ORIGINAL RESEARCH

Vulnerabilities to Health Disparities and Statin Use in the REGARDS (Reasons for Geographic and Racial Differences in Stroke) Study

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***Background*—**Statins may be underutilized in certain vulnerable populations, but the effect of cumulative vulnerabilities within 1 individual is not well described. We sought to determine the likelihood of receiving statins with an increasing number of vulnerabilities in an individual, after controlling for factors known to influence health services utilization.

***Methods and Results*—**We identified 18 216 participants from the REGARDS (Reasons for Geographic and Racial Differences in Stroke) study who had a statin indication or who were taking statins, as verified by pill bottle review. Statin use was assessed with respect to 5 major vulnerability domains alone and in combination: older age, black race, female sex, high area-level poverty, and lack of health insurance. The study included 5286 white men, 4180 black men, 2791 white women, and 4194 black women; 5.6% of the sample had no vulnerabilities, 20.6% had 1 vulnerability, 29.2% had 2 vulnerabilities, 27.3% had 3 vulnerabilities, and 17.3% had 4 or 5 vulnerabilities. All race–sex groups were less likely than white men to use statins; prevalence of use was 0.80 in black women with reference to white men ($P<0.0001$). In both unadjusted and adjusted models, as the number of vulnerabilities increased, statin use steadily decreased. After adjusting for factors that influence health services utilization, compared with those without any vulnerabilities, statin use prevalence was 0.91, 0.83, 0.74 and 0.68 ($P<0.0001$) in those with 1, 2, 3, and 4 or 5 vulnerabilities, respectively.

***Conclusions*—**Participants with more simultaneously occurring vulnerabilities experienced the greatest disparities in statin use. Black women and those without health insurance were at particularly high risk of underutilization. **(*J Am Heart Assoc*. 2017;6: e005449. DOI: 10.1161/JAHA.116.005449.)**

Key Words: cumulative • health disparities • health insurance • health services research • race and ethnicity • statin • stroke • underutilization • vulnerabilities

Statin use has been well documented to reduce incidence of major coronary and cerebrovascular events in cardiovascular disease.[1,2] The Adult Treatment Panel III (ATP III) guidelines recommended statin use for persons with elevated low-density lipoprotein cholesterol (LDL-C) in 2002.[3] Statin use has been rising consistently since these guidelines were published, and newer guidelines expanded the indications for use in an even larger number of people.[4]

Unfortunately, a large proportion of adults at high risk for coronary heart disease (CHD) do not receive statin therapy.[5,6] Statin use has been found to be particularly suboptimal in racial and ethnic minorities,[7] with black patients less likely to be prescribed lipid-lowering medications compared with white patients.[6,8] According to the 2013 National Healthcare Disparities Report by the Agency for Healthcare Research and Quality,[9] in addition to racial and ethnic minorities, low-income groups, older adults, rural residents, and southeastern US residents were cited as being particularly vulnerable to healthcare disparities. These factors have been frequently studied for their effect on statin use along with other cardiovascular medications. Low income and high cost lead to reduction in statin use despite adequate availability.[10] Moreover, lack of health insurance has repeatedly been shown to be a significant barrier to accessing health care[11] and increasing out-of-pocket costs are directly related to decreasing statin use.[12] Although each of these vulnerabilities has been studied individually, few reports have examined the effect of multiple co-occurring vulnerabilities on receipt of health services and treatments such as statins for evidence-

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An accompanying Data S1 is available at http://jaha.ahajournals.org/content/6/9/e005449/DC1/embed/inline-supplementary-material-1.pdf

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Clinical Perspective

What Is New?

- Persons with indications for statins and more simultaneously occurring vulnerabilities experience the greatest disparities in statin use.
- This difference is large, with 65% of individuals without any vulnerabilities, and 45% with ≥4 vulnerabilities, receiving statins.

What Are the Clinical Implications?

- Greater effort and specific interventions targeting patients with multiple vulnerabilities, especially black women living in low socioeconomic circumstances and those without health insurance, are needed to optimize statin utilization.
- It is noteworthy that this subgroup also tends to have the greatest risk factor burden, thus more aggressive efforts to treat such patients are warranted.

based indications. A better understanding of the effect of multiple co-occurring vulnerabilities on risk of undertreatment would help policy makers direct resources appropriately.

Data from the national REGARDS (Reasons for Geographic and Racial Differences in Stroke) cohort study were utilized to examine statin use based on 6 vulnerability domains: race–sex groups, age, area-level poverty, health insurance, rural residence, and Southeast residence. We hypothesized that as the number of vulnerabilities present in 1 person rises, the likelihood of receiving statins falls, even after controlling for predisposing, enabling, and need-related factors known to influence health services utilization, as framed by Aday and Andersen.[13]

Methods

Study Design

The REGARDS study is a population-based prospective cohort study that includes 30 239 adults aged ≥45 years from the 48 continental US states and the District of Columbia. The REGARDS study was constituted to elucidate mechanisms leading to higher stroke mortality in the southeastern United States and among black persons. Participants were enrolled between January 2003 and October 2007, with oversampling from the black population, the "Stroke Buckle" (coastal North Carolina, South Carolina, and Georgia), and the "Stroke Belt" (the remainder of North Carolina, South Carolina, and Georgia, as well as Alabama, Mississippi, Tennessee, Arkansas, and Louisiana). Baseline data were collected through computer-assisted telephone surveys that assessed medical history and health status as well as in-home exams performed by trained health professionals following standardized, quality-controlled protocols to collect fasting blood and urine samples; ECGs; blood pressure, height, and weight; and pill bottle review for medication information. Blood and urine samples were centrally analyzed at the University of Vermont, and ECGs were centrally analyzed at Wake Forest University. The institutional review boards at each participating institution approved the study protocol before data collection, and all participants provided written informed consent.

Study Sample

The current cross-sectional analysis was restricted to 18 216 REGARDS study participants who had a statin indication for primary prevention of CHD, as defined by the ATP III guidelines,[3] or who were taking statins, as verified by pill bottle review; 39.7% of the total REGARDS sample did not have a statin indication. We used the ATP III guidelines because newer guidelines had not yet been released at the time of recruitment.

ATP III guidelines[3] were used to determine which participants were indicated for statins and thus included in the study sample. CHD and CHD risk equivalents, Framingham risk scores (FRS), major risk factors, and LDL-C were all assessed. CHD included myocardial infarction, and additional cases were detected by history of coronary artery bypass grafting, angioplasty, and stenting. CHD risk equivalents were carotid artery disease, peripheral arterial disease, abdominal aortic aneurysm, stroke, and diabetes mellitus.[3] Given the expanded focus on all atherosclerotic cardiovascular disease in the American College of Cardiology and American Heart Association's 2013 guidelines on treating blood cholesterol to reduce atherosclerotic cardiovascular risk in adults, we decided to include stroke as a risk equivalent.[4] More detailed explanation of the method used to determine participant inclusion in the study sample is described in Data S1.

The FRS was calculated according to the point-based rubric presented on page 6 of the ATP III "Guidelines At-A-Glance Quick Desk Reference."[14] Age, total cholesterol, smoking status, high-density lipoprotein cholesterol (HDL-C), and systolic blood pressure were used in the risk score calculation. Points were assigned, summed, and matched to the corresponding Framingham 10-year risk percentage. Next, major risk factors were identified in the table "Major Risk Factors (Exclusive of LDL Cholesterol) That Modify LDL Goals" in the ATP III desk reference.[14] Risk factors included cigarette smoking, hypertension (blood pressure ≥140/90 mm Hg or use of antihypertensive medication), low high-density lipoprotein cholesterol (<40 mg/dL), family history of premature CHD (CHD in male first-degree relative aged <55 years or in female first-degree relative aged <65 years), and age (men ≥45 years; women ≥55 years). The number of risk factors was calculated for each participant.[14]

Finally, the risk categories were determined from a combination of disease history, FRS, and number of risk factors. If a participant had an LDL-C level equal to or higher than the LDL-C goal for a particular risk category, then we interpreted this as an indication for statin therapy. Specific sources included Table IV.2-4 in the ATP III full report and the table showing LDL-C goals and cut points in the desk reference.[3,14] Indications for statin therapy were as follows: For participants with atherosclerotic cardiovascular disease, CHD risk equivalents, or FRS >20%, we used LDL-C ≥100 mg/dL; for participants with FRS 10% to 20% or FRS <10% and with ≥2 risk factors, we used LDL-C ≥130 mg/dL; for participants with FRS <10% and 0 to 1 risk factor, we used LDL-C ≥160 mg/dL.[3,14]

Main Outcome: Statin Use

Statin use was based on pill bottle review at the in-home visit, including all medications taken in the previous 2 weeks.

Main Exposure: Vulnerability Domains

Five major vulnerability domains were assessed for their effect on statin use: age, race, sex, area-level poverty, and health insurance. Age was categorized as <65, 65 to 75, and >75 years. Race and sex were analyzed together as race–sex groups since past studies have shown that white men are more likely to be treated compared with other race–sex groups.[6]

Area-level poverty was determined by calculating the percentage of residents living below the federal poverty level within each participant's US Census tract and was classified as highest (>25% of residents), intermediate (10–25%), and lowest (<10%) poverty. Rural and Southeast residence were initially included as major vulnerability domains but were omitted from the final analysis because neither was statistically significantly associated with statin use in this cohort. This left the following vulnerable categories: age 65 to 75 and ≥75 years, black race, female sex, highest or intermediate poverty, and no health insurance.

Covariates

Aday and Andersen proposed that predisposing, enabling, and need-related factors may affect healthcare utilization.[13] Predisposing factors included educational attainment (less than high school education, high school education and higher) and region of residence (Stroke Belt, Stroke Buckle, remainder of the continental United States). Area-level poverty and health insurance are enabling factors but were examined as exposure variables for vulnerability domains. Perceived need included medication adherence, assessed by Morisky's 4-item scale[15] (any affirmative response indicated nonadherence), and awareness of hyperlipidemia (having been told about high cholesterol by a healthcare provider). Evaluated need-related factors included current smoking; depressive symptoms, as assessed using the 4-item Center for Epidemiologic Studies-Depression Scale with a score ≥4[16]; high-density lipoprotein cholesterol <50 mg/dL for women and <40 mg/dL for men; body mass index >30; physical functioning, as reflected in the Medical Outcomes Study Short Form 12 Physical Component Summary (PCS) score as a measure of illness burden[17]; and CHD risk category (per ATP III guidelines: history of cardiovascular disease or risk equivalent; FRS >20%, 10–20%, or <10%).

Statistical Analyses

The study population was characterized by 0, 1, 2, 3, or 4 or 5 vulnerabilities. Descriptive statistics were calculated, and differences across vulnerability score category were tested using χ^2 and ANOVA tests, as appropriate. The proportion of participants in each vulnerability category was calculated, as was the proportion taking statins in each category. In addition, the proportion of participants taking statins was calculated within each vulnerability domain, and χ^2 tests were performed. Collinearity of vulnerability domains was assessed using variance inflation factors as well as coefficients of determination (R^2). We used a linear regression model with statin use as the outcome and vulnerability domains and covariates as the predictors to calculate the variance inflation factors. All variance inflation factors were <10, indicating that multicollinearity was not a concern. In addition to using variance inflation factors as a strategy to examine collinearity, we also used logistic regression models to calculate R^2 for each vulnerability domain regressed on the remaining domains to determine whether a set of predictors strongly predicted any other domain. Multinomial logistic regression models included predicting age groups with race–sex groups, poverty, and insurance (R^2=0.03); predicting race–sex groups with age groups, poverty, and insurance (R^2=0.07); and predicting poverty groups with age groups, race–sex groups, and insurance (R^2=0.09). Insurance was predicted with age groups, race–sex groups, and poverty (R^2=0.13). No group of domains strongly predicted any 1 domain; therefore, each domain can be assumed to be independent.

Because outcomes were common, multivariable-adjusted prevalence ratios (PRs) and 95% confidence intervals were estimated for statin use from Poisson models with robust variance estimators to determine the association between various exposures and statin use. PRs were estimated for each vulnerability domain in a model that simultaneously adjusted for other vulnerability domains. The model was then additionally adjusted for the factors influencing health services utilization, guided by Andersen and Aday's model.

Table 1. Descriptive Characteristics of Vulnerability Domains and Healthcare Utilization Factors By Vulnerability Score Among REGARDS Study Participants With Indications for Statins, N=16,451*

	Vulnerability Count†					
	None (n=915)	1 (n=3394)	2 (n=4797)	3 (n=4494)	4 or 5 (n=2851)	*P* Value
Vulnerability domains						
Age (y), n (%)						<0.001
<65	915 (100.0)	1689 (49.8)	1654 (34.5)	1191 (26.5)	21 (0.7)	
65–75	…	1217 (35.9)	2308 (48.1)	2475 (55.1)	2310 (81.0)	
>75	…	488 (14.4)	835 (17.4)	828 (18.4)	520 (18.2)	
Race–sex group, n (%)						<0.001
White men	915 (100.0)	2618 (77.1)	1645 (34.3)	108 (2.4)	…	
Black men	…	622 (18.3)	1934 (40.3)	1499 (33.4)	125 (4.4)	
White women	…	154 (4.5)	1072 (22.3)	1386 (30.8)	179 (6.3)	
Black women	…	…	146 (3.0)	1501 (33.4)	2547 (89.3)	
Area-level poverty, n (%)						<0.001
Lowest (<10%)	915 (100.0)	2486 (73.2)	1700 (35.4)	413 (9.2)	32 (1.1)	
Intermediate (10–25%)	…	698 (20.6)	2204 (45.9)	2447 (54.5)	1416 (49.7)	
Highest (≥25%)	…	210 (6.2)	893 (18.6)	1634 (36.4)	1403 (49.2)	
No health insurance, n (%)	…	5 (0.1)	56 (1.2)	211 (4.7)	688 (24.1)	<0.001
Predisposing factors						
Less than high school education, n (%)	43 (4.7)	233 (6.9)	550 (11.5)	839 (18.7)	596 (21.0)	<0.001
Stroke region, n (%)						
Non–Stroke Belt	535 (58.5)	1756 (51.7)	2062 (43.0)	1913 (42.6)	1241 (43.5)	
Stroke Belt	253 (27.7)	1029 (30.3)	1695 (35.3)	1563 (34.8)	1035 (36.3)	
Stroke Buckle	127 (13.9)	609 (17.9)	1040 (21.7)	1018 (22.7)	575 (20.2)	
Perceived need factors						
Adherent with medication, n (%)	608 (69.6)	2216 (70.1)	3087 (69.0)	2871 (68.7)	1800 (68.1)	0.60
Aware of hyperlipidemia, n (%)	666 (73.1)	2416 (71.8)	3333 (70.2)	3051 (68.5)	1892 (66.9)	<0.001
Evaluated need factors						
Current smoking, n (%)	74 (8.1)	355 (10.5)	663 (13.9)	788 (17.6)	548 (19.3)	<0.001
Depressive symptoms‡, n (%)	41 (4.5)	205 (6.1)	415 (8.7)	646 (14.5)	578 (20.4)	<0.001
Low HDL-C§, n (%)	338 (37.7)	1278 (38.4)	1780 (38.1)	1658 (37.8)	1158 (41.9)	0.007
BMI >30, n (%)	250 (27.4)	1071 (31.6)	1712 (35.9)	1967 (44.0)	1659 (58.8)	<0.001
PCS score, mean, SD	48.8±8.8	47.9±9.6	46.3±10.4	44.0±11.2	42.9±11.2	<0.001
ATP III risk group, n (%)						<0.001
History of CVD/risk equivalent	516 (56.8)	1792 (53.2)	2399 (50.5)	2482 (55.8)	1649 (58.4)	
FRS >20%	55 (6.1)	165 (4.9)	236 (5.0)	145 (3.3)	47 (1.7)	
FRS 10–20%	305 (33.6)	856 (25.4)	918 (19.3)	557 (12.5)	221 (7.8)	
FRS<10%	32 (3.5)	556 (16.5)	1198 (25.2)	1265 (28.4)	908 (32.1)	

ATP III indicates Adult Treatment Panel III; BMI, body mass index; CVD, cardiovascular disease; FRS, Framingham risk score; HDL-C, high-density lipoprotein cholesterol; PCS, Physical Component Summary; REGARDS, Reasons for Geographic and Racial Differences in Stroke.

*Data for 1765 participants missing information on ≥1 vulnerability domain were excluded because the number of vulnerabilities could not be determined. Missingness was attributed to poverty status ($n_{missing}$=1751) and health insurance (additional $n_{missing}$=14).

†Vulnerability score was constructed by assigning 1 point to each vulnerable level (age ≥65 years, black race, female sex, intermediate or highest poverty tertile, or no health insurance) and summing.

‡Center for Epidemiological Studies–Depression Scale score ≥4

§HDL-C <40 mg/dL for men and <50 mg/dL for women.

Separately, PRs for statin use were estimated for the cumulative number of vulnerabilities. A P value <0.05 was considered statistically significant for all analyses.

For modeling, missing information was imputed by chained equations with 14 imputations and 10 iterations.[18] The fraction of the sample with any missing information was 24%, which included 6% missing only medication adherence and 4% missing only rurality/poverty information. To balance analysis time with accurate multiply imputed estimates, the number of imputations, M, were reduced from M=100−f to M=100−f−Σ (x), where f was the fraction of missing information and x was the fraction missing 1 variable, given that <10% of participants were missing the single variable. All covariates that were adjusted for in models and the outcomes were included in the imputation model. Logistic regression was used to impute health insurance, education, medication adherence, hyperlipidemia awareness, smoking status, depressive symptoms, obesity, and low level of high-density lipoprotein cholesterol. Ordinal logistic regression was used to impute poverty status, and predictive mean matching with a nearest neighbor value of 5 was used to impute PCS score. Multiple imputation was performed using the *mi estimate, Poisson*, and *mlogit* commands with a robust variance estimator. Nonimputed data were used for all remaining analyses. Analyses with imputed data were performed in Stata 12 (StataCorp), and the remaining analyses were performed in SAS 9.3 (SAS Institute).

Results

Of the 18 216 participants with a statin indication, 1765 were missing information in ≥1 vulnerability domain and were excluded from the assessment. The characteristics of the study sample of statin-eligible and statin-using REGARDS participants by number of vulnerabilities are shown in Table 1. The sample included 5286 white men, 4180 black men, 2791 white women, and 4194 black women. Of note, 89.3% of those with 4 or 5 vulnerabilities were black women, and no white men had 4 or 5 vulnerabilities. Only 1.1% of those with 4 or 5 vulnerabilities were living in the areas with the lowest poverty, whereas most of the population with ≥3 vulnerabilities resided in areas with intermediate or highest poverty. Nearly one-quarter of those with 4 or 5 vulnerabilities had no health insurance.

Among the predisposing factors, the prevalence of less than a high school education was greater as the number of vulnerabilities increased (Table 1). Among the perceived needs, awareness of hyperlipidemia became less common with increasing numbers of vulnerabilities. Among the evaluated needs, current smoking, depressive symptoms, obesity, and a history of cardiovascular disease were all increasingly more common with increasing numbers of cumulative

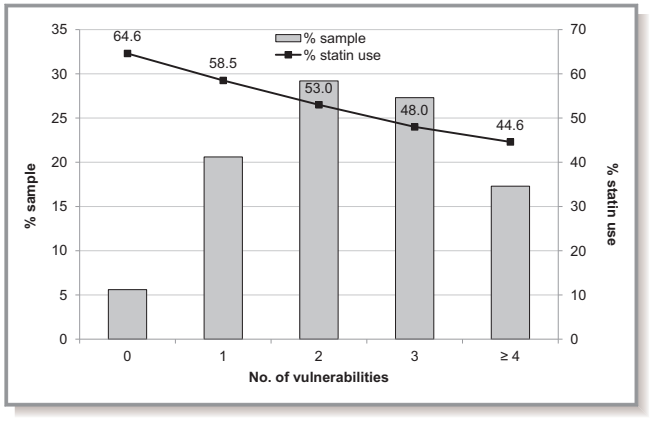

Figure. Percentage of the study sample with each cumulative number of vulnerabilities and percentage using statins in each category of number of vulnerabilities. The vulnerabilities included age 65 to 75 or >75 years, being a woman, being black, area-level poverty of 10% to 25% or >25%, and no health insurance. Of 18 216 participants, 1765 (9.7%) were missing information on ≥1 vulnerability domain, and statin use among this group was 52.3%.

vulnerabilities. Those with 4 or 5 vulnerabilities had lower physical functioning than those with fewer vulnerabilities.

Only 5.6% of the sample had no vulnerabilities, 20.6% had 1 vulnerability, 29.2% had 2 vulnerabilities, 27.3% had 3 vulnerabilities, and 17.3% had 4 or 5 vulnerabilities (Figure). Steadily lower percentages of the sample used statins as the number of vulnerabilities increased—64.6% of those with no vulnerabilities used statins, whereas only 44.6% of those with 4 or 5 vulnerabilities did so.

Statin use varied significantly within each domain (Table 2). Across the domains, statin use was highest among those aged <65 years (57.4%), white men (57.2%), those living in higher income census tracts (55.4%), and those with health insurance (53.2%). Statin use was lowest among those aged 65 to 75 years (47.3%), white women (46.8%), those living in the lowest income census tracts (47.9%), and those without health insurance (33.6%). Statin use also varied significantly by the number of vulnerability groups. Among those without vulnerabilities, 64.6% used statins, whereas among those with 4 or 5 vulnerabilities, 44.6% used statins.

In a model simultaneously adjusted for the vulnerability domains, those aged >65 years were less likely to be on statins than those <65 years; only those aged 65 to 75 years remained 14% less likely to use statins compared with those aged <65 years in a model fully adjusted for vulnerability domains as well as predisposing and need-related factors (Table 3). All race–sex groups were less likely than white men to use statins, with lower PRs for black men and black women compared with white women. Participants living in areas of highest poverty had the lowest PRs for statin use compared with those residing in

Table 2. Proportions of Statin Use by Vulnerability Domains and Number of Vulnerabilities Among REGARDS Study Participants With Indications for Statins, N=18 216

Vulnerability Domains	n	Statin Use, %	*P* Value
Age, y			
<65	6037	57.4	<0.001
65–75	9243	47.3	
>75	2936	55.6	
Race–sex groups			
White men	5908	57.2	<0.001
Black men	4721	52.3	
White women	3024	46.8	
Black women	4563	48.4	
Area-level poverty*			
<10%	5549	55.4	<0.001
10–25%	6774	51.6	
>25%	4142	47.9	
Health insurance†			
Yes	17 113	53.2	<0.001
No	1087	33.6	
No. of vulnerabilities‡			
None	915	64.6	<0.001
1	3394	58.5	
2	4797	53.0	
3	4494	48.0	
≥4	2851	44.6	

REGARDS indicates Reasons for Geographic and Racial Differences in Stroke.
*Missing 1751 (9.6%) participants.
†Missing 16 (0.1%) participants.
‡Missing 1765 participants. The number of vulnerabilities was calculated by assigning 1 point to the vulnerable category or categories of each domain, which included age 65–75 or >75 years, being a woman, being black, area-level poverty of 10–25% or >25%, and no health insurance.

Table 3. PRs (95% CI) for Statin Use By Individual Vulnerability Domains Among REGARDS Study Participants With Indications for Statin Use

Vulnerability Domains	Simple Adjustment* PR (95% CI)	Full Adjustment† PR (95% CI)
Age, y		
<65	1 (referent)	1 (referent)
65–75	0.85 (0.82–0.88)	0.86 (0.84–0.89)
>75	0.96 (0.92–0.99)	1.04 (1.00–1.08)
P value	<0.001	<0.001
Race–sex groups		
White men	1 (referent)	1 (referent)
Black men	0.92 (0.89–0.95)	0.82 (0.79–0.85)
White women	0.85 (0.81–0.89)	0.90 (0.86–0.94)
Black women	0.89 (0.85–0.92)	0.80 (0.77–0.83)
P value	<0.001	<0.001
Area-level poverty		
<10%	1 (referent)	1 (referent)
10–25%	0.96 (0.93–0.99)	0.96 (0.93–0.99)
>25%	0.93 (0.89–0.97)	0.94 (0.90–0.98)
P value	<0.001	0.005
Health insurance		
Yes	1 (referent)	1 (referent)
No	0.70 (0.64–0.76)	0.78 (0.72–0.84)
P value	<0.001	<0.001

CI indicates confidence interval; PR, prevalence ratio; REGARDS, Reasons for Geographic and Racial Differences in Stroke.
*Simultaneously adjusted for each vulnerability domain.
†Simultaneously adjusted for each vulnerability domain plus healthcare utilization factors, including predisposing (education, stroke region), perceived need (awareness of hyperlipidemia, medication adherence), and evaluated need-related factors (current smoking, depressive symptoms, obesity, high-density lipoprotein cholesterol, Physical Component Summary score, and Adult Treatment Panel III risk group).

the wealthiest areas. A lack of health insurance had the greatest effect on statin use, which was 22% lower among those without health insurance compared with those with health insurance.

In both unadjusted and adjusted models, as the number of vulnerabilities increased, statin use steadily decreased (Table 4). The presence of every additional vulnerability significantly lowered statin use by 8% to 9%, with the adjusted prevalence of use 32% lower in those with 4 or 5 vulnerabilities compared with those with none.

Discussion

Statin use was shown to be significantly lower among persons with each of the major vulnerabilities discussed in this article.[6,19,20] Nevertheless, we showed the impact of the accumulation of multiple vulnerabilities within an individual on statin use. The graded decrease in statin use with greater accumulation of vulnerabilities highlights that patients with more simultaneously occurring vulnerabilities experience the greatest disparities in the health service studied—statin use—in a large national biracial sample of persons who all had indications for this evidence-based treatment.

These findings are concordant with past reports of lower treatment of vulnerable groups individually. An analysis of NHANES III (Third National Health and Nutrition Examination Survey) showed that black persons were less likely to be taking cholesterol lowering medications compared with white persons.[19] A recent REGARDS analysis showed that black women were the least likely to be treated for hyperlipidemia compared with all other race–sex groups.[21] Black women are

Table 4. PRs (95% CI) for Statin Use by Number Of Cumulative Vulnerabilities

	Unadjusted	Fully Adjusted*
	PR (95% CI)	PR (95% CI)
Number of vulnerabilities†		
None	1 (referent)	1 (referent)
1	0.91 (0.86–0.96)	0.91 (0.87–0.96)
2	0.82 (0.78–0.87)	0.83 (0.79–0.87)
3	0.74 (0.70–0.78)	0.74 (0.70–0.78)
≥4	0.69 (0.64–0.73)	0.68 (0.64–0.72)
P value	<0.001	<0.001

CI indicates confidence interval; PR, prevalence ratio.
*Adjusted for healthcare utilization factors, including predisposing (education, stroke region), perceived need (awareness of hyperlipidemia, medication adherence), and evaluated need-related factors (current smoking, depressive symptoms, obesity, high-density lipoprotein cholesterol, Physical Component Summary score, and Adult Treatment Panel III risk group).
†The vulnerabilities included age 65–75 or >75 years, being a woman, being black, living in a census tract with area-level poverty of 10–25% or >25%, and having no health insurance.

at particularly high risk: Nearly 90% of those with 4 or 5 vulnerabilities were black women, yet black women made up only 27% of the study sample. These findings suggest that more effort is needed to target persons with multiple vulnerabilities, especially black women living in poverty, with interventions specifically tailored to engage them.

Another finding of this study was the dramatic impact of health insurance on statin use, consistent with previous research.[11] Our study showed that lack of health insurance was associated with dramatically lower treatment with statins, indicating a virtual chasm of unmet need.

The use of the Aday and Andersen model permitted us to examine the role of factors hypothesized to influence health services utilization, which had remarkably modest effects on the findings. Although a large number of covariates were available, important influences were not available, such as trust in physicians and the healthcare system or more nuanced aspects of access to care than the simple availability of any health insurance.

This susceptibility to disparity with the presence of multiple vulnerabilities is an important factor to consider when making clinical decisions. The presence of any of the vulnerabilities explored in this study warrants careful review of the patient's medical history and further investigation. Even in the presence of multiple comorbidities that would benefit from statin use, prescription rates are lower in the vulnerable population groups.[22,23] Despite widely accepted guidelines, a wide gap exists between recommendations and actual practice.[24] Further research and changes in prescribing practices are needed to close this gap.

The major strengths of the study include its national reach, the large sample size, and the large number of available covariates, together with rigorously collected physiological measures including statin use by pill bottle review. Limitations, in addition to those discussed, include self-reporting of some variables, the observational design with resultant limited ability to draw causal influences, and data that are not current (2003–2007).

In summary, greater number of vulnerabilities was associated with progressively less treatment with statins in this sample of persons with indications for treatment. These findings persisted after accounting for factors that influence health services utilization. Interventions targeting persons with multiple vulnerabilities, especially black women, are needed to optimize statin utilization.

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SUPPLEMENTAL MATERIAL

Data S1.

Supplemental Methods

Adult Treatment Panel III guidelines(1) were used to determine which participants were indicated for statins and thus included in the study sample. Coronary heart disease (CHD) and CHD risk equivalents, Framingham Risk Scores (FRS), major risk factors, and low-density lipoprotein cholesterol (LDL-C) were all assessed. CHD included myocardial infarction and additional cases were detected by history of coronary artery bypass graft, bypass surgery, angioplasty, and stenting. CHD risk equivalents were carotid artery disease, peripheral arterial disease, abdominal aortic aneurysm, stroke, and diabetes.(1) Given the "2013 ACC/AHA Guideline on the Treatment of Blood Cholesterol to Reduce Atherosclerotic Cardiovascular Risk in Adults" report's expanded focus on all atherosclerotic cardiovascular disease, we decided to include stroke as a risk equivalent.(2)

The FRS was calculated according to the point-based rubric presented on p. 6 of the ATP III Guidelines At-A-Glance Quick Desk Reference.(3) Age, total cholesterol, smoking status, high-density lipoprotein cholesterol (HDL-C), and systolic blood pressure (SBP) were used in the risk score calculation. Points were assigned, summed, and matched to the corresponding Framingham 10-Year Risk percentage. Next, major risk factors were identified in the table "Major Risk Factors (Exclusive of LDL Cholesterol) That Modify LDL Goals" on p. 1 of the desk reference.(3) Risk factors included cigarette smoking, hypertension (BP ≥140/90 mmHg or on antihypertensive medication), low HDL-C (< 40 mg/dL), family history of premature CHD (CHD in male first degree relative <55 years; CHD in female first degree relative <65 years), and age (men ≥45 years; women ≥55 years). The number of risk factors was calculated for each participant.(3)

Finally, the risk categories were determined from a combination of history of disease, FRS, and number of risk factors. If a participant had an LDL-C ≥ the LDL-C goal for a particular risk category, then we interpreted this as an indication for statin therapy. Specific sources included Table IV.2-4 of the full report and the table titled "LDL Cholesterol Goals and Cutpoints for Therapeutic Lifestyle Changes (TLC) and Drug Therapy in Different Risk Categories" on p.2 of the desk reference.(1,3) Therefore, indications for statin therapy were as follows: for participants with ASCVD, CHD risk equivalents, or FRS >20% we used LDL-C ≥100 mg/dL; for participants with FRS 10-20%, or FRS <10% and having 2 or more risk factors, we used LDL-C ≥130 mg/dL; for participants with FRS <10% and 0-1 risk factors we used LDL-C ≥160 mg/dL.(1,3)

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