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Association of rurality and identifying as black with receipt of specialty care among patients hospitalized with a diabetic foot ulcer: a Medicare cohort study

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ABSTRACT

Introduction Rural patients with diabetic foot ulcers, especially those identifying as black, face increased risk of major amputation. Specialty care can reduce this risk. However, care disparities might beget outcome disparities. We aimed to determine whether a smaller proportion of rural patients, particularly those identifying as black, receive specialty care compared with the national proportion.

Research design and methods This 100% national retrospective cohort examined Medicare beneficiaries hospitalized with diabetic foot ulcers (2013–2014). We report observed differences in specialty care, including: endocrinology, infectious disease, orthopedic surgery, plastic surgery, podiatry, or vascular surgery. We used logistic regression to examine possible intersectionality between rurality and race, controlling for sociodemographics, comorbidities, and ulcer severity and including an interaction term between rurality and identifying as black.

Results Overall, 32.15% (n=124 487) of patients hospitalized with a diabetic foot ulcer received specialty care. Among rural patients (n=13 100), the proportion decreased to 29.57%. For patients identifying as black (n=21 649), the proportion was 33.08%. Among rural patients identifying as black (n=1239), 26.23% received specialty care. This was >5 absolute percentage points less than the overall cohort. The adjusted OR for receiving specialty care among rural versus urban patients identifying as black was 0.61 (95% CI 0.53 to 0.71), which was lower than that for rural versus urban patients identifying as white (aOR 0.85, 95% CI 0.80 to 0.89). This metric supported a role for intersectionality between rurality and identifying as black.

Conclusions A smaller proportion of rural patients, particularly those identifying as black, received specialty care when hospitalized with a diabetic foot ulcer compared with the overall cohort. This might contribute to known disparities in major amputations. Future studies are needed to determine causality.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Rural patients, particularly those who identify as black, face increased risk of major amputation following hospitalization with a diabetic foot ulcer.

WHAT THIS STUDY ADDS

⇒ A smaller proportion of these same patients receive specialty care for their foot ulcer.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Differences in specialty care might be contributing to disparities in major amputations among patients with diabetic foot ulcers. Further research on the impact of specialty care on disparities in diabetic foot ulcer outcomes is needed.

INTRODUCTION

Rural patients face an estimated 35% higher odds of major amputation following diabetic foot ulcers compared with patients living in urban areas.[1 2] Patients identifying as black are twice as likely to undergo a major amputation compared with those identifying as non-Hispanic white.[3 4] The intersection of these social identities amplifies the risk of poor outcomes: rural Medicare patients identifying as black face a greater than 10% absolute increased risk of major amputation or death.[3] Both social determinants of health and health system factors may contribute to these disparities, although we know little about disease-specific root causes or ultimate solutions.

To investigate the associations between social determinants of health and health system factors with disparities in major amputation, we adopted an intersectionality lens.[5–8] Intersectionality emerged from black feminism as a way to understand and address social injustices faced by multiply marginalized people.[9] Its goal is to improve social justice for multiply marginalized people, such as rural Americans identifying as black. Core tenets include: overlapping identities, historically oppressed populations, and

social determinants of health.[10] These overlaps have the capacity to amplify disparities, including healthcare disparities.

Our study's objective was to identify healthcare system factors that may be contributing to rural disparities in major amputations, particularly among rural patients identifying as black. The main factor we investigated was inpatient specialty care, as advocated by multiple professional societies as best practice for those with diabetic foot ulcers.[11–13] We hypothesize that rural patients hospitalized with diabetic foot ulcers receive less specialty care when compared with the national overall cohort of patients with similar comorbidities and ulcer severities. We further hypothesize that differences in specialty care particularly impact rural patients identifying as black, consistent with our use of an intersectionality lens. We restricted our analysis to patients identifying as black because our data set contained few rural patients identifying as Hispanic and concerns for misclassification of other racial and ethnic identities.[14] Our hypothesis is based on (1) The construct of intersectionality, (2) Previous Medicare findings that rural Medicare patients identifying as black face a 1.24-fold amplified risk of major amputation or death following hospitalization with a diabetic foot ulcer, and (3) Prior work demonstrating that rural patients lack access to specialists.[3 9 15] Our hope is that this initial study will identify potential differences in healthcare that may be contributing to disparities in major amputations. Further studies defining a more causal relationship will be needed, with the ultimate goal of designing interventions to provide equitable healthcare and alleviate disparities in major amputations.

MATERIALS AND METHODS

Data sources

We used a 100% national sample of adult Medicare beneficiaries hospitalized between January 1, 2013 and December 31, 2014, obtained through the Centers for Medicare and Medicaid Services. We required patients to be continuously enrolled in Medicare parts A and B for 12 months preceding index hospitalization and have a geolinkable address. We used five-digit ZIP codes to link Medicare data to categorize rurality (Rural-Urban Commuting Area, or RUCA, codes) and nine-digit ZIP codes to categorize neighborhood disadvantage (Neighborhood Atlas Area Deprivation Index, or ADI).[16 17]

Study design

We constructed a retrospective, national cohort of Medicare beneficiaries hospitalized with diabetic foot ulcers by first identifying patients with diabetes based on the Chronic Conditions Warehouse (CCW) flag, which is based on diabetes-related diagnostic billing codes (eg, 1 code in inpatient, skilled nursing facility, home health claims or 2 codes in hospital outpatient or carrier claims within a 2-year window).[18] Next, we categorized diabetic foot ulcers as early stage (ie, ulcers not complicated by osteomyelitis or gangrene), osteomyelitis, or gangrene. This was done using a validated algorithm generating severity categories that corresponded to hospital length of stay, amputation, and mortality.[19] We excluded patients with incomplete claims due to health maintenance organization or railroad benefits, as well as those admitted to psychiatric or long-term acute care hospitals, due to the potential for incomplete claims.[20] For patients hospitalized more than once, only the first index admission was included to maintain statistical independence. We used the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) cohort reporting guidelines to present our findings.[21]

Outcome

Our outcome was receipt of specialty care during the index hospitalization. This was defined dichotomously as being seen by at least one of six specialists identified using National Provider and Plan Enumeration System Medical Specialty codes/Provider Taxonomy codes: endocrinology, infectious disease, orthopedic surgery, plastic surgery, podiatry, or vascular surgery (online supplemental table 1).[22 23] We chose these six specialties because they are the most frequent disciplines represented in published descriptions of multidisciplinary teams caring for patients with diabetic foot ulcers as identified through systematic review.[11] To ensure that the specialist provided care for the ulcer, we required them to code for it during billing. Endocrinologists were the exception. We required endocrinologists to code for diabetes during billing instead of the ulcer, since this most directly reflected the physiologic aspect addressed by their specialty.[11]

Primary explanatory variables

We investigated two primary explanatory variables: rurality and identifying as black. Rurality was captured using RUCA codes: urban (RUCA 1, metropolitan area core, referent), suburban (RUCA 2–6, metropolitan area with commuting and micropolitan areas), and rural (RUCA 7–10, small town and rural areas) which is based on population density, urbanization, and daily commuting factors (figure 1).[17 24] We operationalized race using

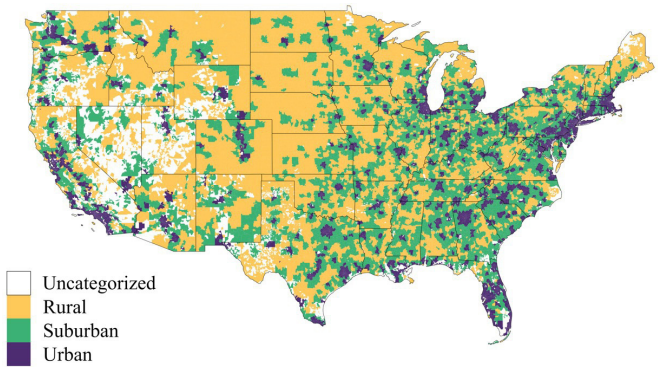

Figure 1 Map of the contiguous USA identifying ZIP codes by the rurality categorization used in our primary analysis.

Research Triangle Institute codes, where patients identify as: American Indian/Alaskan Native, Asian/Pacific Islander, black/African American (hereafter black), Hispanic, other, unknown, and non-Hispanic white (hereafter white).[25] We focused analysis on patients identifying as black because of low numbers of rural patients identifying as Hispanic and concerns for misclassification of other racial and ethnic identities.[14]

Covariates

Sociodemographic variables included age, sex, receiving Medicaid coverage the year prior to hospitalization, and neighborhood disadvantage. Neighborhood disadvantage was measured using the ADI, a social determinant of health composite construct consisting of 17 census block group measures that describe housing, poverty, employment and education characteristics.[16] More disadvantaged neighborhoods have higher national ADI rankings. Ulcer severity was operationalized using the validated algorithm described above.[14] Comorbidities were adjusted for using Medicare CCW flags, Elixhauser Comorbidity Index variables, and baseline-year Hierarchical Condition Category (HCC) scores.[26 27] Higher HCC scores correlate with higher healthcare costs and utilization and is commonly used as a proxy for illness burden and patient complexity.[27] The following comorbidities were identified using validated CCW conditional categories: myocardial infarction, ischemic heart disease, hyperlipidemia, hypertension, and stroke.[18] Nine Elixhauser comorbidities with <5% prevalence in our cohort were consolidated into a single indicator (positive if at least one was present).[26]

Statistical analysis

We described patient characteristics, overall and stratified by both rurality and racial and ethnic identity. Capitalizing on the strength of a full US Medicare population, we used observed differences in specialty care as well as predicted probabilities to explore the intersection of rurality and identifying as black on an additive scale (testing whether interactions were greater than the sum of each, individual effect).[28] We used ORs to describe the potential role of intersectionality on a multiplicative scale (testing whether interactions were greater than the product of each, individual effect).[28] Because we used a full, 100% hospitalized Medicare patient data set, observations are actual differences between subgroups, not estimates; therefore, no tests of statistical differences were run.

Our main analysis focused on the primary outcome of receiving care from at least one specialist. We performed logistic regression, sequentially building models to assess how covariates and interactions influence the associations between rurality and receipt of specialty care. We started with univariable analysis (Model 1), then added age and sex (Model 2). Model 3 included all sociodemographic factors. When examining race, we only report regression results for patients identifying as black or white because (1) Our study's hypothesis was focused on this difference, (2) Our data set contained limited numbers of rural patients identifying as Hispanic (n=431) and (3) The Research Triangle Institute race variable may miscategorize patients identifying as other races.[14] Our fourth model added ulcer severity and comorbidities. Model 5 included an interaction term between rural residence and identifying as black if it met our *a priori* level of significance with a two-sided value of p<0.001. For the interaction model (Model 5), ORs and adjusted predicted probabilities were calculated by racial identity and rurality.[28] When reporting predicted probabilities, we used a hypothetical patient with the common characteristics of the cohort. We used R software to perform our statistical analysis.[29]

We performed supportive, stratified analyses: observed rates of specialty care stratified by ulcer severity to account for confounding by indication (eg, patients with more advanced ulcers may be more likely to receive specialty care). Stratified analysis may begin to identify ulcer severity windows or targets for potential future interventions. We also performed secondary analysis, categorizing rurality differently using RUCA codes and Census data, to ensure our findings with respect to rurality were robust.[30] Specifically, in the secondary analysis rurality was categorized as urban (RUCA codes 1.0, 1.1, 2.0, 2.1, 3.0, 4.1, 5.1, 7.1, 8.1, 10.1), large rural (4.0, 4.2, 5.0, 5.2, 6.0, 6.1), and small rural/isolate (7.0, 7.2, 7.3, 7.4, 8.0, 8.2, 8.3, 8.4, 9.0, 9.1, 9.2, 10.0, 10.2, 10.3, 10.4, 10.5, 10.6; online supplemental table 2).

RESULTS

During the 2-year study period, 124 487 Medicare beneficiaries were hospitalized with diabetic foot ulcers. Over half of the cohort was male with a mean age of 72 years, and 28.51% identified as a racial or ethnic minority. Of the total patients, 13 100 (10.52%) lived in a rural setting. Most rural patients identified as white, with a higher proportion living in disadvantaged neighborhoods and previously receiving Medicaid compared with the overall cohort. Prior diagnoses of comorbid conditions were slightly lower among rural patients compared with the overall population (table 1). Relative to the overall cohort, the group of patients identifying as black—regardless of where they lived—had higher proportions of those who: lived in disadvantaged neighborhoods, previously received Medicaid, experienced a higher prevalence of comorbidities, and received more severe ulcer diagnoses (table 1).

Receipt of specialty care

Overall, 40 027 (32.2%) patients saw at least one specialist (table 1). A smaller proportion (29.57%) of rural patients received specialty care. A higher proportion of patients identifying as black (33.08%) received specialty care; however, among rural patients also identifying as black, the observed proportion receiving specialty care

Table 1 Characteristics of patients hospitalized with diabetic foot ulcer by rurality and racial and ethnic identity

		Rurality			Racial and ethnic identity		
Characteristic	**Full cohort* n=124 487 (100%)**	**Urban patients n=84 590 (67.95%)**	**Suburban patients n=26 262 (21.10%)**	**Rural patients n=13 100 (10.52%)**	**Non-Hispanic white n=88 525 (71.11%)**	**Black n=21 649 (17.39%)**	**Hispanic n=10 158 (8.16%)**
Specialty care							
Endocrinology	377 (0.30)	290 (0.34)	61 (0.23)	26 (0.20)	287 (0.32)	52 (0.24)	32 (0.32)
Infectious disease	2020 (1.62)	1463 (1.73)	369 (1.41)	187 (1.43)	1477 (1.67)	337 (1.56)	143 (1.41)
Orthopedic surgery	6435 (5.17)	3882 (4.59)	1641 (6.25)	900 (6.87)	4848 (5.48)	858 (3.96)	496 (4.88)
Plastic surgery	1018 (0.82)	799 (0.94)	150 (0.57)	63 (0.48)	655 (0.74)	222 (1.03)	95 (0.94)
Podiatry	16 267 (13.07)	11 973 (14.15)	2980 (11.35)	1285 (9.81)	11 360 (12.83)	2609 (12.05)	1682 (16.56)
Vascular surgery	15 668 (12.59)	10 934 (12.93)	3139 (11.95)	1556 (11.88)	10 444 (11.80)	3405 (15.73)	1297 (12.77)
Received specialty care	40 027 (32.15)	28 021 (33.13)	8049 (30.65)	3874 (29.57)	27 868 (31.48)	7162 (33.08)	3577 (35.21)
Sociodemographics							
Age, mean (SD)	71.54 (13.02)	71.94 (13.15)	70.54 (12.71)	70.99 (12.64)	72.86 (12.43)	68.19 (14.14)	68.38 (13.50)
Male	71 286 (57.26)	48 019 (56.77)	15 287 (58.21)	7663 (58.50)	51 447 (58.12)	11 263 (52.03)	6062 (59.68)
Race and ethnicity							
Black	21 649 (17.39)	17 346 (20.51)	3003 (11.43)	1239 (9.56)	--	--	--
Hispanic	10 158 (8.16)	8075 (9.55)	1283 (4.89)	431 (3.29)	--	--	--
Non-Hispanic white	88 525 (71.11)	56 585 (66.89)	21 175 (80.63)	10 707 (81.73)	--	--	--
Other/unknown†	4155 (3.34)	2584 (3.05)	801 (3.05)	723 (5.52)	--	--	--
Reside in ≥ 80th percentile ADI	26 430 (21.23)	16 044 (18.97)	6198 (23.60)	4050 (30.92)	14 111 (15.94)	8252 (38.12)	3219 (31.69)
Mean ADI percentile (SD)	53.29 (27.56)	48.34 (28.65)	61.68 (22.07)	69.09 (18.37)	50.09 (26.51)	64.31 (27.48)	59.51 (28.50)
Medicaid receipt	46 199 (37.11)	30 731 (36.33)	10 033 (38.20)	5365 (40.95)	25 551 (28.86)	11 929 (55.10)	6570 (64.68)
Ulcer severity and comorbidities							
Ulcer severity							
Early stage	81 277 (65.29)	55 144 (65.19)	17 189 (65.45)	8603 (65.67)	60 227 (68.03)	12 735 (58.82)	5823 (57.32)
Osteomyelitis	26 892 (21.60)	18 188 (21.50)	5705 (21.72)	2890 (22.06)	18 967 (21.43)	4486 (20.72)	2432 (23.94)
Gangrene	16 318 (13.11)	11 258 (13.31)	3368 (12.82)	1607 (12.27)	9331 (10.54)	4428 (20.45)	1903 (18.73)
History of myocardial infarction	22 768 (18.29)	15 097 (17.85)	5052 (19.24)	2521 (19.24)	16 635 (18.79)	3510 (16.21)	1898 (18.68)
History of ischemic heart disease	104 863 (84.24)	72 016 (85.14)	21 672 (82.52)	10 742 (82.00)	74 645 (84.32)	18 209 (84.11)	8710 (85.75)
History of stroke or TIA	40 772 (32.75)	28 754 (33.99)	8061 (30.69)	3767 (28.76)	27 557 (31.13)	8571 (39.59)	3452 (33.98)
History of hyperlipidemia	116 144 (93.30)	79 315 (93.76)	24 331 (92.65)	12 028 (91.82)	82 855 (93.60)	19 895 (91.90)	9593 (94.44)
History of hypertension	123 368 (99.10)	83 867 (99.15)	26 012 (99.05)	12 957 (98.91)	87 612 (98.97)	21 575 (99.66)	10 079 (99.22)

Continued

Table 1 Continued

		Rurality				**Racial and ethnic identity**	
History of obesity	29 370 (23.59)	19 826 (23.44)	6468 (24.23)	3030 (23.13)	21 578 (24.38)	4999 (23.09)	1998 (19.67)
History of peripheral vascular disease	48 077 (38.62)	32 929 (38.93)	10 130 (38.57)	4864 (37.13)	32 813 (37.07)	9313 (43.02)	4436 (43.67)
History of renal failure	51 841 (41.64)	36 231 (42.83)	10 401 (39.60)	4864 (37.13)	32 941 (37.21)	11 786 (54.44)	5182 (51.01)
HCC Community Score, mean (SD)	2.68 (1.90)	2.68 (1.94)	2.68 (1.85)	2.68 (1.77)	2.59 (1.85)	2.98 (2.06)	2.74 (1.97)

*We were unable to categorize the rurality of 535 patients.
ADI, Area Deprivation Index; HCC, hierarchical conditional category; TIA, transient ischemic attack.

decreased to 26.23%. This was 5.92 absolute percentage points less than the overall cohort, more than twice the decrease experienced by the general rural population, and a 6.85 absolute percentage point decrease from the overall population identifying as black.

After controlling for sociodemographic factors, comorbidity and ulcer severity, rural patients remained less likely to receive specialty care than their urban counterparts (aOR 0.83, 95% CI 0.79 to 0.86; table 2, Model 4). In the same model, patients identifying as black were less likely to receive specialty care than those identifying as white (aOR 0.92, 95% CI 0.89 to 0.97). Applying an intersectionality perspective, we found a significant interaction between identifying as black and rural residence, indicating that the intersection of these two social identities diminished the likelihood of receiving specialty care (table 2, Model 5). On the multiplicative scale, the OR for rural versus urban patients identifying as black was 0.61 (95% CI 0.53 to 0.71), which was lower than the OR for rural versus urban patients identifying as white (aOR 0.85, 95% CI 0.80 to 0.89). On the additive scale, the predicted probability of receiving specialty care when diagnosed with an early stage ulcer was 8.89 absolute percentage points less among rural patients identifying as black compared with urban patients identifying as black ($p<0.05$). This rural-urban difference was more pronounced than the difference in predicted probabilities of receiving specialty care for rural compared with urban patients identifying as white presenting with early ulcer, which was only 3.25 absolute percentage points ($p<0.05$; figure 2). In a secondary analysis when categorizing rurality four ways, these results were not substantially changed (online supplemental file 1).

When stratifying by ulcer severity, we observed that patients with diabetic foot ulcers complicated by osteomyelitis or gangrene were more than twice as likely to be seen by a specialist, compared with those with early stage disease (figure 3). Rural differences in specialty care also became more pronounced; among those with osteomyelitis, there was an absolute percentage point decrease of 4.83 among rural patients compared with the overall cohort. Among those with osteomyelitis, the difference for those who identified as black compared with the overall cohort was 3.5 absolute percentage points. Observed differences were particularly pronounced for rural patients identifying as black, who experienced a 16.66 absolute percentage point decrease in specialty care when diagnosed with osteomyelitis and a 14.57 absolute percentage point decrease when diagnosed with gangrene, compared with the overall cohort. Given specialty care has been associated with reduced risk of major amputation, this difference is likely to be clinically and statistically significant.[11 31]

DISCUSSION

We observed lower proportions of specialty care among rural patients compared with the overall, national cohort

Table 2 Adjusted ORs (aORs) of receiving specialty care for rural patients and patients identifying as black.

		Specialty care,* aOR (95% CI)	
		Patient characteristic	
Model	Model variables	Rural patients	Patients identifying as black
1	Patient characteristic	0.85 (0.81 to 0.88)	1.08 (1.04 to 1.11)
2	Patient characteristic + age +sex	0.83 (0.80 to 0.87)	1.03 (0.99 to 1.07)
3	Rural residence + identifying as black+age +sex + sociodemographic factors‡	0.87 (0.84 to 0.91)	1.04 (1.01 to 1.08)
4	Rural residence + identifying as black + age +sex + sociodemographic factors‡ + comorbidities + ulcer severity	0.83 (0.79 to 0.86)	0.92 (0.89 to 0.97)
5	Rural residence + age +sex identifying as black + sociodemographic factors + comorbidities + ulcer severity + interaction (rural residence × identifying as black)	White rural 0.85 (0.80 to 0.89)	Black rural 0.61 (0.53 to 0.71)

of patients hospitalized with diabetic foot ulcers. The most striking disparity was revealed by using an intersectionality approach: only 26.23% of rural patients identifying as black were seen by a specialist. This was >5 absolute percentage points lower than the overall national cohort and the overall group identifying as black. It was nearly twice the difference experienced by rural patients in general. Given the importance of specialty care on limb salvage and our conservative comparator group, we think a >5% difference is clinically and socially meaningful.

We identified this difference in the hospitalized setting, however, the intersection of rurality and identifying as black has been associated with decreased access to medical treatment across the healthcare continuum.[32–34]

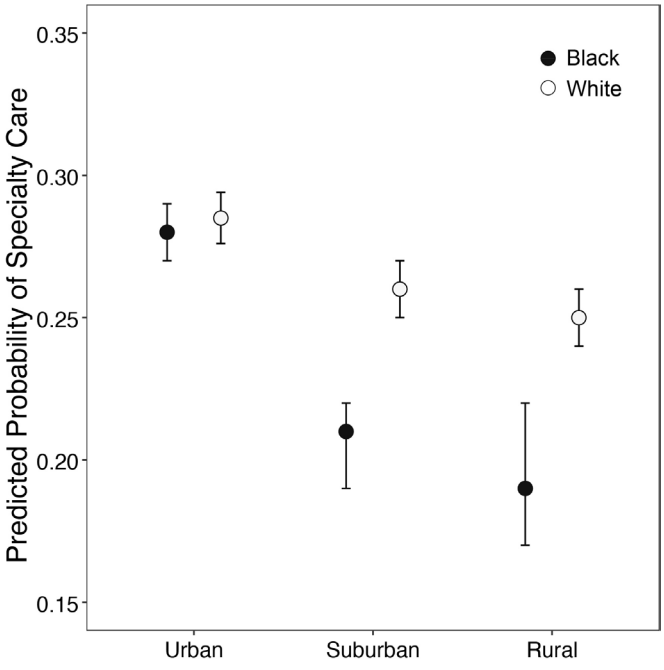

Figure 2 Predicted probabilities of receiving specialty care by social identity were calculated from Model 5 (interaction model), specifying the most common patient characteristics from this cohort (eg, a hypothetical 72-year-old patient with diabetes, hyperlipidemia, and hypertension hospitalized with an early stage ulcer).

Improving access to specialty care for rural patients in general might yield profound reductions in major amputation disparities currently faced by rural patients identifying as black.[11 35] Doing so may require policy shifts and programs to address structural inequities within the current healthcare system to either attract and retain specialists in rural, predominantly black communities or facilitate access for rural patients who identify as black to urban-based specialists. We also recognize that healthcare system inequities themselves are likely to be rooted in more long-standing social injustices. Rural educational disadvantages, which are pronounced in school systems serving predominantly black communities, are further exacerbated by migration patterns.[5] Those who remain in rural communities often face limited educational opportunities that translate into restricted employment and health insurance opportunities.[5] Local poverty and lack of insurance make the financial solvency of community hospitals challenging; while 65% of rural American counties are whole or partial health professional shortage areas, this percentage rises to 83% among rural counties with a majority of residents identifying as black.[5] Addressing disparities at the level of the health system may be a partial solution to a much more socially rooted problem.

Barriers to specialty care for rural patients hospitalized with diabetic foot ulcers regardless of race might include: limited access to providers in general and specialists in particular—especially infectious disease physicians and vascular surgeons. Compounding provider shortages are facility closures and an understaffed healthcare workforce.[1 6 8 36] The majority of multidisciplinary limb salvage teams operate in urban, tertiary care centers.[11] Rural patients are likely to have limited access to such teams.[37] More research is needed to identify the exact health system factors driving barriers to care. In addition, research on healthcare policy would be useful to help curtail rural disparities.[6 8 37–40] Currently, our healthcare policies favor large populations due to, among other things: (1) Financial marketing systems that rely on large populations of insured beneficiaries in order to provide

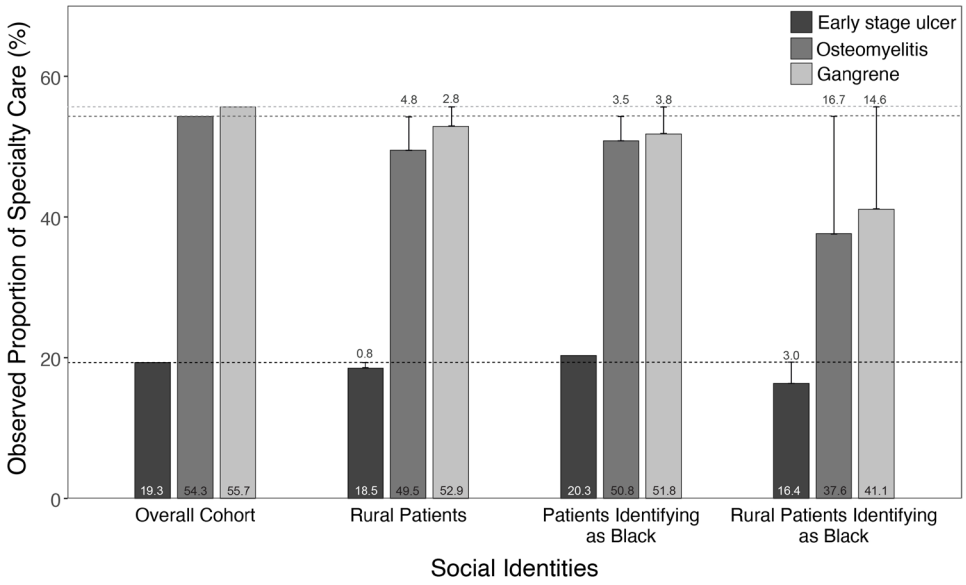

Figure 3 Observed proportion of patients who received specialty care based on social identities and stratified by ulcer severity. Dashed lines indicate the percentage of the overall cohort who received specialty care stratified by ulcer severity. Vertical bars indicate the decrease from the observed proportions of each social identity group compared with the overall cohort, with the exact percentage noted above the bar.

services, (2) Prioritization of outcomes on the national level, which shifts resource allocation to large population centers, and (3) No method of compensating for innate efficiencies in remote healthcare settings.[6] Policies that recognize and respond to these challenges facing rural communities have the potential to significantly and broadly impact rural disparities, beyond those germane to patients with diabetic foot ulcers.

Rural disparities in specialty care were larger for patients with advanced ulcers, compared with early stage ulcers. This deficit is particularly concerning because patients with osteomyelitis or gangrene are (1) At highest risk of undergoing major amputation, and (2) May be most likely to benefit from specialty care.[41] Arguably, this is the tipping point at which specialty care is critical for limb salvage. Referral systems that prioritize access to specialty care based on ulcer severity may be particularly useful.[3 5 36] Such a system hinges on frontline providers—primary care providers, urgent care clinicians, emergency medicine specialists, and general medicine admitting teams—accurately staging ulcers and diagnosing peripheral vascular disease.

Despite the strengths of using a complete Medicare population, which significantly reduces internal validity concerns, some limitations should be noted. First, the generalizability of our findings may be limited because our data set was largely composed of older adults and a Medicare-insured population. Second, our data set spanned 2013–2014 and may not reflect current trends. Contemporary referral patterns and telemedicine practices may have shifted access to specialty care, especially amid the COVID-19 pandemic.[42] However, there is evidence that the rural mortality gap, both overall and related to diabetes, is increasing.[6 43] Third, claims data may introduce misclassification bias or underestimate comorbidities, especially vascular disease. Vascular disease is underdiagnosed and undercoded since less than 25% of patients presenting with gangrenous ulcers previously carried a diagnosis of peripheral vascular disease.[44] These gaps may be larger for marginalized patients, including rural patients, who interact less with the healthcare system and simultaneously have higher rates of smoking that serves as a precursor to vascular disease.[45–47] It may also underestimate or misclassify clinician specialties as physicians may register with Medicare after completing a general residency but before completing their final, specialty fellowships.[22 23] Finally, our study investigated inpatient healthcare factors that might contribute to disparities in major amputations. However, it is unlikely that differences in healthcare delivery alone (whether delivered in the ambulatory or hospitalized setting) fully account for rural disparities in major amputations.[48–50] Future studies should explore additional social determinants of health that may underpin poor outcomes among rural patients with diabetic foot ulcers, such as educational and employment opportunities.

In conclusion, our findings indicate that rural disparities exist in healthcare delivery for hospitalized patients with diabetic foot ulcers. Specifically, a smaller proportion of rural patients receive specialty care. Racial and rural social identities overlap to amplify disparities in specialty care for rural patients identifying as black. Further research is needed to identify specific barriers to care and investigate whether addressing them will help reduce disparities in major amputations.

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Contributors All authors made substantial contributions to the conception or design of the work; acquisition, analysis, or interpretation of data for the work; drafting the work or revising it critically for important intellectual content; final approval of the version to be published; and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The principal investigator (MB) is the guarantor who accepts full responsibility for the finished work and/or the conduct of the study, had access to the data, and controlled the decision to publish.

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Competing interests None declared.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants. The University of Wisconsin Health Sciences Institutional Review Board approved this study and waived written informed consent (2021–0013). Written informed consent was waived because: (1) The study was minimal risk, (2) The study did not adversely affect study participants' rights and welfare because use of the data is not expected to affect patients from whom the data are derived, and (3) It was impractical to obtain informed consent given the national cohort size was quite large and a number of the study participants were likely to be deceased.

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Data availability statement Data are available upon reasonable request. Due to data use agreements with CMS, summary data will be made available upon reasonable request to the corresponding author.

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