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# Longitudinal ethnic differences in multiple cardiovascular risk factor control in a cohort of US adults with diabetes

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## Abstract

**Aim—**To examine longitudinal differences in multiple cardiovascular risk factor control (glycemia, blood pressure, and lipids) by race/ethnicity.

**Methods—**Data were analyzed on a cohort of 11,203 veterans with type 2 diabetes. Primary outcome was odds of none of the risk factors out of control vs. having at least one out of control (HbA1c > 8.0%, BP > 140/90 mmHg, and LDL > 100 mg/dL). Secondary outcome was odds of having none out of control vs. having one, two or three risk factors out of control, respectively. Generalized linear mixed models assessed the relationship between race/ethnicity and multiple risk factor control adjusted for covariates.

**Results—**Adjusted models for primary outcome showed that NHB had two-fold (95%CI 1.8–2.3) and Hispanics had 48% higher (95%CI 1.3–1.7) odds of multiple risk factors out of control over time compared to NHW. Adjusted models for secondary outcome showed that NHB and Hispanics also had higher odds of having one, two, and three risk factors out of control over time compared to NHW.

**Conclusions—**Ethnic minority veterans with diabetes are less likely to have multiple cardiovascular risk factor control over time compared to whites. Thus, greater risk reduction efforts are needed to reduce the heavier disease burden among ethnic minorities.

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**Keywords**

Diabetes; Cardiovascular disease; Risk factor control; Ethnicity; Veterans

Diabetes is the seventh leading cause of all deaths in the United States [1] but is the leading cause of cardiovascular disease (CVD), stroke, blindness, kidney disease, and non-traumatic lower limb amputations [2]. Patients with diabetes often have hypertension and hyperlipidemia as co-morbid conditions, each being independent and strong risk factors for CVD morbidity and mortality [1]. Furthermore, many will not meet diabetes-specific guidelines for blood pressure and cholesterol goals so, patients start out "behind the eight ball" in controlling these important CVD risk factors. This comorbidity pattern has been demonstrated in several industrialized countries [3–7], even among younger adults [8]. Optimal management of patients with diabetes demands a simultaneous and aggressive three-pronged approach for control of glycemia, blood pressure (BP), and lipid levels [9,10].

Several cross-sectional and cohort studies have examined composite control of diabetes, hypertension, and hyperlipidemia [11–16] and provide compelling evidence for comprehensive risk factor management that results in improved survival, reduction in recurrent CVD events and the need for interventional procedures, and improved quality of life [9]. However, few investigators have examined longitudinal differences between those who have and do not have good control of the 3 major CVD risk factors (i.e., diabetes, hyperlipidemia and hypertension), which often requires the combination of behavioral and pharmacological treatment strategies.

Compared to the general population, veterans who use the Veterans Healthcare Administration (VHA) for health care (VA users) are typically older in age and have a higher prevalence of CVD risk factors [17]. Those veterans having 3 or more chronic conditions (35% of VA users) account for 73% of total VA expenditures [17]. A higher burden of diabetes and disability has been identified in the population of military veterans receiving care at Veteran Hospital Administration (VHA) facilities [18] with a prevalence as high as 19.6% and annual incidence rate of ~2% per year among veterans [19] compared to a prevalence of 7.8% in the US population. In addition, veterans with diabetes appear to have poor simultaneous control of intermediate markers of CVD, namely A1c, blood pressure, and LDL-cholesterol [12]. The aim of this study was to examine longitudinal differences in multiple CVD risk factor control (glycosylated hemoglobin – HbA1c ≤ 8.0%; blood pressure – BP < 140/90 mmHg; and low density lipoprotein-cholesterol – LDL < 100 mg/dL) in veterans with type 2 diabetes by race/ethnicity. Based on prior literature, we hypothesized that ethnic minority veterans would be less likely to achieve multiple CVD risk factor control over time compared to their white counterparts after adjusting for relevant confounders.

# 1. Materials and methods

## 1.1. Study data set

We created a cohort of adults with type 2 diabetes at a Veterans Administration (VA) facility in the Southeastern United States by linking multiple patient and administrative files from the VHA Decision Support System (DSS) files using Social Security Number (SSN) [20]. Eligibility for VHA health care benefits is based solely on active military service in any branch and discharged under other than dishonorable conditions. The study was approved by our institutional review board and our local VA research and development committee.

## 1.2. Longitudinal data set

Individuals with type 2 diabetes were identified based on having at least two International Classification of Diseases, Ninth Revision (ICD-9) codes for diabetes in either outpatient or inpatient files and having two or more visits each year since diagnosis based on a previously validated algorithm [19]. We created a person-period data set for each subject from April 1997 to March 2006. Annual values of HbA1c, BP, and LDL for each subject were ascertained for analysis. An average value of the corresponding measure for that year was taken for subjects with two or more values of HbA1c, BP, or LDL in a given year interval. Subjects were followed from time of entry into the study until death, loss to follow-up, or March 2006. The data set included a total of 11,203 subjects, of which 5282 were non-Hispanic white (NHW), 3051 were non-Hispanic black (NHB), 51 were Hispanic and 1862 were other veterans with type 2 diabetes. There were also 957 subjects with either missing or unknown race/ethnicity information. All subjects were included in the analysis.

## 1.3. Outcome measures

The primary outcome measure was the odds of having none of the three risk factors out of control vs. having at least one out of control (HbA1c > 8.0%, BP > 140/90 mmHg, and LDL > 100 mg/dL). This dichotomous variable was coded as (0 = none out of control and 1 = at least one out of control). The secondary outcome measure was the odds of having none of the three risk factors out of control vs. having one, two or three risk factors out of control, respectively. This was defined as a categorical variable with four levels (0 = none out of control, 1 = at least one out of control, 2 = at least two out of control, and 3 = all three out of control). The VA clinical practice guidelines for hypertension indicates the goal for BP management is <140/90 mmHg, which is higher than the more commonly used US-based clinical guidelines with a cutoff at <130/80 mmHg [21]. Therefore, sensitivity to the BP cutoff values was checked using lower cutpoints at 130/80 mmHg and 135/85 mmHg (see online Appendix Tables 1a–2b).

## 1.4. Primary covariate

The primary covariate race/ethnicity was classified as NHW, NHB, Hispanic/other and missing/unknown.

### 1.5. Demographic variables

Age was treated as a continuous variable. Marital status was classified as never married, married, or separated/widowed/divorced. Employment was classified as employed, not employed, or retired. A marker of income among veterans was service-connectedness classified as a dichotomous variable (yes/no). Service-connectedness is defined by the VA as being "primarily a guide in the evaluation of disability resulting from all types of diseases and injuries encountered as a result of or incident to military service". The percentage ratings for service connection represent a practicable determination of the average impairment in earning capacity in civil occupations resulting from military-related and their residual conditions. Thus, it is reasonable to examine service-connectedness as a proxy for income.

### 1.6. Medical comorbidity measures

Medical comorbidity variables were defined based on enhanced ICD-9 codes using validated algorithms [22]. We used these billing codes to include diagnoses for cancer, congestive heart failure (CHF), coronary heart disease (CHD), hypertension, and stroke. All medical comorbidities were dichotomized with presence coded as 1 and absence of the comorbidity as 0.

### 1.7. Psychiatric comorbidity measures

Six psychiatric comorbidities were recorded as being present (1) or absent (0) and also defined based on enhanced ICD-9 codes using validated algorithms [22]. Diagnoses included bipolar disorder, generalized anxiety disorder (GAD), major depressive disorder (MDD), post traumatic stress disorder (PTSD), psychotic disorder, and substance use.

### 1.8. Statistical analysis

We first examined the characteristics of the sample through univariate analysis. This was followed by pre-model building analysis, which includes testing if each covariate was individually associated with the outcome. Then models for the association between race and the outcome variables were developed in a sequential fashion with a group of predictors entering into the regression model.

For the primary outcome variable, we used a generalized linear mixed model (GLMM) approach (PROC GLIMMIX, SAS 9.2) [23] using a logit link (equivalent to mixed effects logistic regression) to fit the models assessing the relationship between multiple CVD risk factor control and race after adjusting for potential confounders [24,25]. For the secondary outcome variable defined as the number of CVD risk factors not controlled (values of 0, 1, 2, or 3), a mixed effects multinomial logistic model for correlated categorical response data approach was used to model the relationship between the outcome and covariates since test for proportional odds was not significant. All models contained this categorical outcome variable as response variable, time and race as primary variables of interest and a person-level random effect to account for within-individual correlations. Methods suggested in Kuss and McLerran [26] were used to fit the models using GLIMMIX. While the magnitude of missing data was minimal (8.6%), GLMM were used to deal with missingness. Sensitivity to missingness was assessed by fitting missing race as separate category and multiple

imputation of race. Since results were similar, results from GLMM with separate missing category are reported. We performed additional imputations to verify the mechanism of missingness and found that race was missing at random in this sample so our approach is appropriate [27]. Both unadjusted and covariate adjusted models were fitted in a sequential fashion. The final models for both the primary and secondary outcomes were adjusted for age, gender, marital status, employment status, medical comorbidities and psychiatric comorbidities. All statistical tests were performed using SAS statistical software version 9.2 [23] with two tailed significance of alpha <0.05.

## 2. Results

Table 1 shows the characteristics of the cohort by race/ethnicity ($n$ = 11,203). Mean age was 66 years, ~50% were NHW, 27% were NHB and 17% were Hispanic/other and 97% were male. The most prevalent medical comorbidity was hypertension (26%) and the most prevalent psychiatric comorbidity was substance use disorder (14.5%). The baseline mean HbA1c was 7.6, mean baseline systolic pressure was 146 mmHg and mean baseline diastolic pressure was 82 mmHg. Only 12.8% had none of the risk factors out of control at baseline. There were significant ethnic differences for socio-demographic, comorbidity, and primary/secondary outcome variables at baseline. NHW veterans were older than other ethnic groups. There were also a higher proportion of NHW that were married, retired, had CHD and CHF, and one risk factor out of control than other ethnic groups. NHB were among the youngest veterans (mean age 64) with the highest proportion of females, divorced or never married, and unemployed. In addition, a higher proportion of NHB had cancer, hypertension, MDD, PTSD, psychotic and substance use disorders as well as poorer baseline CVD risk factor control.

Table 2 shows the results of the final random effects logistic regression model for the primary outcome. After adjusting for all covariates, compared to NHW, the risk of having at least one CVD risk factor not controlled was 2-fold (95%CI 1.8–2.3) higher among NHB and 1.5-fold (95%CI 1.3–1.7) higher among Hispanic veterans. Veterans who were never married (OR 1.38, 95%CI 1.13–1.70) or divorced (OR 1.16, 95%CI 1.05–1.29) were more likely to have at least one outcome measure not controlled compared to married veterans. Veterans with CHD (OR 0.63, 95%CI 0.54–0.74), CHF (OR 0.78, 95%CI 0.65– 0.93) or psychotic disorder (OR 0.61, 95%CI 0.45–0.83) had lower odds of having at least one risk factor out of control.

Table 3 shows the results for the final random effects multinomial logistic regression model for the secondary outcome. The odds ratios compare differences in the odds of having one, two or three outcome measures (HbA1c, BP, LDL) not controlled versus those who had all three outcome measures controlled among race/ethnicity groups. NHB were 1.4 times (95%CI 1.3–1.6), 3.6-times (95%CI 3.0–4.3) and 7.7 times (95% CI 4.1–14.3) more likely to have one, two, and three risk factors out of control compared to NHW. Similarly, Hispanics were 1.2-times (95%CI 1.0–1.3), 2.3-times (95%CI 1.8–2.8) and 4.1-times (95%CI 1.9–8.8) more likely to have one, two, and three risk factors out of control compared to NHW.

Results from the sensitivity analyses conducted to check differences in BP cutoff values defining out of control for the primary outcomes showed no difference in the risk pattern by sociodemographic factors or by medical or psychiatric conditions. The odds ratios and confidence intervals for primary and secondary outcomes can be seen in online Appendix Tables 1a and 1b for BP cutoff <130/80 mmHg, respectively, and in Tables 2a and 2b for BP cutoff <135/85 mmHg, respectively.

## 3. Discussion

In this large cohort of veterans with type 2 diabetes followed over a mean period of 5 years, lower odds of multiple CVD risk factor control (A1c, BP, and LDL) was shown among NHB and Hispanics compared to NHW. The odds of multiple CVD risk factor control also decreased with increasing number of risk factors examined such that odds of having all three risk factors out of control over time was also significantly higher in ethnic minorities compared to whites. The major contribution of this study is the ability to examine multiple CVD risk factor control across multiple racial/ethnic groups using a large sample of patients followed over time. To our knowledge, this is the first US-based study to address this question in an equal access system using a longitudinal design. These findings strongly suggest that multiple CVD risk factor control in all veterans with diabetes need to improve, but most especially among ethnic minority veterans.

Prior studies have examined trends in risk factor control in adults with diabetes. Analyses of series of cross-sectional data from the National Health and Nutrition Examination Survey (1988–1994, 1999–2002) and the Behavioral Risk factor Surveillance Survey (1995 and 2002) provided data on changes in quality of diabetes care among adults age 18–75 using standardized measures from the National Diabetes Quality Improvement Alliance [13]. Over the course of a decade encouraging improvements were shown in annual lipid testing and other processes of care (i.e., dilated eye and foot exams, self-monitoring of blood glucose, aspirin use, and pneumococcal and influenza vaccinations). Lipid control had changed dramatically with an absolute 23% increase in the proportion of people with an LDL <100 mg/dL (from 10.8% to 33.8%) and a 14.8% increase in the proportion of people with a total cholesterol <200 mg/dL (from 32.6% to 47.4%) [13]. Progress in glycemic control was also found among those who reached A1c goals (6.0–8.0%), increasing from 34.2% to 47.0%. Blood pressure control did not demonstrate any significant change in this time period. Despite the observed improvements, the extent of CVD risk factor control remained low.

An analysis of data from the Translating Research Into Action for Diabetes (TRIAD) study examined differences in control of these 3 CVD risk measures between the VA healthcare system and commercial managed care organizations and found significantly better glycemic (HbA1c < 8.5%; 83% vs. 65%) and lipid (LDL < 100 mg/dL; 52% vs. 36%) control among 1273 veterans compared to 6901 privately insured patients [11]. However, BP control (<135/85 mmHg) was comparable at a rate of 29% for both groups. A prior study from the VA has also examined control of the same intermediate risk factors for CVD. This study found that based on 1997 VHA practice guidelines of HbA1c < 9.0%, systolic BP < 140 mmHg, diastolic BP < 90 mmHg, LDL < 130 mg/dL, simultaneous control was achieved only among 30.7% of the sample [12]. When the more stringent 2004 ADA Clinical Practice

Recommendations was used in that study (i.e., HbA1c < 7.0%, systolic BP < 130 mmHg, diastolic BP < 80 mmHg, LDL < 100 mg/dL), simultaneous control was achieved by only 3.9% of patients [12]. An interesting finding in this study was the lower odds of having at least 1 risk factor out of control among veterans with CHD, CHF or psychotic disorder. Various systematic advancements within the VA healthcare system likely lead to greater behavioral and/or clinical support for secondary and tertiary prevention through mechanisms such as telehealth monitoring, and better medication adjustment and adherence through pharmacy education support and monitoring. Aside from system-level factors, alternate reasons may be fewer clinical problems particularly in younger veterans with likely greater mental health than physical health issues, and unrecognized comorbid conditions.

Approximately 12% of veterans in our study sample had all 3 risk factors and nearly the same proportion had control of none of these factors. Achieving control of each individual CVD risk factor was lowest among NHB veterans. Likewise, multiple risk factor control using several definitions was substantially lower for NHB (16.7%) compared to all other racial/ethnic groups (<11%). Overall, the extent of comprehensive risk factor control in these studies is considerably suboptimal and puts into perspective the magnitude of work ahead of patients and providers to reduce the risk of adverse CVD outcomes in adults with diabetes.

Both US-based and non-US-based studies have tried to understand the reasons for ethnic disparities in CVD risk factor control. A case–control study of 3533 community-dwelling adult enrollees with diabetes, also drawn from the TRIAD study involving managed care organizations in 7 states [14], evaluated psychosocial and behavioral factors and aspects of the relationship between patient, provider and system of care, testing in each case whether these factors help to explain associations with demographic and clinical characteristics. While participants had received high-quality diabetes care (i.e., at least 5 of 7 recommended clinical care processes) during the prior 12 months for 3 vascular disease risk factors (A1c < 8.0%, systolic BP < 140 mmHg, and LDL < 130 mg/dL), findings showed 23% of the sample had poor control of at least 2 risk factors and these individuals were more likely to have poor glycemic control (83.9%) and poor BP control (76.6%) than poor LDL control (56.9%). Factors most strongly and consistently associated with poor control were African American race and low education levels in this sample of insured patients. In addition, this study showed that being younger, female, and not married were linked to poor control of 2 or all 3 vascular risk factors; however, behavioral factors such as obesity and smoking also demonstrated a similar association. While socioeconomic status (SES) was considered a significant factor in poor vascular risk factor control, it did not account for cost-sharing that is typical and increasingly burdensome among privately insured patients.

A cross-sectional study of 7605 patients with diabetes in the UK where universal health coverage exists demonstrated similar findings of no significant difference in A1c, BP or cholesterol measurements [28]. However, ethnic disparities persisted such that blacks and south Asians with diabetes were less likely than whites to achieve national targets for these CV risk factors. While the finding that diabetes processes of care can be substantially improved within healthcare systems, it is clear that these improved processes likely do not translate to improved intermediate clinical outcomes [5,28,29]. Moreover, the international evidence for ethnic disparities in risk factor control continues to be demonstrated between

white and non-white populations (British and Caribbean blacks, African Americans, and South Asians) [5,28,30].

Potential racial/ethnic disparities in CVD risk factors (hypertension, diabetes, obesity, hypercholesterolemia, no leisure-time physical activity, and smoking) were examined in a systematic review of 16 studies from 1995 to 2007. This review found that, compared to NHW, there was a higher prevalence of hypertension and diabetes among NHB individuals [31]. However, there were no apparent differences by race/ethnicity for hyperlipidemia or obesity. In our findings, despite the higher prevalence of hypertension in NHB veterans, hypertension was not significantly related to having at least one risk factor out of control. Another TRIAD study [15] examined the contribution of mutable risk factors such as medication adherence, perceived poor quality of provider communication, depression, low self-efficacy for reducing cardiovascular risk, and low health literacy on CVD risk factor control. The study showed that 34% of whites and 56% of blacks had poor vascular risk factor control, and missed medication doses and depression were most strongly associated with poor control among blacks but not among whites.

New studies are working on identifying strategies to improve multiple CVD risk factor control in adults with diabetes. A recent intervention study tracked control of systolic blood pressure < 140 mmHg, HbA1c < 9%, and LDL-C < 130 mg/dL and compared physician feedback only (control) to physician feedback coupled with patient reminder letters to determine the impact on multiple risk factor control. While each risk factor measure was only marginally better for intervention patients, the intervention group was 2.4-times more likely to have all 3 measures under control compared to the control group [16]. This is one of many potential strategies for improving CVD risk factor control in patients with this constellation of complex conditions.

While the study findings highlights some key points about the racial/ethnic differences in long-term CVD risk control based on a large cohort of patients with type 2 diabetes, it has certain limitations that are worth mentioning. First, males comprised the vast majority of the study sample so the findings have limited generalizability to female veterans. Although no significant difference in multiple risk factor control was found by gender in the current study, it is important to note that women must be a high priority population since gender differences in multiple risk factor control are understudied and women appear to have even worse CVD risk control [12,14]. Second, we did not control for tobacco use history as a major confounder of CVD risk control. Third, veterans who use the VHA health care system generally do not have access to care as a major barrier but, there are likely some socioeconomic limitations that impact on their ability to more optimally control disease risk factors. We only included employment status and service-connected disability as proxy measures for SES. Therefore, our findings may have limited generalizability to non-VA user veteran and civilian populations among whom SES has a larger effect on disease management and access to care plays a more important role. Nevertheless, the VA population provides the ideal environment to examine racial/ethnic differences in outcomes given that access to care, which is a major contributor to disparities in care, is less of an issue. Fourth, approximately 9% of our sample had missing race data, which may have biased our results. However, we performed additional analyses to verify the mechanism of

missingness and found that race was missing at random in this sample so our approach of dealing with missing data using GLMM is appropriate [27]. Finally, the cutoffs for control of each risk factor were based on less stringent VHA clinical guidelines, which may not be applicable to environments where more stringent cutoffs are used. In spite of this, we believe are findings are robust and application to most populations.

In conclusion, in this large cohort of veterans with type 2 diabetes followed over a mean period of 5 years, lower odds of multiple CVD risk factor control (A1c, BP, and LDL) was shown among NHB and Hispanics compared to NHW. The odds of multiple CVD risk factor control also decreased with increasing number of risk factors examined such that odds of having all three risk factors out of control over time was also significantly higher in ethnic minorities compared to whites. Further studies are needed to identify explanatory factors and test effective behavioral and clinical interventions for aggressive multiple CVD risk control in adults with type 2 diabetes.

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## Appendix A

**Table 1a**

**Random effects logistic regression model for primary outcome (at least one CVD risk factor out of control versus none out of control; BP 130/80 mmHg defined as out of control)**

| Variable | At least 1 out of control vs. none | |
|---|---|---|
| | Odds ratio | 95% Confidence interval |
| Non-Hispanic White | 1.00 | |
| Non-Hispanic Black | 2.18 | (1.88, 2.52) |
| Hispanic/other | 1.50 | (1.26, 1.79) |
| Missing | 1.46 | (1.16, 1.84) |
| Time | 0.77 | (0.76, 0.79) |
| Female | 1.00 | |
| Male | 1.06 | (0.72, 1.55) |
| Age, in years | 0.98 | (0.98, 0.99) |
| Unemployed | 1.00 | |
| Employed | 1.14 | (0.97, 1.35) |
| Retired | 0.91 | (0.80, 1.05) |
| Married | 1.00 | |
| Never married | 1.56 | (1.18, 2.05) |
| Divorced | 1.08 | (0.95, 1.23) |
| Service connected | 0.90 | (0.80, 1.01) |
| Cancer[a] | 0.94 | (0.71, 1.23) |

| Variable | At least 1 out of control vs. none | |
|---|---|---|
| | Odds ratio | 95% Confidence interval |
| Coronary heart disease[a] | 0.53 | (0.43, 0.64) |
| Congestive heart failure[a] | 0.59 | (0.47, 0.74) |
| Hypertension[a] | 1.09 | (0.91, 1.29) |
| Stroke[a] | 1.21 | (0.88, 1.67) |
| Bipolar disorder[a] | 0.92 | (0.60, 1.42) |
| Substance use disorder[a] | 0.84 | (0.71, 0.99) |
| Psychotic disorder[a] | 0.56 | (0.38, 0.82) |
| Generalized anxiety disorder[a] | 0.85 | (0.59, 1.22) |
| Major depressive disorder[a] | 0.86 | (0.68, 1.10) |
| Post traumatic stress disorder[a] | 0.97 | (0.74, 1.27) |

[a]Reference group: absence of condition/disease.

**Table 1b**

**Random effects multinomial logistic regression model for secondary outcome (values for 1, 2, 3 risk factors out of control versus none out of control; BP 130/80 mmHg defined as out of control)**

| Variable | One vs. None | | Two vs. None | | Three vs. None | |
|---|---|---|---|---|---|---|
| | OR | 95% CI | OR | 95% CI | OR | 95% CI |
| Non-Hispanic White | 1.00 | | 1.00 | | 1.00 | |
| Non-Hispanic Black | 1.45 | (1.27, 1.65) | 3.86 | (3.07, 4.86) | 681.58 | (209.59, 2216.52) |
| Hispanic/other | 1.17 | (1.00, 1.38) | 2.34 | (1.77, 3.09) | 19.74 | (7.36, 52.95) |
| Missing | 1.20 | (0.97, 1.48) | 2.12 | (1.47, 3.07) | 11.85 | (3.30, 42.56) |
| Time | 0.85 | (0.83, 0.87) | 0.64 | (0.62, 0.67) | 0.35 | (0.32, 0.39) |
| Female | 1.00 | | 1.00 | | 1.00 | |
| Male | 1.07 | (0.75, 1.52) | 1.21 | (0.66, 2.21) | 2.33 | (0.46, 11.66) |
| Age, years (centered at mean) | 1.00 | (0.99, 1.00) | 0.97 | (0.96, 0.98) | 0.82 | (0.80, 0.85) |
| Unemployed | 1.00 | | 1.00 | | 1.00 | |
| Employed | 1.04 | (0.90, 1.20) | 1.25 | (0.97, 1.60) | 2.17 | (1.04, 4.54) |
| Retired | 0.95 | (0.84, 1.07) | 0.86 | (0.69, 1.06) | 0.56 | (0.30, 1.06) |
| Married | 1.00 | | 1.00 | | 1.00 | |
| Never married | 1.42 | (1.10, 1.81) | 1.93 | (1.27, 2.93) | 5.64 | (1.70, 18.73) |
| Divorced | 1.01 | (0.90, 1.14) | 1.19 | (0.96, 1.46) | 2.30 | (1.25, 4.23) |
| Service connected | 0.89 | (0.80, 0.99) | 0.84 | (0.70, 1.01) | 0.73 | (0.43, 1.26) |
| Cancer[a] | 1.03 | (0.82, 1.30) | 0.82 | (0.53, 1.25) | 0.70 | (0.22, 2.29) |
| Coronary heart disease[a] | 0.65 | (0.55, 0.77) | 0.33 | (0.24, 0.45) | 0.11 | (0.05, 0.28) |
| Congestive heart failure[a] | 0.67 | (0.55, 0.81) | 0.39 | (0.27, 0.56) | 0.28 | (0.11, 0.73) |
| Hypertension[a] | 1.03 | (0.89, 1.20) | 1.21 | (0.93, 1.58) | 2.19 | (1.03, 4.66) |
| Stroke[a] | 1.19 | (0.91, 1.56) | 1.28 | (0.78, 2.12) | 2.68 | (0.63, 11.35) |
| Bipolar disorder[a] | 0.84 | (0.57, 1.22) | 0.87 | (0.44, 1.71) | 0.91 | (0.14, 5.84) |

| Variable | One vs. None | | Two vs. None | | Three vs. None | |
|---|---|---|---|---|---|---|
| | OR | 95% CI | OR | 95% CI | OR | 95% CI |
| Substance use disorder[a] | 0.91 | (0.79, 1.06) | 0.79 | (0.61, 1.03) | 0.25 | (0.12, 0.53) |
| Psychotic disorder[a] | 0.82 | (0.59, 1.13) | 0.32 | (0.17, 0.59) | 0.01 | (0.00, 0.08) |
| Generalized anxiety disorder[a] | 0.80 | (0.58, 1.09) | 0.97 | (0.54, 1.75) | 1.12 | (0.21, 5.86) |
| Major depressive disorder[a] | 0.83 | (0.67, 1.02) | 0.81 | (0.55, 1.19) | 1.69 | (0.59, 4.88) |
| Post traumatic stress disorder[a] | 1.03 | (0.81, 1.30) | 0.85 | (0.55, 1.30) | 0.43 | (0.13, 1.43) |

*Abbreviations:* OR – Odds ratio; CI – confidence interval.

[a]Reference group: absence of condition/disease.

**Table 2a**

**Random effects logistic regression model for primary outcome (at least one CVD risk factor out of control versus none out of control; BP 135/85 mmHg defined as out of control)**

| Variable | At Least 1 Out of Control vs. None | |
|---|---|---|
| | Odds Ratio | 95% Confidence Interval |
| Non-Hispanic White | 1.00 | |
| Non-Hispanic Black | 2.04 | (1.81, 2.31) |
| Hispanic/other | 1.44 | (1.24, 1.68) |
| Missing | 1.39 | (1.14, 1.69) |
| Time | 0.78 | (0.77, 0.79) |
| Female | 1.00 | |
| Male | 0.99 | (0.71, 1.37) |
| Age, in years | 0.99 | (0.98, 0.99) |
| Unemployed | 1.00 | |
| Employed | 1.11 | (0.97, 1.27) |
| Retired | 0.93 | (0.83, 1.04) |
| Married | 1.00 | |
| Never married | 1.43 | (1.14, 1.80) |
| Divorced | 1.15 | (1.02, 1.28) |
| Service connected | 0.96 | (0.87, 1.06) |
| Cancer[a] | 0.82 | (0.65, 1.02) |
| Coronary heart disease[a] | 0.60 | (0.50, 0.71) |
| Congestive heart failure[a] | 0.67 | (0.55, 0.82) |
| Hypertension[a] | 1.12 | (0.97, 1.29) |
| Stroke[a] | 1.20 | (0.91, 1.57) |
| Bipolar disorder[a] | 0.99 | (0.69, 1.44) |
| Substance use disorder[a] | 0.90 | (0.78, 1.03) |
| Psychotic disorder[a] | 0.61 | (0.44, 0.85) |
| Generalized anxiety disorder[a] | 0.80 | (0.59, 1.09) |
| Major depressive disorder[a] | 0.81 | (0.66, 1.00) |

| Variable | At Least 1 Out of Control vs. None | |
|---|---|---|
| | Odds Ratio | 95% Confidence Interval |
| Post traumatic stress disorder[a] | 0.99 | (0.79, 1.25) |

[a]Reference group: absence of condition/disease.

## Table 2b

**Random effects multinomial logistic regression model for secondary outcome (values for 1, 2, 3 risk factors out of control versus none out of control; BP 135/85 mmHg defined as out of control)**

| Variable | One vs. None | | Two vs. None | | Three vs. None | |
|---|---|---|---|---|---|---|
| | OR | 95% CI | OR | 95% CI | OR | 95% CI |
| Non-Hispanic White | 1.00 | | 1.00 | | 1.00 | |
| Non-Hispanic Black | 1.39 | (1.25, 1.55) | 3.34 | (2.78, 4.01) | $6.9 \times 10^6$ | $(1.9 \times 10^6, 2.4 \times 10^6)$ |
| Hispanic/other | 1.13 | (0.99, 1.29) | 2.04 | (1.63, 2.55) | 6.18 | (2.82, 13.52) |
| Missing | 1.12 | (0.94, 1.33) | 1.88 | (1.39, 2.53) | 3.76 | (1.38, 10.25) |
| Time | 0.85 | (0.84, 0.87) | 0.66 | (0.65, 0.68) | 0.43 | (0.40, 0.47) |
| Female | 1.00 | | 1.00 | | 1.00 | |
| Male | 1.00 | (0.74, 1.34) | 1.15 | (0.71, 1.87) | 1.31 | (0.26, 6.71) |
| Age, years (centered at mean) | 1.00 | (0.99, 1.00) | 0.98 | (0.97, 0.98) | 0.91 | (0.88, 0.94) |
| Unemployed | 1.00 | | 1.00 | | 1.00 | |
| Employed | 1.00 | (0.88, 1.13) | 1.31 | (1.07, 1.60) | 1.88 | (0.93, 3.78) |
| Retired | 0.96 | (0.87, 1.06) | 0.87 | (0.73, 1.04) | 1.21 | (0.64, 2.29) |
| Married | 1.00 | | 1.00 | | 1.00 | |
| Never married | 1.30 | (1.06, 1.59) | 1.75 | (1.26, 2.45) | 1.74 | (0.55, 5.54) |
| Divorced | 1.08 | (0.97, 1.19) | 1.27 | (1.07, 1.50) | 1.26 | (0.69, 2.31) |
| Service connected | 0.95 | (0.87, 1.04) | 0.92 | (0.79, 1.07) | 0.95 | (0.56, 1.63) |
| Cancer[a] | 0.89 | (0.73, 1.08) | 0.71 | (0.51, 1.00) | 0.53 | (0.14, 1.95) |
| Coronary heart disease[a] | 0.72 | (0.62, 0.83) | 0.39 | (0.30, 0.51) | 0.29 | (0.11, 0.76) |
| Congestive heart failure[a] | 0.75 | (0.64, 0.89) | 0.52 | (0.39, 0.70) | 0.66 | (0.23, 1.89) |
| Hypertension[a] | 1.05 | (0.93, 1.20) | 1.28 | (1.03, 1.58) | 1.75 | (0.79, 3.90) |
| Stroke[a] | 1.17 | (0.93, 1.48) | 1.30 | (0.87, 1.95) | 0.93 | (0.19, 4.49) |
| Bipolar disorder[a] | 0.94 | (0.68, 1.29) | 0.97 | (0.56, 1.68) | 1.17 | (0.15, 8.93) |
| Substance use disorder[a] | 0.99 | (0.87, 1.12) | 0.84 | (0.68, 1.04) | 0.42 | (0.19, 0.95) |
| Psychotic disorder[a] | 0.86 | (0.65, 1.14) | 0.36 | (0.22, 0.59) | 0.00 | (0.00, 0.00) |
| Generalized anxiety disorder[a] | 0.78 | (0.60, 1.02) | 0.91 | (0.57, 1.45) | 0.97 | (0.17, 5.52) |
| Major depressive disorder[a] | 0.77 | (0.65, 0.93) | 0.82 | (0.60, 1.12) | 1.12 | (0.37, 3.40) |
| Post traumatic stress disorder[a] | 1.02 | (0.84, 1.25) | 0.89 | (0.63, 1.25) | 0.68 | (0.19, 2.39) |

*Abbreviations:* OR – Odds ratio; CI – confidence interval.

[a]Reference group: absence of condition/disease.

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**Table 1**

**Sample characteristics by race/ethnicity**

| Variable | All (*n* = 11,203) | NHW (*n* = 5282) | NHB (*n* = 3051) | Hispanic/other (*n* = 1913) | Missing (*n* = 957) | *P*-value |
|---|---|---|---|---|---|---|
| Age (years mean, sd) | 66 (11.5) | 68 (10.7) | 64 (12.3) | 65 (13.3) | 66 (11.5) | <0.0001 |
| Male | 97.3 | 97.9 | 96.6 | 100.0 | 97.7 | 0.0032 |
| Female | 2.7 | 2.1 | 3.4 | 0.0 | 2.3 | 0.0032 |
| Married | 65.3 | 67.3 | 58.3 | 70.6 | 70.2 | <0.0001 |
| Divorced | 28.5 | 28.0 | 31.6 | 27.5 | 25.5 | <0.0001 |
| Never married | 6.2 | 4.7 | 10.0 | 2.0 | 4.3 | <0.0001 |
| Unemployed | 48.2 | 48.8 | 52.9 | 35.3 | 43.9 | <0.0001 |
| Retired | 30.8 | 32.7 | 25.4 | 37.3 | 32.0 | <0.0001 |
| Employed | 20.8 | 18.4 | 21.6 | 27.5 | 24.0 | <0.0001 |
| Service connected disability | 38.3 | 38.3 | 36.3 | 45.1 | 36.4 | 0.0004 |
| Cancer | 5.0 | 5.2 | 7.4 | 2.0 | 2.1 | <0.0001 |
| Coronary heart disease | 14.0 | 20.0 | 12.4 | 7.8 | 4.2 | <0.0001 |
| Congestive heart failure | 8.1 | 10.0 | 9.4 | 7.8 | 2.7 | <0.0001 |
| Hypertension | 25.8 | 29.3 | 33.9 | 23.5 | 8.8 | <0.0001 |
| Stroke | 3.0 | 4.1 | 3.1 | 5.9 | 0.4 | <0.0001 |
| Baseline HbA1c ≥ 8.0% | 33.9 | 29.9 | 42.9 | 32.5 | 29.7 | <0.0001 |
| Baseline HbA1c (mean ± sd) | 7.6 (1.9) | 7.4 (1.7) | 8.1 (2.2) | 7.6 (1.9) | 7.6 (1.9) | <0.0001 |
| Insulin (mean ± std) | 61.2 (26.8) | 61.5 (26.4) | 59.8 (26.2) | 64.8 (28.3) | 59.1 (28.3) | 0.0043 |
| OHA (mean ± std) | 82.5 (22.2) | 82.5 (21.7) | 77.7 (23.9) | 87.6 (19.7) | 87.7 (20.5) | <0.0001 |
| Insulin & OHA (mean ± std) | 71.8 (19.8) | 72.5 (19.3) | 70.0 (20.5) | 74.4 (19.3) | 69.4 (20.1) | 0.0054 |
| Insulin compliance | 31.4 | 30.1 | 29.3 | 38.2 | 31.3 | 0.0074 |
| OHA compliance | 66.1 | 66.0 | 56.7 | 75.9 | 76.6 | <0.0001 |
| Insulin & OHA compliance | 36.2 | 37.1 | 35.0 | 39.4 | 29.3 | 0.1793 |
| No medication | 18.6 | 17.4 | 19.2 | 20.6 | 19.3 | 0.0114 |
| Bipolar disorder | 1.9 | 2.2 | 2.5 | 3.9 | 0.4 | <0.0001 |
| Generalized anxiety disorder | 2.2 | 3.2 | 1.9 | 3.9 | 0.2 | <0.0001 |
| Major depressive disorder | 7.8 | 8.8 | 10.5 | 5.9 | 2.8 | <0.0001 |
| Post traumatic stress disorder | 5.1 | 4.6 | 8.0 | 5.9 | 3.3 | <0.0001 |

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| Variable | All (*n* = 11,203) | NHW (*n* = 5282) | NHB (*n* = 3051) | Hispanic/other (*n* = 1913) | Missing (*n* = 957) | *P*-value |
|---|---|---|---|---|---|---|
| Psychotic disorder | 2.4 | 1.6 | 4.9 | 2.0 | 1.0 | <0.0001 |
| Substance use disorder | 14.5 | 14.8 | 21.4 | 7.8 | 6.2 | <0.0001 |
| Baseline SBP (mean ± sd) | 146 (22) | 146 (22) | 148 (22) | 147 (21) | 146 (23) | 0.0002 |
| Baseline DBP (mean ± sd) | 82 (33) | 81 (40) | 84 (27) | 81 (25) | 80 (13) | <0.0001 |
| Baseline SBP > 140 or DBP > 90 | 59.7 | 58.4 | 62.4 | 60.1 | 57.9 | 0.0044 |
| Baseline LDL (mean ± sd) | 116 (39) | 113 (36) | 124 (43) | 114 (38) | 112 (40) | <0.0001 |
| Baseline LDL > 99 | 63.6 | 61.8 | 69.7 | 61.7 | 58.0 | <0.0001 |
| 3 Out of control at baseline | 11.9 | 10.1 | 16.7 | 10.7 | 8.8 | 0.4459 |
| 2 Out of control at baseline | 37.6 | 36.0 | 41.9 | 36.5 | 34.7 | <0.0001 |
| 1 Out of control at baseline | 37.7 | 40.4 | 32.9 | 36.8 | 39.7 | <0.0001 |
| 0 Out of control at baseline | 12.8 | 13.4 | 8.5 | 15.9 | 16.8 | <0.0001 |

All values represent percentages unless otherwise is indicated. Abbreviations: NHW = non-Hispanic white, NHB = non-Hispanic black, SBP = systolic blood pressure (measured in mmHg), DBP = diastolic blood pressure (measured in mmHg), LDL = low-density lipoprotein-cholesterol (measured in mg/dL).

## Table 2

**Random effects logistic regression model for primary outcome (at least one CVD risk factor out of control versus none out of control)**

| Variable | At least 1 out of control vs. None | |
|---|---|---|
| | Odds ratio | 95% Confidence interval |
| Non-Hispanic White | 1.00 | |
| Non-Hispanic Black | 2.02 | (1.81, 2.26) |
| Hispanic/other | 1.48 | (1.29, 1.70) |
| Missing | 1.36 | (1.14, 1.63) |
| Time | 0.78 | (0.76, 0.79) |
| Female | 1.00 | |
| Male | 0.92 | (0.68, 1.24) |
| Age, in years | 0.98 | (0.98, 0.99) |
| Unemployed | 1.00 | |
| Employed | 1.09 | (0.96, 1.24) |
| Retired | 0.90 | (0.81, 1.00) |
| Married | 1.00 | |
| Never married | 1.38 | (1.13, 1.70) |
| Divorced | 1.16 | (1.05, 1.29) |
| Service connected | 0.95 | (0.87, 1.04) |
| Cancer[a] | 0.91 | (0.73, 1.12) |
| Coronary heart disease[a] | 0.63 | (0.54, 0.74) |
| Congestive heart failure[a] | 0.78 | (0.65, 0.93) |
| Hypertension[a] | 1.05 | (0.91, 1.19) |
| Stroke[a] | 1.12 | (0.88, 1.44) |
| Bipolar disorder[a] | 0.97 | (0.69, 1.36) |
| Substance use disorder[a] | 0.90 | (0.79, 1.03) |
| Psychotic disorder[a] | 0.61 | (0.45, 0.83) |
| Generalized anxiety disorder[a] | 0.86 | (0.65, 1.15) |
| Major depressive disorder[a] | 0.85 | (0.71, 1.04) |
| Post traumatic stress disorder[a] | 0.96 | (0.77, 1.18) |

[a]Reference group: absence of condition/disease.

**Table 3**

**Random effects multinomial logistic regression model for secondary outcome (values for 1, 2, 3 risk factors out of control versus none out of control)**

| Variable | One vs. None | | Two vs. None | | Three vs. None | |
|---|---|---|---|---|---|---|
| | OR | 95% CI | OR | 95% CI | OR | 95% CI |
| Non-Hispanic White | 1.00 | | 1.00 | | 1.00 | |
| Non-Hispanic Black | 1.41 | (1.28, 1.56) | 3.57 | (2.99, 4.27) | 7.66 | (4.09, 14.33) |
| Hispanic/other | 1.17 | (1.04, 1.33) | 2.25 | (1.80, 2.80) | 4.06 | (1.87, 8.83) |
| Missing | 1.11 | (0.95, 1.31) | 1.86 | (1.39, 2.49) | 3.63 | (1.37, 9.60) |
| Time | 0.84 | (0.83, 0.86) | 0.65 | (0.64, 0.67) | 0.47 | (0.43, 0.51) |
| Female | 1.00 | | 1.00 | | 1.00 | |
| Male | 0.95 | (0.73, 1.25) | 1.05 | (0.65, 1.68) | 1.54 | (0.28, 8.35) |
| Age, years (centered at mean) | 0.99 | (0.99, 1.00) | 0.97 | (0.97, 0.98) | 0.94 | (0.91, 0.97) |
| Unemployed | 1.00 | | 1.00 | | 1.00 | |
| Employed | 1.02 | (0.92, 1.14) | 1.20 | (0.99, 1.47) | 1.42 | (0.71, 2.85) |
| Retired | 0.93 | (0.85, 1.02) | 0.84 | (0.71, 0.99) | 1.10 | (0.60, 2.02) |
| Married | 1.00 | | 1.00 | | 1.00 | |
| Never married | 1.27 | (1.06, 1.52) | 1.58 | (1.14, 2.19) | 1.61 | (0.51, 5.11) |
| Divorced | 1.10 | (1.00, 1.20) | 1.30 | (1.10, 1.53) | 1.26 | (0.71, 2.24) |
| Service connected | 0.95 | (0.87, 1.03) | 0.91 | (0.79, 1.05) | 0.90 | (0.53, 1.51) |
| Cancer | 1.00 | (0.83, 1.20) | 0.82 | (0.59, 1.15) | 0.79 | (0.25, 2.55) |
| Coronary heart disease | 0.74 | (0.65, 0.85) | 0.42 | (0.32, 0.54) | 0.51 | (0.21, 1.24) |
| Congestive heart failure | 0.83 | (0.71, 0.97) | 0.65 | (0.48, 0.86) | 0.69 | (0.25, 1.90) |
| Hypertension | 0.98 | (0.87, 1.10) | 1.23 | (1.00, 1.52) | 1.22 | (0.58, 2.58) |
| Stroke | 1.08 | (0.87, 1.34) | 1.30 | (0.88, 1.92) | 1.14 | (0.29, 4.51) |
| Bipolar disorder | 0.94 | (0.70, 1.26) | 1.12 | (0.65, 1.92) | 0.83 | (0.12, 5.85) |
| Substance use disorder | 0.98 | (0.88, 1.10) | 0.81 | (0.66, 1.00) | 0.31 | (0.14, 0.68) |
| Psychotic disorder | 0.81 | (0.62, 1.05) | 0.36 | (0.22, 0.59) | 0.27 | (0.05, 1.56) |
| Generalized anxiety disorder | 0.85 | (0.67, 1.09) | 0.96 | (0.61, 1.53) | 0.91 | (0.17, 4.78) |
| Major depressive disorder | 0.84 | (0.71, 0.99) | 0.84 | (0.62, 1.13) | 1.06 | (0.35, 3.25) |
| Post traumatic stress disorder | 1.01 | (0.84, 1.22) | 0.80 | (0.57, 1.12) | 1.01 | (0.31, 3.26) |

Abbreviations: OR – Odds ratio; CI – confidence interval.