Associations Between Racial and Ethnic Groups and Foot Self-Inspection in People With Diabetes

Diabetes Care 2020;43:956–963 | https://doi.org/10.2337/dc19-1486

Alyson J. Littman,[1,2,3] Catherine J. Knott,[1] Edward J. Boyko,[1,2,4] and Stephen E. Hawes[1]

OBJECTIVE

Daily foot self-inspection may permit earlier detection and treatment of a foot lesion, reducing the risk of infection and lower-limb amputation (LLA). Though race and ethnicity are strongly associated with LLA risk, with higher risk seen in African Americans (AA), American Indians/Alaska Natives (AI/AN), and Native Hawaiians/Pacific Islanders (NH/PI), associations between foot self-inspection and racial and ethnic groups are inconsistent. We aimed to assess differences in foot self-inspection among people with diabetes by race/ethnicity.

RESEARCH DESIGN AND METHODS

Using national, cross-sectional data from the 2015–2017 Behavioral Risk Factor Surveillance System surveys and including 88,424 individuals with diabetes, we estimated prevalence ratios (PRs) and associated 95% CIs of daily foot checking for sores or irritation by racial and ethnic groups using log-binomial linear regression models, after accounting for survey weights.

RESULTS

Compared with whites (who had a weighted prevalence [P] of daily foot self-inspection of 57%), AA (P 67%, PR 1.18 [95% CI 1.14, 1.23]), AI/AN (P 66%, PR 1.15 [95% CI 1.07, 1.25]), and NH/PI (P 71%, PR 1.25 [95% CI 1.03, 1.52]) had higher prevalences of daily foot self-inspection. The prevalence of daily foot inspection was significantly lower among Asians (P 35%, PR 0.62 [95% CI 0.48, 0.81]) and Hispanics (P 53%, PR 0.93 [95% CI 0.88, 0.99]) compared with whites. Associations did not vary importantly by insulin use, years since diabetes diagnosis, or having received diabetes self-management education.

CONCLUSIONS

The higher frequency of foot self-inspection in racial and ethnic groups at elevated risk of diabetes-related LLA is not sufficient to eliminate LLA disparities; additional interventions are needed to achieve this aim.

More than 30 million Americans (~1 in 10) have diabetes and are consequently at increased risk of lower-limb amputation (LLA), a preventable complication of diabetes that has substantial negative impacts on functioning and quality of life (1,2). The most common pathway to LLA in people with diabetes involves minor trauma, cutaneous ulceration, and wound-healing failure (3). Factors that contribute to wound-healing failure include neuropathy, ischemia, and infection (4). The severity of diabetic foot

[1]Department of Epidemiology, University of Washington School of Public Health, Seattle, WA
[2]Seattle Epidemiologic Research and Information Center, Department of Veterans Affairs Puget Sound Health Care System, Seattle, WA
[3]Seattle-Denver Center of Innovation for Veteran-Centered and Value-Driven Care, Health Services Research and Development, Department of Veterans Affairs Puget Sound Health Care System, Seattle, WA
[4]Department of Medicine, University of Washington School of Medicine, Seattle, WA

Corresponding author: Alyson J. Littman, alyson@uw.edu

Received 26 July 2019 and accepted 28 January 2020

This article contains Supplementary Data online at https://care.diabetesjournals.org/lookup/suppl/doi:10.2337/dc19-1486/-/DC1.

The findings and conclusion in this manuscript are those of the authors and do not necessarily represent the views of the Department of Veterans Affairs or the University of Washington.

complications and likelihood of LLA can be reduced by timely self-recognition of the early signs of diabetic foot complications and self-referral to diabetes specialists (4). Thus, current guidelines recommend patient education and daily foot monitoring (5).

There is substantial geographic and racial/ethnic variation in LLAs, indicating that socioeconomic and health care–related factors may contribute to the variation (6–9). Specifically, among people with diabetes, African Americans (AA) have LLA rates that are 1.5–4.0 times greater than rates in whites (6–8). Possible reasons for this disparity proposed include biological factors (e.g., greater prevalence of undiagnosed diabetes, more advanced diabetic neuropathy, and peripheral artery disease) and sociocultural factors (such as less aggressive treatment once symptoms develop, which may be a function of poorer access to high-quality health care, greater reliance on self-care methods, and distrust of medical treatment) (7,10). LLA rates are also elevated among American Indian/Alaska Natives (AI/AN) and Hispanics and lower among Asians compared with whites (6–8), though relatively few studies have examined rates in these subgroups, and at least one study (11) observed no association.

Experts estimate that more than half of diabetes-related foot complications could be avoided by proper preventive measures, patient education, and foot care (12). Important components of foot care include inspecting feet daily, compliance with other foot care recommendations (e.g., keeping feet clean and dry, protecting feet from temperature extremes, and wearing appropriate footwear), and rapid self-referral when problems with the foot appear. Daily feet checking may permit earlier detection and treatment of a foot lesion and is associated with reduced risk of complications and amputation (13,14).

There is a dearth of studies on factors associated with foot self-inspection. Generally, studies found that those who are at high risk (e.g., based on history of conditions such as diabetic foot ulcers) (15–18), take insulin (16,19), and have had diabetes for longer (e.g., >20 vs. <10 years) (16,19,20) were more likely to check their feet daily than those classified as low risk, though studies are not entirely consistent (21). Receipt of diabetes self-management education was associated with higher rates of foot self-inspection in several studies including two conducted in Europe (16,17) but not in one conducted in the U.S. in rural North Carolina (22). Several studies (19,23,24) have examined foot self-inspection by racial and ethnic groups, including a review article published in 2016 (25). In this review article, Mayberry et al. (25) identified eight studies published between 2011 and 2016 that examined disparities in foot self-exams. Findings were mixed; half of studies reported that non-Hispanic AA were more likely to perform regular foot checks than non-Hispanic whites, and half of studies did not observe significant differences, indicating that more research is needed.

The objective of this study was to include a population-based sample that was large enough to assess differences in foot self-inspection by racial and ethnic groups, including those that are understudied, such as AI/AN, Asians, and Native Hawaiian/Pacific Islanders (NH/PI). This information can help us to understand possible reasons for disparities in LLA risk and aid in identifying priorities for future interventions that tailor education, monitoring, and treatment for different subgroups.

RESEARCH DESIGN AND METHODS

Data Source

We used data from the Centers for Disease Control and Prevention 2015–2017 Behavioral Risk Factor Surveillance System (BRFSS) surveys. BRFSS completes >400,000 interviews each year in noninstitutionalized adults aged ≥18 years from all 50 states and territories (26). Surveys are conducted in English and Spanish. The selection and weighting methodology result in a population that is representative of the population of not only each state but also the entire U.S. A complete description of survey methodology is available online (26). Interviews include a core component, optional modules (including one for diabetes), and state-added questions. The diabetes optional module was completed by 36 states/territories in 2015, 18 states/territories in 2016, and 35 states/territories in 2017. Some states (four in 2015, four in 2016, and six in 2017) only surveyed a subset of respondents (Fig. 1). The University of Washington Institutional Review Board has determined that use of BRFSS data for research does not involve "human subjects" (as defined by federal regulations and guidance) and therefore requires neither institutional review board review nor an exempt determination.

Population

We included individuals who lived in a state/territory that included the diabetes module; reported being told by a doctor, nurse, or other health care professional that they had diabetes; and answered the questions on race and ethnicity. We excluded individuals who reported being told that they had diabetes during pregnancy only, prediabetes, or borderline diabetes or refused to answer the questions on checking their feet or on race.

Self-Reported Race/Ethnicity

The exposure of interest for this study was self-reported race and ethnicity (27). We conceptualize race as a social/cultural construct that is used by members of society to explain perceived biological differences (27,28). Categories were determined based on responses to two questions—one on race and a second on Hispanic ethnicity. The first question asked, "Which one of these groups would you say best represents your race? White, black or African American, American Indian or Alaska Native, Asian [Asian Indian, Chinese, Filipino, Japanese, Korean, Vietnamese, other Asian], Pacific Islander [Native Hawaiian, Guamanian or Chamorro, Samoan, other Pacific Islander]." Though the BRFSS collects information on Asian ethnicity (showed above in square brackets), this detailed information is not available in the national public release data. The question on Hispanic ethnicity asks, "Are you Hispanic, Latino/a, or Spanish origin?" If the answer is yes, interviewers are trained to ask respondents to specify one or more categories: Mexican, Mexican American, Chicano/a; Puerto Rican; Cuban; or another Hispanic, Latino/a, or Spanish origin. More detailed information on Hispanic ethnicity is also not released. We used a BRFSS-constructed variable that was created from the race and Hispanic ethnicity questions with eight categories: white, AA, AI/AN, Asian, NH/PI, other, multiracial, and Hispanic. Note that if someone reported being Hispanic, they were classified as Hispanic regardless of their self-reported race; thus, all categories other than Hispanic excluded those who self-identified being Hispanic (e.g., non-Hispanic white, non-Hispanic AA, etc.).

Daily Foot Inspection

Daily foot inspection was the primary outcome of this study and was determined based on responses to the question,

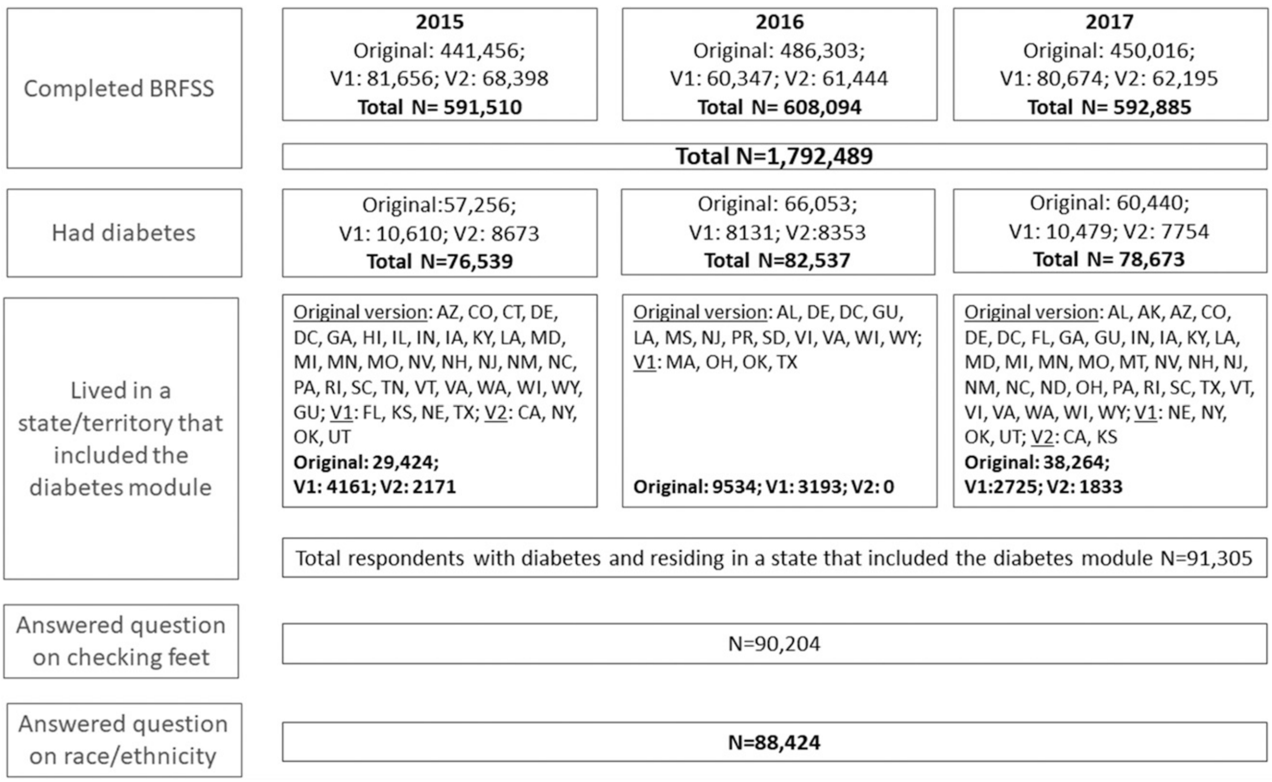

Figure 1—Numbers of individuals who completed the BRFSS in the study years and were included in analyses of the association between racial/ethnic group and checking feet in adults with diabetes. V1, Version 1; V2, Version 2.

"About how often do you check your feet for any sores or irritations? Include times when checked by a family member or friend, but do NOT include times when checked by a health professional." We created two categories: "less than once a day" and "once a day or more," with the latter being the recommended frequency. Individuals who respond "never" or "don't know/not sure" were categorized as "less than once a day" under the assumption that those who checked their feet daily would know the usual frequency. As a secondary analysis, we reclassified foot inspection as ever versus never checking feet. Those who refused to answer the question on foot inspection or reported they did not know or were not sure (n = 2,814) were dropped from this sensitivity analysis.

Covariates

We considered age (18–39, 40–49, 50–59, 60–69, ≥70 years), sex (male, female), annual household income (<\$15,000, \$15,000–\$24,999, \$25,000–\$34,999, \$35,000–\$49,999, ≥\$50,000), and education level (less than a high school degree, high school degree, some college but no degree, and college graduate) as potential confounders. Physical/mental limitations (poor mental health, disabilities, and BMI as a measure of obesity) may impair one's ability to check feet daily and differ by our exposure of interest. Poor mental health was operationalized as a diagnosis of depression (no/yes) or frequent poor mental health days. Diagnosis of depression was determined based on responses to the question, "Have you ever been told you have a depressive disorder (including depression, major depression, dysthymia, or minor depression)?" Frequent poor mental health days was determined based on response to the question, "Now thinking about your mental health, which includes stress, depression, and problems with emotions, for how many days during the past 30 days was your mental health not good?" Individuals who reported having ≥14 poor mental health days in the past 30 were classified as having frequent poor mental health. To determine the presence of a disability, we used information from the following questions: *1*) "Are you blind or do you have serious difficulty seeing, even when wearing glasses?" *2*) "Do you have serious difficulty walking or climbing stairs?" *3*) "Do you have difficulty dressing or bathing?" Individuals who reported "yes" to one or more of the three questions were classified as having a disability. BMI was categorized into four categories (<25, 25–29.9, 30–34.9, and ≥35 kg/m^2) based on self-reported weight and height.

The BRFSS diabetes module includes several questions related to diabetes, which we evaluated to describe the population and considered as potential modifiers of the association between racial and ethnic groups and foot self-inspection. We inferred diabetes type based on an approach used in other studies (29). Participants were considered to have type 2 diabetes if their age at diagnosis was at least 30 years or if their age at diagnosis was <30 years and they were currently not using insulin. Diabetes is a progressive disease, and complications (e.g., peripheral neuropathy) more frequently develop after decades. As endogenous insulin secretory capacity progressively declines with time, most people with type 2 diabetes will eventually require insulin therapy. Thus, as a proxy for diabetes severity for individuals with type 2 diabetes, we used information on diabetes duration and use of insulin.

Diabetes duration was determined based on subtraction of age at interview from age at diagnosis and categorized as follows: <5, 5–9, 10–14, 15–19, and ≥20 years. BRFSS classifies those age ≥80 years as 80 years old (regardless of their actual age), which would underestimate the true time since diagnosis among those >80 years old. Individuals classified as at least 80 years of age with an age at diagnosis of diabetes >80 years were categorized as diagnosed <5 years ago. We created categories for visits to a doctor for diabetes (0, 1, 2, 3, and ≥4 times in the previous year) based on responses to the question, "About how many times in the past 12 months have you seen a doctor, nurse, or other health professional for your diabetes?" History of taking a diabetes self-management course was dichotomized (yes/no) from responses to the question, "Have you ever taken a course or class in how to manage your diabetes yourself?"

Among individuals with type 2 diabetes, we evaluated diabetes severity (described above), frequency of visit to a doctor for diabetes, and having taken a diabetes self-management course as potential effect modifiers. We hypothesized that group differences in foot self-inspection might be reduced when stratified by a proxy for diabetes severity in those who saw a doctor more frequently and who took a diabetes self-management course.

Statistical Analyses

We first conducted descriptive analyses, assessing the frequency of daily foot inspection overall and within subgroups. In these and our analytic analyses, we accounted for the complex survey design of BRFSS as well as nonresponse by using survey commands and Centers for Disease Control and Prevention–calculated weights (30). Prevalence ratios (PRs) and associated 95% CIs were estimated using log-binomial linear regression models. We used an iterative approach to assess confounding by examining whether factors included in multivariable models changed the PR for daily foot inspection of AA, Hispanics, or AI/AN (the largest three groups other than multiracial) versus whites by ≥10%. We assessed the presence of effect modification through inclusion of interaction term(s) into multivariable models. Analyses were conducted using Stata, version 15 (College Station, TX).

RESULTS

We included 88,424 individuals with diabetes in our study: 62,175 whites, 12,793 AA, 2,120 AI/AN, 1,279 Asians, 396 Native Hawaiian/Pacific Islanders (NH/PI), 482 other, 1,671 multiracial, and 7,508 Hispanics (Table 1). There were numerous differences between groups in terms of age (e.g., 65% of NH/PI were 40–59 years old compared with 30% of whites) and sex (e.g., AA and NH/PI were more frequently female, while Asians were more frequently male) as well as other demographic characteristics. For example, a greater proportion of whites and Asians had greater educational attainment and higher incomes than other groups. A smaller percentage (20%) of Asians were obese (BMI ≥30 kg/m^2) compared with the percentage of whites who were obese (55%) and of AI/AN and AA (58%). The prevalence of poor mental health, depression, disability, and use of insulin was particularly high among AI/AN. Compared with whites, the proportion of AA, AI/AN, and NH/PI who had not had their feet checked by a doctor or other health professional in the past year was lower, while the proportion of Asians and Hispanics who had not had their feet checked in the past year was higher.

Daily foot checking differed substantially across groups: Asians had the lowest prevalence of daily foot inspection (35%) and NH/PI had the highest (71%); "other" (47%), Hispanics (53%), multiracial (55%), whites (57%), AI/AN (66%), and AA (67%) fell between these two extremes (Table 2). There was no evidence of confounding by any factors; PRs changed minimally (<10%) after adjustment for each of our a priori potential confounders; thus, unadjusted results are presented. Compared with whites, AA (PR 1.18 [95% CI 1.14, 1.23]), AI/AN (PR 1.15 [95% CI 1.07, 1.25]), and NH/PI (PR 1.25 [95% CI 1.03, 1.52]) had a 15–25% higher prevalence of daily foot inspection. The prevalence of daily foot inspection was lower among Asians (PR 0.62 [95% CI 0.48, 0.81]) and Hispanics (PR 0.93 [95% CI 0.88, 0.99]) compared with whites. Associations did not vary importantly by insulin use and years since diagnosis (Table 3). Generally, results were also similar among those who did and did not have diabetes self-management education, except for Asians, for whom the PR compared with whites was attenuated among those who had taken a diabetes self-management class. Lastly, when we considered ever versus never checking feet, associations were attenuated but similar to those for daily versus less than daily (Supplementary Table 1).

CONCLUSIONS

Results from our study indicate that groups at highest risk of LLA—AA, AI/AN, and NH/PI—were more likely to check their feet on a daily basis compared with whites. Hispanics, whose risk of LLA is greater than whites (7,8), were less likely to check their feet. Asians, who have lower rates of LLA compared with whites (31), were significantly less likely to check their feet daily.

The reasons for this paradox of more foot self-inspection among groups with higher rates of LLA are not clear, but we present the following speculative explanations. It is possible that AA, for example, are less adherent to other components of diabetes self-management, e.g., diet, medication use, smoking, exercise, and other aspects of foot care, though evidence is not consistent and suggests reverse disparities for self-monitoring of blood glucose (with AA more likely to self-monitor than whites) and no consistent differences for diet, exercise, or smoking (25). A second possible explanation for the unexpected findings may be that race/ethnicity is a marker for disease severity, family history of LLA, and/or socioeconomic status. Prior studies have found that those at high risk of complications (as determined by factors such as foot deformities, history of ulceration, or peripheral neuropathy) were more likely to check their feet (15,18), though generally people underestimated their risk (15). Several other studies have found that foot self-examinations were performed more frequently by those with longer diabetes duration (16,20), treated with insulin (16,32), and with a history of foot complications (16,17). We did not have information on history of foot complications, though it is possible that a greater proportion of AA had a personal or family history of foot complications. It may be that checking feet is a particularly salient self-care behavior among AA because of their higher risk for diabetes-related LLA. Nevertheless, when we stratified analyses based on diabetes duration and use of insulin as a marker for diabetes severity, associations were not meaningfully different across groups.

Although one might hypothesize that lower socioeconomic status would be

Table 1—Demographic and health characteristics of U.S. adults with diabetes by racial and ethnic groups: BRFSS, 2015–2017, *n* = 88,424

	White	AA	AI/AN	Asian	NH/PI	Other	Multiracial	Hispanic
n	62,175	12,793	2,120	1,279	396	482	1,671	7,508
Age (years)								
18–39	5	7	9	8	5	7	15	9
40–49	9	14	13	16	34	16	10	16
50–59	21	26	28	22	31	18	21	30
60–69	30	29	30	25	17	28	28	25
≥70	34	23	21	29	13	32	26	20
Male sex	52	44	53	59	44	56	49	49
Highest education level								
<High school	13	20	23	10	14	19	21	55
High school graduate	34	33	29	19	42	29	24	22
Some college	34	33	36	23	23	35	34	16
College degree or more	20	14	12	48	20	16	21	7
Marital status								
Married/living as married	59	40	53	74	55	46	50	63
Divorced/separated	17	25	23	7	16	16	22	19
Widowed	16	14	13	11	13	22	16	9
Never married	9	21	10	8	16	17	12	9
Annual household income								
<$15,000	12	22	25	10	13	19	17	30
$15,000–$24,999	20	27	30	21	20	25	24	29
$25,000–$34,999	13	12	9	11	9	11	14	14
$35,000–$49,999	15	13	13	5	16	14	17	11
≥$50,000	40	27	23	53	43	30	29	17
Missing	*17*	*19*	*15*	*14*	*9*	*22*	*16*	*19*
BMI (kg/m^2)								
<25†	14	12	11	32	30	13	21	14
25–29.9	31	30	34	48	25	34	23	35
30–34.9	28	27	29	15	24	24	26	26
≥35	27	31	26	5	21	29	31	24
Missing	*7*	*7*	*6*	*6*	*4*	*8*	*5*	*10*
≥14 days of poor mental health in past 30	16	17	26	8	24	18	19	17
Depression	27	23	34	15	23	30	30	24
Difficulty walking, seeing, or dressing	40	45	51	24	44	41	45	41
Type 1 diabetes‡	6	7	9	3	2	7	9	6
Missing	*6*	*12*	*6*	*5*	*3*	*10*	*6*	*7*
Years since diabetes diagnosis§								
<5	26	26	26	32	25	18	28	28
5–9	21	20	17	17	13	19	19	20
10–14	18	18	17	22	14	23	17	19
15–19	13	14	14	12	33	18	13	13
≥20	22	22	25	17	15	22	23	20
Missing	*6*	*12*	*6*	*6*	*3*	*10*	*6*	*7*
Currently taking insulin	32	35	41	20	29	32	32	31
Missing	*6*	*12*	*6*	*5*	*3*	*10*	*6*	*7*
Foot inspected by doctor in past year	75	79	79	68	85	71	71	65
Ever taken a diabetes management course	55	57	59	48	40	53	61	45

Data are weighted percentages. Percentages of missing (raw) are presented in italics for variables where at least 5% were missing. *n* (%) missing for other variables are as follows: age, *n* = 885 (1.0%); sex, *n* = 32 (0.04%); education, *n* = 315 (0.4%), marital status, *n* = 457 (0.5%); depression, *n* = 446 (0.5%); poor mental health days, *n* = 1,944 (2.2%); disability, *n* = 2,982 (3.3%); health insurance, *n* = 253 (0.3%); self-reported health, *n* = 349 (0.4%); currently taking insulin, *n* = 102 (0.1%); visits to doctor for diabetes, *n* = 3,237 (3.6%); foot checks by doctor, *n* = 2,907 (3.2%); and diabetes management class, *n* = 364 (0.4%). †Category of <25 kg/m^2 includes 484 individuals with BMI <18.5 kg/m^2. ‡Individuals were classified as having type 1 diabetes if they reported diagnosis with diabetes before age 30 years and insulin use; otherwise, individuals were assumed to have type 2 diabetes. §If respondent was ≥80 years old (age data truncated above age 80 years) and diagnosis exceeded the imputed age of the individual, years since diagnosis was recorded at <5 years. If individual's age was available (individuals <80 years) and the age of diagnosis exceeded the individual's recorded age, time since diagnosis was coded as missing.

associated with poorer self-management, studies are not consistent. For example, lower socioeconomic status at the county level has been associated with more foot self-checking. Using 2008–2010 BRFSS data from Appalachia, investigators found that patients living in "at-risk counties" (defined as having economic indicators that classified them in the 10th–25th centiles) were 41% more likely to perform daily foot checks (odds ratio 1.41 [95% CI 1.11–1.79]) than patients living in "competitive" counties (defined as

Table 2—Associations between racial/ethnic group and checking feet among adults with diabetes: BRFSS, 2015–2017

Racial/ethnic group	Weighted prevalence of checking feet one or more times/day (%)	Unadjusted PR	95% CI
White	57	1.00	Reference
AA	67	1.18	1.14, 1.23
AI/AN	66	1.15	1.07, 1.25
Asian	35	0.62	0.48, 0.81
NH/PI	71	1.25	1.03, 1.52
Other	47	0.83	0.66, 1.05
Multiracial	55	0.97	0.85, 1.11
Hispanic	53	0.93	0.88, 0.99

All groups are non-Hispanic unless otherwise noted.

those in the 75th–90th centiles) (33). The authors hypothesized that residents in the less affluent counties in Appalachia may have been practicing self-care as a compensatory behavior due to lack of access to medical care. In the current study, results were similar after adjustment for income and education, indicating that differences in foot checking by socioeconomic status cannot explain the differences observed. Furthermore, having feet checked by a health care professional in the past year was somewhat higher among AA, AI/AN, and NH/PI compared with whites.

Barriers to foot care include physical limitations (e.g., vision problems and physical disabilities that impaired accessing feet), knowledge, education (18), and psychological factors such as emotional distress (34). A study by Hernandez et al. (32) found that across racial/ethnic subgroups, lower diabetes-related distress was correlated with a higher frequency of foot care activities among AA and Latinos. We considered disability, depression, and poor mental health days as potential confounders and found that none confounded the association between racial and ethnic groups and checking feet. Furthermore, results were similar when we stratified on diabetes self-management education.

The literature with respect to variation in self-foot examination by racial and ethnic groups is not consistent, and relatively few studies have examined this question. Mayberry et al. (25) summarized the literature published between 2011 and 2016 and found that four of eight studies reported evidence of significant racial/ethnic disparities in foot self-examination; non-Hispanic AA performed regular foot self-checks more frequently than both whites and Hispanics, and Hispanics were less likely to perform foot self-exams than whites. Notably, population diversity (e.g., single states vs. multiple states), study sample size (from 100–200 to >1,000), and outcome of interest (daily foot inspection vs. never checking feet) of prior studies varied substantially, which may account for the heterogeneity in results. Few studies have investigated prevalence of foot self-examination in Asian Americans. Our results are consistent with prior research indicating lower screening rates among Asian Americans. Specifically, a large cross-sectional study found that despite their higher risk of diabetes, Asian Americans were the racial/ethnic group least likely to be screened for the presence of diabetes (35). Based on results of the current study, it appears that Asian Americans are less likely to check their feet, to have their feet checked by a health care professional, and to receive diabetes self-management education. Notably, our results stratified on diabetes self-management education indicated that among those who obtained self-management training, racial/ethnic disparities were reduced.

Major strengths of this study include its large sample size, national breadth, and inclusion of rarely studied groups. An important potential limitation is that foot inspection was self-reported and thus subject to social desirability bias. However, for overreporting of foot inspection to induce bias in PRs, whites would need to substantially underreport foot inspection and/or AA, AI/AN, and NH/PI would

Table 3—PRs (95% CI) of the association between racial/ethnic group and daily foot checking by use of insulin, years since diagnosis, and history of diabetes self-management education

	AA	AI/AN	Asian	NH/PI	Other	Multiracial	Hispanic
Use of insulin ($P = 0.24$)							
No	1.20 (1.14, 1.27)	1.14 (1.02, 1.28)	0.59 (0.41, 0.83)	1.34 (1.08, 1.66)	0.82 (0.61, 1.11)	1.00 (0.83, 1.22)	0.94 (0.87, 1.02)
Yes	1.12 (1.06, 1.18)	1.11 (0.97, 1.27)	0.74 (0.47, 1.16)	1.21 (0.84, 1.73)	1.15 (0.99, 1.34)	0.95 (0.79. 1.15)	0.95 (0.85, 1.05)
Years since diagnosis ($P = 0.39$)							
<5	1.21 (1.13, 1.32)	1.18 (1.02, 1.38)	0.69 (0.41, 1.16)	1.23 (0.82, 1.87)	0.72 (0.47, 1.12)	0.89 (0.62, 1.28)	0.91 (0.79, 1.04)
5–19	1.17 (1.10, 1.23)	1.14 (1.03, 1.27)	0.56 (0.38, 0.84)	1.31 (1.03, 1.67)	0.86 (0.62, 1.18)	1.20 (1.02, 1.42)	0.94 (0.86, 1.02)
≥20	1.17 (1.10, 1.24)	1.14 (0.95, 1.37)	0.69 (0.43, 1.11)	1.24 (0.55, 2.81)	1.21 (1.01, 1.45)	1.20 (1.02, 1.42)	0.96 (0.85, 1.09)
Diabetes self-management class ($P = 0.08$)							
No	1.21 (1.14, 1.28)	1.17 (1.03, 1.33)	0.43 (0.30, 0.61)	1.24 (0.87, 1.77)	0.82 (0.57, 1.19)	1.05 (0.87, 1.26)	0.99 (0.91, 1.08)
Yes	1.16 (1.11, 1.21)	1.14 (1.02, 1.24)	0.84 (0.63, 1.13)	1.25 (1.19, 1.53)	0.84 (0.61, 1.15)	0.92 (0.76, 1.11)	0.91 (0.83, 0.99)

Whites, non-Hispanic, are the reference group. P values are based on the Wald test.

have to substantially overreport foot inspection. We have no reason to suspect that such differential reporting exists. A second limitation relates to the substantial heterogeneity within groups, including, for example, Asians. Data from the 2017 U.S. census provide some insight into the breakdown of countries of origin for Asians living in the U.S. and indicate that 22% are Chinese, 20% are Asian Indian, 18% are Filipino, 9% are Vietnamese, 8% are Korean, 7% are Japanese, and 16% include other Asian ethnicities (e.g., Pakistani, Thai, Laotian, Hmong, etc.) (36). Furthermore, since race and ethnicity are social constructs, and many people belong to more than one group, the approach employed by BRFSS impairs our ability to better understand important social and cultural factors that may impact behaviors. Future studies should collect information to allow for better classification by ethnicity by including questions on birthplace, language, religion, and family origins as well as other cultural/behavioral factors that might contribute to differences.

In conclusion, in the largest study to our knowledge of foot self-examination to date among persons with diabetes, high-risk groups including AA, AI/AN, and NH/PI were more likely to practice this preventive behavior daily, indicating that efforts to increase foot self-examination in these populations may be effective. Nevertheless, increased self-checking does not appear to be effective in eliminating the elevated risk of LLA in these groups, as recent studies indicate that AA, AI/AN, and NH/PI remain at higher risk of diabetes-related LLA (7,8,37,38). Continued efforts are needed to develop strategies and interventions to reduce disparities in LLA.

Funding. This work was unfunded. Partial support for this research came from a *Eunice Kennedy Shriver* National Institute of Child Health and Human Development research infrastructure grant (P2C HD042828) to the Center for Studies in Demography and Ecology at the University of Washington.

Duality of Interest. E.J.B. served on an advisory board for Bayer AG. No other potential conflicts of interest relevant to this article were reported.

Author Contributions. A.J.L. conceived and designed the study, conducted the literature search, performed statistical analyses, interpreted data, and drafted and revised the manuscript. C.J.K. contributed to the analysis design, interpretation of data, and drafting and revision of the manuscript. E.J.B. and S.E.H. contributed to the analysis design, interpretation of data, and revision of the manuscript. All authors read and approved the final manuscript. A.J.L. is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

References

1. Centers for Disease Control and Prevention (CDC). Hospital discharge rates for nontraumatic lower extremity amputation by diabetes status–United States, 1997. MMWR Morb Mortal Wkly Rep 2001;50:954–958
2. Centers for Disease Control and Prevention. *National Diabetes Statistics Report*. Centers for Disease Control and Prevention, Atlanta, GA, 2017
3. Pecoraro RE, Reiber GE, Burgess EM. Pathways to diabetic limb amputation. Basis for prevention. Diabetes Care 1990;13:513–521
4. Jeffcoate WJ, Harding KG. Diabetic foot ulcers. Lancet 2003;361:1545–1551
5. American Diabetes Association. 11. Microvascular complications and foot care: *Standards of Medical Care in Diabetes—2019*. Diabetes Care 2019;42(Suppl. 1):S124–S138
6. Lefebvre KM, Lavery LA. Disparities in amputations in minorities. Clin Orthop Relat Res 2011: 469:1941–1950
7. Garcia M, Hernandez B, Ellington TG, et al. A lack of decline in major nontraumatic amputations in Texas: contemporary trends, risk factor associations, and impact of revascularization. Diabetes Care 2019;42:1061–1066
8. Tan TW, Shih CD, Concha-Moore KC, et al. Disparities in outcomes of patients admitted with diabetic foot infections [published correction appears in PLoS One 2019;14:e0215532]. PLoS One 2019;14:e0211481
9. Margolis DJ, Hoffstad O, Nafash J, et al. Location, location, location: geographic clustering of lower-extremity amputation among Medicare beneficiaries with diabetes. Diabetes Care 2011; 34:2363–2367
10. Barshes NR, Sharath S, Zamani N, Smith K, Serag H, Rogers SO. Racial and geographic variation in leg amputations among Texans. Tex Public Health J 2018;70:22–27
11. Karter AJ, Ferrara A, Liu JY, Moffet HH, Ackerson LM, Selby JV. Ethnic disparities in diabetic complications in an insured population. JAMA 2002;287:2519–2527
12. Boulton AJM, Bowling F. Diabetic foot ulcers. In *Pharmacotherapy of Diabetes: New Developments: Improving Life and Prognosis for Diabetic Patients*. Mogensen CE, Ed. Springer, Boston, MA, 2007, pp. 229–235
13. National Health Service. National Diabetes Foot Care Audit Third Annual Report: England and Wales: 14 July 2014 to 31 March 2017 [Internet], 2018. Available from https://files.digital.nhs.uk/73/39E604/ndfa-3ar-rep-1.pdf. Accessed 1 July 2019
14. Singh N, Armstrong DG, Lipsky BA. Preventing foot ulcers in patients with diabetes. JAMA 2005;293:217–228
15. Harwell TS, Helgerson SD, Gohdes D, McInerney MJ, Roumagoux LP, Smilie JG. Foot care practices, services and perceptions of risk among medicare beneficiaries with diabetes at high and low risk for future foot complications. Foot Ankle Int 2001;22:734–738
16. De Berardis G, Pellegrini F, Franciosi M, et al.; QuED Study Group-Quality of Care and Outcomes in Type 2 Diabetes. Are type 2 diabetic patients offered adequate foot care? The role of physician and patient characteristics. J Diabetes Complications 2005;19:319–327
17. Schmidt S, Mayer H, Panfil EM. Diabetes foot self-care practices in the German population. J Clin Nurs 2008;17:2920–2926
18. Matricciani L, Jones S. Who cares about foot care? Barriers and enablers of foot self-care practices among non-institutionalized older adults diagnosed with diabetes: an integrative review. Diabetes Educ 2015;41:106–117
19. White JC, Bell RA, Langefeld CD, Jackson SA. Preventive foot-care practices among adults with diabetes in North Carolina, 1997 to 2001. J Am Podiatr Med Assoc 2004;94:483–491
20. Al Sayah F, Soprovich A, Qiu W, Edwards AL, Johnson JA. Diabetic foot disease, self-care and clinical monitoring in adults with type 2 diabetes: the Alberta's Caring for Diabetes (ABCD) cohort study. Can J Diabetes 2015;39(Suppl. 3):S120–S126
21. Neil JA. Assessing foot care knowledge in a rural population with diabetes. Ostomy Wound Manage 2002;48:50–56
22. Bell RA, Arcury TA, Snively BM, et al. Diabetes foot self-care practices in a rural triethnic population. Diabetes Educ 2005;31:75–83
23. Nwasuruba C, Osuagwu C, Bae S, Singh KP, Egede LE. Racial differences in diabetes self-management and quality of care in Texas. J Diabetes Complications 2009;23:112–118
24. Nwasuruba C, Khan M, Egede LE. Racial/ethnic differences in multiple self-care behaviors in adults with diabetes. J Gen Intern Med 2007; 22:115–120
25. Mayberry LS, Bergner EM, Chakkalakal RJ, Elasy TA, Osborn CY. Self-care disparities among adults with type 2 diabetes in the USA. Curr Diab Rep 2016;16:113
26. Centers for Disease Control and Prevention. About BRFSS [Internet], 2014. Available from https://www.cdc.gov/brfss/about/index.htm. Accessed 15 April 2019
27. Dressler WW, Oths KS, Gravlee CC. Race and ethnicity in public health research: models to explain health disparities. Annu Rev Anthropol 2005;34:231–252
28. Ford CL, Airhihenbuwa CO. The public health critical race methodology: praxis for antiracism research. Soc Sci Med 2010;71:1390–1398
29. Tsai J, Ford ES, Li C, Zhao G, Balluz LS. Physical activity and optimal self-rated health of adults with and without diabetes. BMC Public Health 2010;10:365
30. Centers for Disease Control and Prevention. The Behavioral Risk Factor Surveillance System: Complex Sampling Weights and Preparing 2017 BRFSS Module Data for Analysis [Internet], 2018. Available from https://www.cdc.gov/brfss/annual_data/2017/pdf/Complex-Smple-Weights-Prep-Module-Data-Analysis-2017-508.pdf. Accessed 2 April 2019
31. Young BA, Maynard C, Reiber G, Boyko EJ. Effects of ethnicity and nephropathy on lower-extremity amputation risk among diabetic veterans. Diabetes Care 2003;26:495–501
32. Hernandez R, Ruggiero L, Riley BB, et al. Correlates of self-care in low-income African American and Latino patients with diabetes. Health Psychol 2014;33:597–607
33. Sohn M-W, Kang H, Park JS, et al. Disparities in recommended preventive care usage among

persons living with diabetes in the Appalachian region. BMJ Open Diabetes Res Care 2016;4: e000284
34. Shin N, Hill-Briggs F, Langan S, Payne JL, Lyketsos C, Golden SH. The association of minor and major depression with health problem-solving and diabetes self-care activities in a clinic-based population of adults with type 2 diabetes mellitus. J Diabetes Complications 2017;31:880–885
35. Tung EL, Baig AA, Huang ES, Laiteerapong N, Chua KP. Racial and ethnic disparities in diabetes screening between Asian Americans and other adults: BRFSS 2012-2014. J Gen Intern Med 2017;32:423–429
36. United States Census Bureau. American FactFinder [Internet]. Available from https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_17_5YR_DP05&prodType=table. Accessed 7 October 2019
37. Rizzo JA, Chen J, Laurich C, et al. Racial disparities in PAD-related amputation rates among Native Americans and non-Hispanic whites: an HCUP analysis. J Health Care Poor Underserved 2018;29:782–800
38. Suckow BD, Newhall KA, Bekelis K, et al. Hemoglobin A1c testing and amputation rates in black, Hispanic, and white medicare patients. Ann Vasc Surg 2016;36:208–217