* 2022;83:97–107.
- [39] Bakouny Z, Paciotti M, Schmidt AL, et al. Cancer screening tests and cancer diagnoses during the COVID-19 pandemic. *JAMA Oncol* 2021;7:458–60.
- [40] Wright A, Salazar A, Mirica M, et al. The invisible epidemic: neglected chronic disease management during COVID-19. *J Gen Intern Med* 2020;35:2816–17.
- [41] Cortez C, Mansour O, Qato DM, et al. Changes in short-term, long-term, and preventive care delivery in US office-based and telemedicine visits during the COVID-19 pandemic. *JAMA Health Forum* 2021;2(7):e211529.
- [42] Mobula LM, Heller DJ, Commodore-Mensah Y, et al. Protecting the vulnerable during COVID-19: treating and preventing chronic disease disparities. *Gates Open Res* 2020;4:125.
- [43] Andraska EA, Alabi O, Dorsey C, et al. Health care disparities during the COVID-19 pandemic. *Semin Vasc Surg* 2021;34:82–8.
- [44] Moore JT, Pilkington W, Kumar D. Diseases with health disparities as drivers of COVID-19 outcome. *J Cell Mol Med* 2020;24:11038–45.
- [45] Winter Beatty J, Clarke JM, Sounderajah V, et al. Impact of the COVID-19 pandemic on emergency adult surgical patients and surgical services: an international multi-center cohort study and department survey. *Ann Surg* 2021;274:904–12.
- [46] COVID-19: Elective Case Triage Guidelines for Surgical Care. American College of Surgeons. October 20, 2022. <https://www.facs.org/for-medical-professionals/covid-19/clinical-guidance/elective-case/>.

- [47] Cho SK, Mattke S, Sheridan M, et al. Outpatient wound clinics during COVID-19 maintained quality but served fewer patients. *J Am Med Dir Assoc* 2022;23:660–5 e5.
- [48] Henry AJ, Hevelone ND, Belkin M, et al. Socioeconomic and hospital-related predictors of amputation for critical limb ischemia. *J Vasc Surg* 2011;53(330–9):e1.
- [49] Wadhera RK, Shen C, Gondi S, et al. Cardiovascular deaths during the COVID-19 pandemic in the United States. *J Am Coll Cardiol* 2021;77:159–69.
- [50] Janus SE, Makhoul M, Chahine N, et al. Examining disparities and excess cardiovascular mortality before and during the COVID-19 pandemic. *Mayo Clin Proc* 2022;97:2206–14.
- [51] Rural hospital closures threaten access solutions to preserve care in local communities. American Hospital Association. Accessed October 20, 2022. <https://www.aha.org/system/files/media/file/2022/09/rural-hospital-closures-threaten-access-report.pdf>.
- [52] Anzalone AJ, Horswell R, Hendricks BM, et al. Higher hospitalization and mortality rates among SARS-CoV-2-infected persons in rural America. *J Rural Health* 2023;39:39–54.
- [53] A Presidential Document by the Executive Office of the President. Advancing Racial Equity and Support for Underserved Communities Through the Federal Government. *Federal Register*. Published January 25, 2021. Accessed October 17, 2022. <https://www.federalregister.gov/d/2021-01753>.
- [54] CMS Strategic Plan - Pillar: Health Equity. Centers for Medicare and Medicaid Services. Accessed October 17, 2022. <https://www.cms.gov/cms-strategic-plan>.
- [55] Kelly R. This legislation would address social determinants of health, improve access for underserved communities, address maternal health and mental health crises, gun violence and more. Accessed October 20, 2022. <https://robinkelly.house.gov/media-center/press-releases/rep-robin-kelly-introduces-health-equity-and-accountability-act>.
- [56] New Bill Aims to End Racial Disparities in Amputations. *ProPublica*. Accessed October 20, 2022. <https://www.propublica.org/article/new-bill-aims-to-end-racial-disparities-in-amputations>.