



Prevalence of and Racial Disparities in Risk Factor Control in Older Adults With Diabetes: The Atherosclerosis Risk in Communities Study

Christina M. Parrinello,¹ Ina Rastegar,^{1,2}
Job G. Godino,^{1,3} Michael D. Miedema,⁴
Kunihiro Matsushita,¹ and
Elizabeth Selvin^{1,5}

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OBJECTIVE

Controversy surrounds appropriate risk factor targets in older adults with diabetes. We evaluated the proportion of older adults with diabetes meeting different targets, focusing on possible differences by race, and assessed whether demographic and clinical characteristics explained disparities.

RESEARCH DESIGN AND METHODS

We conducted a cross-sectional study of 5,018 participants aged 67–90 years (1,574 with and 3,444 without diagnosed diabetes) who attended visit 5 of the Atherosclerosis Risk in Communities (ARIC) Study (2011–2013). Risk factor targets were defined using both stringent (and less stringent) goals: hemoglobin A_{1c} (HbA_{1c}) <7%, or <53 mmol/mol (<8%, <64 mmol/mol); LDL cholesterol (LDL-c) <100 mg/dL (<130 mg/dL); and blood pressure (BP) <140/90 mmHg (<150/90 mmHg). We used Poisson regression to obtain prevalence ratios (PRs).

RESULTS

Most older adults with diabetes met stringent (and less stringent) targets: 72% (90%) for HbA_{1c}, 63% (86%) for LDL-c, and 73% (87%) for BP; but only 35% (68%) met all three. A higher proportion of whites than blacks met targets, however defined. Among people treated for risk factors, racial disparities in prevalence of meeting stringent targets persisted even after adjustment: PRs (whites vs. blacks) were 1.03 (95% CI 0.91, 1.17) for HbA_{1c}, 1.21 (1.09, 1.35) for LDL-c, 1.10 (1.00, 1.21) for BP, and 1.28 (0.99, 1.66) for all three. Results were similar but slightly attenuated using less stringent goals. Black women were less likely than white women to meet targets for BP and all three risk factors; this disparity was not observed in men.

CONCLUSIONS

Black-white disparities in risk factor control in older adults with diabetes were not fully explained by demographic or clinical characteristics and were greater in women than men. Further study of determinants of these disparities is important.

¹Department of Epidemiology and the Welch Center for Prevention, Epidemiology and Clinical Research, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD

²Baltimore Polytechnic Institute, Baltimore, MD

³Department of Epidemiology and the Center on Aging and Health, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD

⁴Minneapolis Heart Institute and Minneapolis Heart Institute Foundation, Minneapolis, MN

⁵Division of General Internal Medicine, Department of Medicine, Johns Hopkins University, Baltimore, MD

Corresponding author: Elizabeth Selvin, eselvin@jhu.edu.

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The prevalence of type 2 diabetes in adults aged 65 years or older in the U.S. is ~20–25% (1–3). There is currently much controversy regarding the best approaches to treatment and management of diabetes in older adults, particularly appropriate targets for glycemic and cardiovascular risk factor control (4–6).

Randomized clinical trials have demonstrated that in adults with diabetes, lowering hemoglobin A_{1c} (HbA_{1c}) and blood pressure (BP) reduces the risk of microvascular disease, and controlling BP and lipids reduces cardiovascular disease (CVD) risk (7,8). Citing evidence that simultaneously controlling multiple risk factors reduces CVD risk (9,10), the American Diabetes Association (ADA) has established targets for three key modifiable risk factors for people with diabetes: HbA_{1c} <7% (<53 mmol/mol); LDL cholesterol (LDL-c) <100 mg/dL; and systolic BP (SBP) <140 mmHg and diastolic BP (DBP) <90 mmHg (11).

Previous studies have shown that ~20–30% of adults of all ages with diagnosed diabetes in the general population meet all three risk factor targets and that this proportion has increased over the past decade (12–14). Nonetheless, there is evidence for disparities in risk factor control in racial/ethnic minorities compared with whites (12,15–18). Characterizing risk factor control in older adults is particularly important since treatment targets are especially controversial (4,19). The evidence base for current treatment targets comes largely from randomized clinical trials in middle-aged adults. These findings may not apply to older adults with diabetes who may not live long enough to experience the full microvascular benefits of tight glycemic control. Further, adverse effects of pharmacologic treatment and tight control are of particular concern in older adults (20–22). Indeed, hypoglycemia is one of the most common side effects of glucose-lowering treatment and is associated with substantial morbidity and mortality (23–26). In older adults, the risks of stringent glycemic control, in particular, may outweigh the benefits. Individualized, less stringent risk factor targets have been proposed for older adults, for whom the presence of comorbidities and functional status varies greatly (4,11).

We conducted a cross-sectional study in community-dwelling older adults with diabetes to 1) evaluate the prevalence of glycemic, lipid, and BP control, overall and by race (black or white), and 2) to investigate correlates of meeting treatment targets and evaluate if racial differences in risk factor control could be explained by demographic and clinical characteristics.

RESEARCH DESIGN AND METHODS

Study Population

The Atherosclerosis Risk in Communities (ARIC) Study is a community-based cohort of 15,792 participants recruited from Forsyth County, NC; Jackson, MS; Minneapolis, MN; and Washington County, MD (27). Visits 1–5 took place from 1987 to 1989, 1990 to 1992, 1993 to 1995, 1996 to 1998, and 2011 to 2013, respectively. Institutional review boards at each site approved all procedures, and all study participants provided written informed consent.

There were 6,538 ARIC participants who attended visit 5 (2011–2013) (all participants were >65 years of age at the time of this visit). We excluded participants who were nonwhite or non-black ($n = 18$), missing key covariates (additional $n = 1,295$), or not fasting for ≥ 8 h (additional $n = 207$), resulting in 5,018 participants. Our primary analysis was restricted to participants with diagnosed diabetes ($n = 1,574$). We identified people as having diagnosed diabetes if they self-reported a physician diagnosis of diabetes or use of glucose-lowering medication at any of the first four visits or during any of the annual telephone calls conducted after visit 4 or if they were taking any glucose-lowering medications at the visit 5 examination (Supplementary Fig. 1). Self-reported diabetes in the ARIC Study has been previously reported to have moderate sensitivity (>55%), high specificity (>80%), and high reliability (>92%) (28).

Laboratory Measurements

HbA_{1c} was measured in whole blood samples using a Tosoh G7 automated analyzer (Tosoh Medics, Inc., San Francisco, CA) using a high-performance liquid chromatography method standardized to the Diabetes Control and Complications Trial assay. LDL-c was calculated using the Friedewald equation, which includes total cholesterol, HDL

cholesterol, and triglycerides, all of which were measured in stored plasma samples by an enzymatic method using a Beckman Coulter Olympus AU 480 (Beckman Coulter, Inc., Brea, CA). Serum creatinine was measured using a Jaffe reaction, which is a colorimetric method, also on the Beckman Coulter Olympus AU 480 (Beckman Coulter, Inc.).

Additional Variables of Interest

The following characteristics were self-reported during visit 5, unless stated otherwise: age; race/ethnicity; sex; alcohol consumption; current smoking status; education level (asked at visit 1); physical activity level, assessed using the sport index of the Baecke physical activity questionnaire (29); household income; health insurance coverage besides Medicare; self-rated health; and use of glucose-lowering, cholesterol-lowering, and antihypertensive medications. Diabetes duration was calculated as the amount of time between the date of the first report of either physician diagnosis of diabetes or glucose-lowering medication use and the date of the visit 5 exam. BMI was calculated as measured weight (in kilograms) divided by measured height (in meters squared). SBP and DBP were recorded as the mean of the second and third readings.

Physical function was assessed using the Short Physical Performance Battery (SPPB), with higher scores indicating better function (30–32). Functional disability status was defined as self-reported difficulty completing 1 of 12 tasks, based on questionnaires administered during the annual and semiannual phone calls prior to visit 5 (33–36). Reduced renal function was defined as creatinine-based estimated glomerular filtration rate (eGFR) <60 mL/min/1.73 m² (37). Prevalent CVD was defined as history of coronary heart disease, stroke, or heart failure as determined by either self-reported history at visit 1 or an adjudicated event at or prior to the visit 5 exam.

Statistical Analysis

Stringent risk factor targets were defined using 2015 ADA-recommended cut points: glycemic control, HbA_{1c} <7.0% (<53 mmol/mol); lipid control, LDL-c <100 mg/dL; and BP control, SBP <140 and DBP <90 mmHg (11). Less stringent targets were defined as

follows: HbA_{1c} <8% (<64 mmol/mol); LDL-c <130 mg/dL; and SBP <150 and DBP <90 mmHg (11,38–40). We compared characteristics of people with and without diabetes, separately, further stratifying those with diabetes by glucose-lowering medication use. We used Student *t* tests for comparisons of continuous variables and χ^2 tests for comparisons of categorical variables. All subsequent analyses were restricted to people with diabetes. We calculated the prevalence of risk factor control (i.e., proportion of people meeting treatment targets) in people with diabetes, overall and stratified by race and sex. We used Poisson regression models with robust variance to assess unadjusted associations of demographic and clinical characteristics with meeting risk factor targets, and to obtain prevalence ratios (PRs) and 95% CIs for meeting treatment targets in whites versus blacks. We compared four models. Model 1 was adjusted for age (years) and sex (male or female). Model 2 was adjusted for all variables in model 1 plus annual household income (<\$25,000, \$25,000 to <\$50,000, \geq \$50,000, or not reported), education level (<high school, high school or college, or >college), and health insurance status in addition to Medicare (yes or no). Model 3 was adjusted for all variables in model 2 plus cigarette smoking status (current, former, never, or indeterminate), alcohol consumption (current, former, or never), physical activity, BMI (kg/m²), prevalent CVD (yes or no), self-rated health (fair to poor or good to excellent), eGFR <60 mL/min/1.73 m² (yes or no), any functional disability (yes or no), physical function, and duration of diabetes (years). Model 4 was adjusted for all variables in model 3 plus medication use (glucose-lowering, cholesterol-lowering, and BP-lowering medication use) for risk factors other than the outcome of interest (e.g., adjusted for cholesterol-lowering and BP-lowering medication use in analyses of glycemic control). In model 4, we tested the statistical significance of the inclusion of the interaction between race and sex using a Wald test.

We conducted analyses in all people with diabetes, regardless of medication use, as well as restricted to people with diabetes who were treated for each risk factor. As a sensitivity analysis, we

calculated the prevalence of meeting risk factor targets by duration of diabetes (<5, 5–15, and \geq 15 years).

All analyses were conducted using Stata version 13.0 (College Station, TX).

RESULTS

Characteristics of the Study

Population

Among the 5,018 participants with complete data at visit 5, 1,574 (31%) had diagnosed diabetes. Among people with diagnosed diabetes, the mean age was 75 years (SD 5.0; range 67–89 years), 44% were male, and 29% were black. People with diabetes were more likely to be taking cholesterol- or BP-lowering medications compared with people without diabetes ($P < 0.01$). Among people with diabetes, those who were taking glucose-lowering medication were more likely to be black, male, and obese and have lower education or income compared with those not taking glucose-lowering medication ($P < 0.05$ for all) (Table 1). Additionally, 24% of people with treated diabetes were taking insulin.

Unadjusted Prevalence of Meeting Risk Factor Targets

Among all people with diabetes, the percentage of those who met stringent (and less stringent) targets were 72% (90%) for HbA_{1c}, 63% (86%) for LDL-c, 73% (87%) for BP, and 35% (68%) for simultaneous control of all three risk factors. Among people who were pharmacologically treated for the individual risk factors, the percentages were 59% (85%) for HbA_{1c}, 75% (93%) for LDL-c, 71% (85%) for BP, and 37% (70%) for all three. Overall, whites were more likely than blacks to meet risk factor targets for any of the three risk factors (Fig. 1A and Supplementary Table 5). Racial disparities were similar among people who were taking glucose-, cholesterol-, or BP-lowering medication, although the association of race with control of HbA_{1c} was not statistically significant in treated people (Fig. 1B and Table 2).

Of the race-sex groups, black women were least likely to have risk factors that were at or below treatment targets (Fig. 1C). Indeed, greater black-white disparities in risk factor control were observed in women as compared with men (Fig. 1C). Patterns in race-sex differences were similar when restricting analyses to people with diabetes who were treated for risk factors (Fig. 1D).

People with diabetes of \geq 15 years duration were less likely to meet treatment targets for BP and HbA_{1c} compared with people with a shorter duration of diabetes (Supplementary Fig. 2A).

Correlates of Meeting Targets in Older Adults with Diabetes Who Were Pharmacologically Treated for Risk Factors

Older people with diabetes who met risk factor targets were generally more likely to be male, to be white, to have a higher income, to have higher physical function scores, and to have diabetes for a shorter duration (Table 3). These patterns were similar when using less stringent cut points (Supplementary Table 1) (see Supplementary Tables 2 and 3 for study population characteristics stratified by whether meeting stringent or less stringent targets).

In unadjusted models, black-white disparities were statistically significant for meeting all targets except for HbA_{1c} (white vs. black: PR 1.10 [95% CI 0.98, 1.23] for HbA_{1c}, 1.22 [1.11, 1.34] for LDL-c, 1.18 [1.08, 1.28] for BP, and 1.46 [1.15, 1.85] for all three). In fully adjusted models, whites remained more likely to meet LDL-c targets as compared with blacks (PR 1.21 [1.09, 1.35]) (Table 2). There was evidence of a statistical interaction of race and sex with meeting targets for BP and all three risk factors simultaneously (P values for interaction were 0.08 and 0.03, respectively). Among men, there was no significant difference in meeting BP targets in whites versus blacks (PR 0.98 [0.86, 1.13]) (Supplementary Table 4). However, white women were more likely than black women to meet BP targets (PR 1.18 [1.04, 1.35]) (Supplementary Table 4). Likewise, the prevalence of meeting targets for all three risk factors simultaneously was similar in white and black men (PR 0.95 [0.69, 1.32]), whereas white women were more likely than black women to meet all three targets (1.58 [1.08, 2.32]) (Supplementary Table 4). Results in all people with diabetes regardless of medication use were similar (Supplementary Table 5).

When using less stringent cut points, adjusted associations of race (white vs. black) with meeting risk factor targets were marginally significant for HbA_{1c} (PR 1.07 [95% CI 1.00, 1.15]) and

Table 1—Study population characteristics, ARIC visit 5 (2011–2013)

| | No history of diagnosed diabetes (n = 3,444) | | Diagnosed diabetes | | |
|--|--|----------|--|---|----------|
| | Mean (SD) or % | P value* | No glucose-lowering medication (n = 569) | Current glucose-lowering medication (n = 1,005) | |
| | | | Mean (SD) or % | Mean (SD) or % | P value† |
| Age, years | 75.4 (5.1) | 0.16 | 75.7 (5.3) | 75.0 (4.9) | 0.01 |
| White | 82.4 | <0.01 | 80.5 | 65.8 | <0.01 |
| Male | 40.3 | 0.03 | 40.1 | 45.5 | 0.04 |
| <High school education | 10.7 | <0.01 | 14.6 | 18.9 | 0.03 |
| Annual household income <\$25,000 | 22.2 | <0.01 | 26.5 | 33.9 | <0.01 |
| Health insurance in addition to Medicare | 89.0 | <0.01 | 86.3 | 83.1 | 0.09 |
| Self-rated health \geq good‡ | 92.5 | <0.01 | 85.8 | 79.5 | <0.01 |
| Current alcohol consumption | 55.0 | <0.01 | 49.0 | 35.7 | <0.01 |
| Current smoking | 5.7 | 0.96 | 5.8 | 5.6 | 0.85 |
| Obese (BMI \geq 30 kg/m ²) | 28.8 | <0.01 | 38.7 | 52.9 | <0.01 |
| HbA _{1c} , % | 5.6 (0.4) | <0.01 | 5.9 (0.6) | 7.0 (1.2) | <0.01 |
| HbA _{1c} , mmol/mol | 38.2 (4.3) | <0.01 | 40.8 (6.4) | 52.5 (12.6) | <0.01 |
| LDL-c, mg/dL | 109.2 (34.1) | <0.01 | 101.3 (32.7) | 88.1 (32.1) | <0.01 |
| SBP, mmHg | 130.1 (17.3) | 0.65 | 128.6 (18.1) | 130.5 (18.6) | 0.05 |
| DBP, mmHg | 67.2 (10.4) | <0.01 | 65.6 (10.8) | 65.0 (10.4) | 0.23 |
| % meeting stringent targets | | | | | |
| HbA _{1c} <7% (<53 mmol/mol) | 99.4 | <0.01 | 95.8 | 59.2 | <0.01 |
| LDL-c <100 mg/dL | 41.7 | <0.01 | 52.6 | 69.7 | <0.01 |
| SBP <140 and DBP <90 mmHg | 73.5 | 0.57 | 75.2 | 71.3 | 0.10 |
| All three | 31.2 | <0.01 | 38.7 | 33.5 | 0.04 |
| % meeting less stringent targets | | | | | |
| HbA _{1c} <8% (<64 mmol/mol) | 100.0 | <0.01 | 99.3 | 85.4 | <0.01 |
| LDL-c <130 mg/dL | 74.9 | <0.01 | 79.3 | 89.8 | <0.01 |
| SBP <150 and DBP <90 mmHg | 86.5 | 0.90 | 87.7 | 86.1 | 0.36 |
| All three | 65.1 | 0.02 | 70.0 | 67.5 | 0.31 |
| Medication use | | | | | |
| Glucose lowering | N/A | N/A | 0 | 100 | <0.01 |
| Cholesterol lowering | 48.1 | <0.01 | 59.9 | 75.0 | <0.01 |
| BP lowering | 60.5 | <0.01 | 76.3 | 85.6 | <0.01 |
| All of the above | N/A | N/A | 0 | 66.6 | <0.01 |
| Baecke sport index | 2.7 (0.8) | <0.01 | 2.5 (0.8) | 2.4 (0.7) | 0.10 |
| Any functional disability | 47.8 | <0.01 | 61.2 | 66.5 | 0.03 |
| Physical function score (SPPB) | 9.6 (2.3) | <0.01 | 9.1 (2.6) | 8.5 (2.8) | <0.01 |
| Prevalent CVD | 15.7 | <0.01 | 22.7 | 27.0 | 0.06 |
| eGFR <60 mL/min/1.73 m ² | 25.5 | <0.01 | 32.0 | 33.7 | 0.48 |
| Duration of diabetes | | | | | |
| <5 years | N/A | N/A | 28.3 | 18.8 | <0.01 |
| 5–15 years | N/A | | 65.0 | 54.1 | |
| \geq 15 years | N/A | | 6.7 | 27.1 | |

P values were calculated using Student *t* tests for continuous variables and χ^2 tests for categorical variables. N/A, not applicable. *P value for people with vs. without diabetes; †P value for people treated with glucose-lowering medication vs. untreated; ‡Good, very good, or excellent (vs. fair or poor).

statistically significant for LDL-c (1.06 [1.01, 1.11]) (Supplementary Table 6). Results were similar in all participants with diabetes, regardless of whether or not they were treated for risk factors (PRs ranged from 1.04 to 1.10 and *P* values ranged from 0.01 to 0.21) (Supplementary Table 7).

CONCLUSIONS

Each of the stringent (ADA 2015) targets for HbA_{1c}, LDL-c, or BP was met by

approximately two-thirds of older adults with diabetes in the ARIC Study. However, only about one-third of older adults met targets for all three risk factors. A much larger proportion of older adults with diabetes met less stringent risk factor targets. Whites were more likely to meet LDL-c targets than blacks. Adjustment for demographic and clinical characteristics, including functional status and comorbidities, did not appreciably change

the association of race with meeting targets. There were also sex differences in racial disparities for meeting risk factor targets. Among women, whites were more likely than blacks to meet targets for BP and for all three risk factors simultaneously; however, these racial disparities were not observed in men.

Comparing treated versus untreated people, the prevalence of meeting targets was lower for HbA_{1c} and higher for

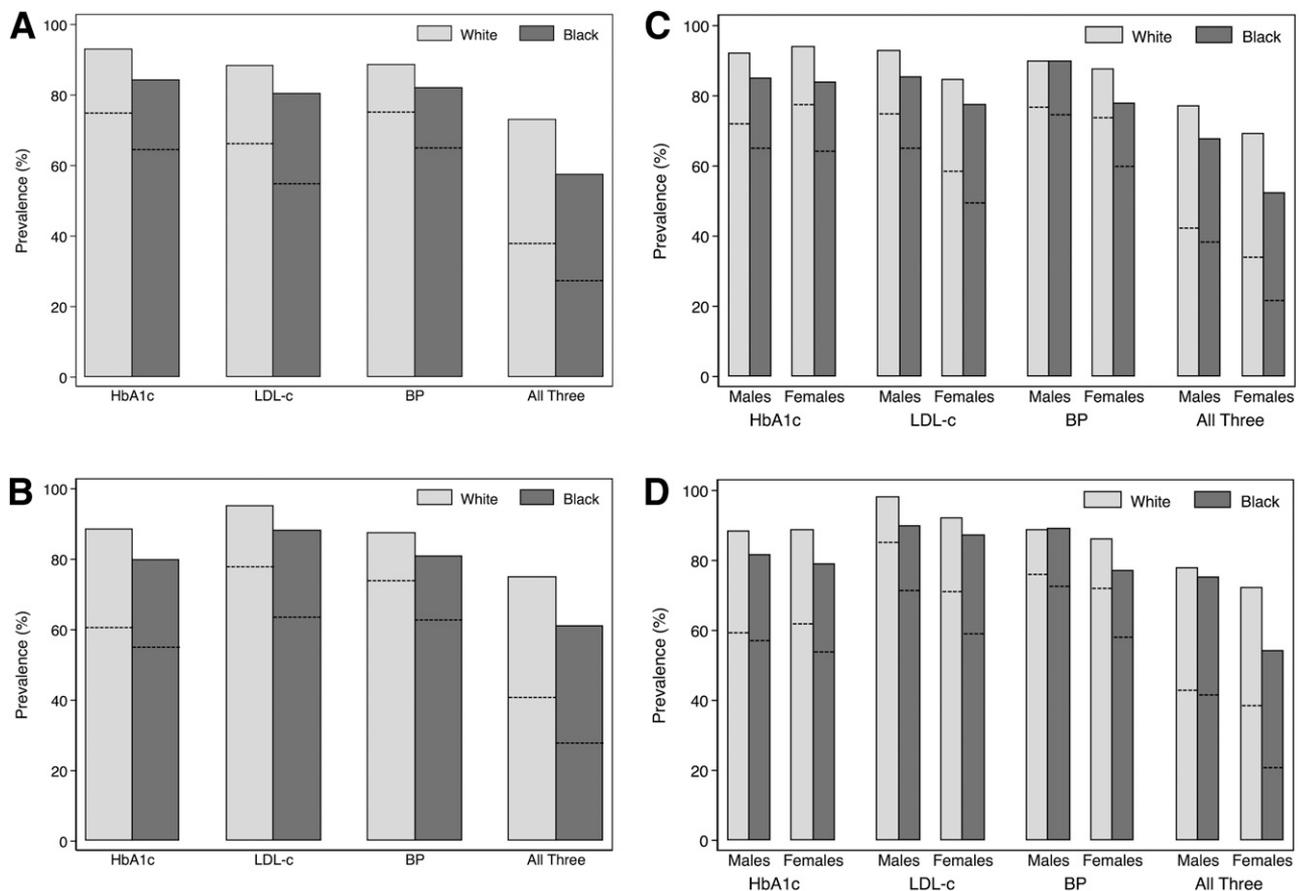


Figure 1—Prevalence of meeting risk factor targets in older adults with diabetes. Stringent targets were HbA_{1c} <7% (<53 mmol/mol), LDL-c <100 mg/dL, SBP <140 mmHg, and DBP <90 mmHg. Less stringent targets were HbA_{1c} <8% (<64 mmol/mol), LDL-c <130 mg/dL, SBP <150 mmHg, and DBP <90 mmHg. Bars indicate the proportion of participants meeting less stringent targets. Dashed lines indicate the proportion of participants meeting stringent targets. **A:** By race, according to either stringent or less stringent risk factor targets. $n = 1,119$ white and $n = 455$ black participants. **B:** By race, according to either stringent or less stringent risk factor targets, and restricted to people pharmacologically treated for risk factors. $n = 661$ white and $n = 344$ black participants treated for glucose; $n = 800$ white and $n = 295$ black participants treated for lipids; $n = 880$ white and $n = 414$ black participants treated for BP; $n = 443$ black and $n = 226$ white participants treated for all three risk factors. **C:** By race and sex, according to either stringent or less stringent risk factor targets. $n = 528$ white male, $n = 157$ black male, $n = 591$ white female, and $n = 298$ black female participants. **D:** By race and sex, according to either stringent or less stringent risk factor targets, and restricted to people pharmacologically treated for risk factors. $n = 339$ white male, $n = 118$ black male, $n = 322$ white female, and $n = 226$ black female participants treated for glucose; $n = 384$ white male, $n = 107$ black male, $n = 416$ white female, and $n = 188$ black female participants treated for lipids; $n = 414$ white male, $n = 134$ black male, $n = 466$ white female, and $n = 280$ black female participants treated for BP; $n = 228$ white male, $n = 76$ black male, $n = 215$ white female, and $n = 150$ black female participants treated for all three risk factors.

LDL-c. Glucose-lowering medication may be a marker of disease severity, and we therefore observed worse glycemic control in people who were treated compared with those who were being managed with diet and/or lifestyle only. In contrast, the large majority of ARIC participants with diagnosed diabetes at visit 5 (70%) reported using cholesterol-lowering medications, and we observed lower LDL-c levels in treated people. Furthermore, a higher proportion of people reporting use of cholesterol-lowering medications had a history of CVD. Guidelines suggest more aggressive treatment targets for

LDL-c in people with a history of CVD, which could have also contributed to our observation of lower lipid levels in treated participants.

Our findings extend those from previous studies that have reported racial and socioeconomic disparities in risk factor control in people with diabetes. Studies conducted in middle-aged (17,18,41,42) and older (43) adults with diabetes have shown that ethnic minority populations are less likely to meet glycemic, lipid, or BP targets. In a recent analysis of adults of all ages with diabetes from the National Health and Nutrition Examination Survey, white

race (compared with black race) was associated with meeting HbA_{1c} targets, and a higher level of education was associated with meeting targets for HbA_{1c} and BP (16). However, in contrast to our study, the authors reported no associations of race or education with lipid control (16). Furthermore, the authors suggested that racial disparities in glycemic control have increased over the past couple of decades and may be driven by improved glycemic control in people with higher education levels, whereas rates of glycemic control have remained stable in people with less than a high school education (16).

Table 2—Adjusted associations of race (white vs. black) with meeting stringent risk factor targets* among participants treated for risk factors

| | HbA _{1c} (n = 1,005) | LDL-c (n = 1,095) | BP (n = 1,294) | HbA _{1c} , LDL-c, and BP (n = 669) |
|------------|---|---|---|---|
| | PR (95% CI) for being at target for white vs. black | PR (95% CI) for being at target for white vs. black | PR (95% CI) for being at target for white vs. black | PR (95% CI) for being at target for white vs. black |
| Unadjusted | 1.10 (0.98, 1.23) | 1.22 (1.11, 1.34) | 1.18 (1.08, 1.28) | 1.46 (1.15, 1.85) |
| Model 1 | 1.09 (0.97, 1.22) | 1.19 (1.09, 1.31) | 1.18 (1.08, 1.28) | 1.39 (1.09, 1.76) |
| Model 2 | 1.03 (0.91, 1.17) | 1.16 (1.05, 1.29) | 1.13 (1.03, 1.24) | 1.30 (1.00, 1.68) |
| Model 3 | 1.05 (0.92, 1.19) | 1.18 (1.06, 1.31) | 1.11 (1.00, 1.22) | 1.28 (0.99, 1.66) |
| Model 4 | 1.03 (0.91, 1.17) | 1.21 (1.09, 1.35) | 1.10 (1.00, 1.21) | N/A |

Used Poisson regression with robust variance (sandwich estimator) to obtain PRs. Bolded results are statistically significant ($P < 0.05$). Model 1 was adjusted for age and sex. Model 2 was adjusted for all variables in model 1 plus income, education, and health insurance. Model 3 was adjusted for all variables in model 2 plus smoking status, alcohol consumption, physical activity, BMI, prevalent CVD, self-rated health, eGFR < 60 mL/min/1.73 m², any functional disability, physical function score, and diabetes duration. Model 4 was adjusted for all variables in model 3 plus glucose-lowering medication use, cholesterol-lowering medication use, and BP-lowering medication use (if not the risk factor of interest). N/A, not applicable. *At target defined as follows: HbA_{1c} $< 7\%$ (< 53 mmol/mol); LDL-c < 100 mg/dL; SBP < 140 and DBP < 90 mmHg.

However, in our study of older adults with diabetes, we did not find that educational differences entirely explained racial differences in risk factor control. There could be racial differences in access to health care or treatment approaches, as well as medication adherence, which could contribute to the observed racial disparities in risk factor control.

Previous studies have also reported sex differences in risk factor control. A recent study of veterans with diabetes found that women had higher lipid levels than men and were less likely to be on cholesterol-lowering medication (44), and another found that among adults with diabetes, women had worse control of cardiovascular risk factors than men (45). Our study extends these findings and suggests there may be important sex disparities in approaches and/or adherence to care.

Some guidelines, such as those from the American Geriatrics Society, recommend different treatment targets based on age or comorbidity status (39,46). Heterogeneity in risk of complications is clearly important in older adults. Many older adults may not reap the full benefits of tight risk factor control, particularly glycemic control, and may be overtreated. Older adults may be at particularly high risk of hypoglycemia and/or hypotension, and risks of tight treatment targets may outweigh the benefits. The competing risk of death and other conditions may make an emphasis on microvascular disease prevention less relevant. Whereas there was

evidence from the Steno-2 Study that simultaneous tight control of all three risk factors reduced the risk of vascular complications and death in middle-aged adults (10), the Action to Control Cardiovascular Risk in Diabetes (ACCORD) trial reported that intensive treatment to low glucose targets did not reduce the risk of cardiovascular events and actually increased the risk of mortality (22). There is growing emphasis on the need for individualized treatment targets but it is unclear how to optimize treatment in older adults to maximize health benefits and minimize adverse outcomes (47–49). It remains unclear whether and how to most appropriately consider less stringent treatment targets in older adults.

There are several limitations that should be considered in the interpretation of our results. We used risk factor treatment targets recommended by the ADA in 2015. However, BP targets have changed over the past several years and were different at the time of participation in visit 5 of the ARIC Study, from 2011 to 2013. Therefore, participants may have actually been treated to lower BP targets during that time period. The large majority of black participants in the ARIC Study were recruited from two of four study sites (Jackson, MS and Forsyth County, NC). Thus, we cannot definitively separate race and geographic differences. We were also unable to fully account for potential racial differences in access to health care, treatment approaches, or medication adherence. This was a cross-sectional study, and attrition

(loss to follow-up) resulting in selection bias is a salient concern. People with poorly controlled diabetes and severe comorbidities may have been less likely to attend ARIC visit 5 than their healthier counterparts and would not have been included in this study. Indeed, cross-sectional studies have found older adults to have better risk factor control than younger individuals (12,14,50,51). Strengths of this study include the large, biethnic community-based population of older adults in the contemporary era and the rigorous measurement of diabetes and cardiovascular risk factors. Our results are highly relevant and may be generalizable to other contemporary community-dwelling populations of older adults living with diabetes.

Among older adults with diabetes, the association of race with meeting targets for lipids was not fully explained by demographic and clinical characteristics. Our results suggest a need to improve care in ethnic minorities, particularly black women, to narrow this racial disparity. However, older adults are a heterogeneous group, and the benefit of treatment to very low risk factor targets is unclear. To define appropriate treatment approaches and risk factor targets in older adults with diabetes, randomized clinical trials in this population may be needed. Additional studies should examine the effects of treating to tight versus less stringent risk factor targets on macrovascular and microvascular outcomes and mortality and should include people with comorbidities to assess the

Table 3—Unadjusted associations of participant characteristics with meeting stringent risk factor targets* in participants with diagnosed diabetes treated for risk factors

| | HbA _{1c} (n = 1,005) | LDL-c (n = 1,095) | BP (n = 1,294) | HbA _{1c} , LDL-c, and BP (n = 669) |
|---|---|---|---|---|
| | PR (95% CI) for at target vs. not at target | PR (95% CI) for at target vs. not at target | PR (95% CI) for at target vs. not at target | PR (95% CI) for at target vs. not at target |
| White (vs. black) | 1.10 (0.98, 1.23) | 1.22 (1.11, 1.34) | 1.18 (1.08, 1.28) | 1.46 (1.15, 1.85) |
| Age (per 5 years) | 1.05 (0.99, 1.10) | 1.03 (1.00, 1.07) | 0.95 (0.92, 0.99) | 1.04 (0.94, 1.15) |
| Male (vs. female) | 1.00 (0.90, 1.11) | 1.22 (1.14, 1.30) | 1.13 (1.05, 1.21) | 1.36 (1.11, 1.65) |
| Education (vs. <high school) | | | | |
| Some college | 0.98 (0.85, 1.12) | 1.08 (0.97, 1.20) | 1.17 (1.05, 1.30) | 1.11 (0.83, 1.48) |
| More than college | 0.99 (0.86, 1.14) | 1.12 (1.00, 1.25) | 1.11 (0.99, 1.24) | 1.16 (0.87, 1.56) |
| Household income (vs. <\$25,000) | | | | |
| \$25,000–49,999 | 1.23 (1.07, 1.41) | 1.10 (1.00, 1.21) | 1.12 (1.02, 1.23) | 1.42 (1.07, 1.88) |
| ≥\$50,000 | 1.26 (1.10, 1.44) | 1.18 (1.08, 1.30) | 1.16 (1.06, 1.27) | 1.75 (1.34, 2.29) |
| Not reported | 1.12 (0.89, 1.41) | 1.19 (1.05, 1.35) | 1.08 (0.93, 1.24) | 1.53 (1.02, 2.29) |
| Additional health insurance (vs. Medicare only) | 1.02 (0.89, 1.17) | 1.14 (1.01, 1.28) | 1.11 (1.00, 1.24) | 1.12 (0.84, 1.48) |
| Good health or better (vs. fair or poor health) | 1.08 (0.94, 1.23) | 1.08 (0.98, 1.19) | 1.07 (0.98, 1.18) | 1.14 (0.89, 1.46) |
| Alcohol consumption (vs. current) | | | | |
| Former | 0.95 (0.85, 1.08) | 0.97 (0.90, 1.05) | 0.93 (0.87, 1.01) | 0.87 (0.70, 1.09) |
| Never | 1.01 (0.88, 1.15) | 0.87 (0.79, 0.96) | 0.86 (0.78, 0.94) | 0.77 (0.60, 1.01) |
| Smoking status (vs. current) | | | | |
| Former | 0.95 (0.77, 1.18) | 1.02 (0.88, 1.19) | 0.95 (0.83, 1.10) | 0.92 (0.60, 1.40) |
| Never | 0.97 (0.78, 1.20) | 0.94 (0.80, 1.09) | 0.89 (0.77, 1.03) | 0.86 (0.56, 1.32) |
| Indeterminate | 0.76 (0.55, 1.04) | 0.99 (0.81, 1.21) | 0.84 (0.68, 1.03) | 0.46 (0.23, 0.94) |
| BMI (per kg/m ²) | 0.99 (0.98, 1.00) | 1.00 (0.99, 1.01) | 1.00 (1.00, 1.01) | 0.99 (0.97, 1.00) |
| Glucose-lowering medication | N/A | 1.20 (1.10, 1.31) | 0.96 (0.89, 1.03) | N/A |
| Cholesterol-lowering medication | 1.11 (0.98, 1.26) | N/A | 1.14 (1.04, 1.24) | N/A |
| BP-lowering medication | 0.91 (0.80, 1.04) | 1.09 (0.97, 1.22) | N/A | N/A |
| Baecke sport index | 1.05 (0.98, 1.12) | 1.04 (0.99, 1.09) | 1.02 (0.98, 1.07) | 1.07 (0.94, 1.23) |
| Any functional disability | 0.87 (0.79, 0.97) | 0.90 (0.84, 0.97) | 1.00 (0.93, 1.08) | 0.79 (0.65, 0.96) |
| Physical function score (SPPB) | 1.02 (1.00, 1.04) | 1.00 (0.99, 1.02) | 1.03 (1.01, 1.04) | 1.07 (1.03, 1.11) |
| Prevalent CVD | 0.89 (0.79, 1.01) | 1.18 (1.11, 1.26) | 0.95 (0.88, 1.03) | 0.98 (0.79, 1.22) |
| eGFR <60 mL/min/1.73 m ² | 0.98 (0.88, 1.09) | 1.04 (0.97, 1.12) | 0.96 (0.89, 1.03) | 0.88 (0.71, 1.08) |
| Duration of diabetes (per 5 years) | 0.83 (0.80, 0.87) | 1.02 (0.99, 1.05) | 0.96 (0.93, 0.99) | 0.81 (0.75, 0.87) |

Bolded results indicate $P < 0.05$. N/A, not applicable. *Risk factor targets defined as follows: HbA_{1c} <7% (<53 mmol/mol); LDL-c <100 mg/dL; SBP <140 and DBP <90 mmHg.

potential benefits of individualized treatment targets.

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