Geographic and Racial/Ethnic Variations in Patterns of Multimorbidity Burden in Patients with Type 2 Diabetes

Cheryl P. Lynch, MD, MPH^{1,2}, Mulugeta Gebregziabher, PhD^{1,3}, R. Neal Axon, MD, MS^{1,2}, Kelly E. Hunt, PhD^{1,3}, Elizabeth Payne, BS^{1,3}, and Leonard E. Egede, MD, MS^{1,2}

¹Health Equity and Rural Outreach Innovation Center, Ralph H. Johnson Department of Veterans Affairs Medical Center, Charleston, SC, USA;

²Center for Health Disparities Research, Division of General Internal Medicine, Medical University of South Carolina, Charleston, SC, USA;

³Department of Public Health Sciences, Medical University of South Carolina, Charleston, SC, USA.

BACKGROUND: Multimorbidity presents a significant public health challenge, but regional, rural/urban, and racial/ethnic differences in patterns of multimorbidity in diabetes are poorly understood.

OBJECTIVE: To describe patterns of multimorbidity in medical and mental health by regional, rural/urban, and racial/ethnic variation in patients with type 2 diabetes mellitus.

DESIGN: Retrospective cohort study from 2002 through 2006

PARTICIPANTS: A national cohort of 892,223 veterans with diabetes

MAIN MEASURES: Multimorbidity was the main outcome defined as: the measure of multimorbidity and two categorical outcomes, with pattern of medical and mental health comorbidities combined and separately.

KEY RESULTS: Among patients, 52% had 2+ comorbidities, 33% had a single comorbidity, and 14% had no comorbidity; 13.9% had both medical and mental health comorbidities, 70.3% had medical only, and 1.5% had mental health only. The odds of having 3+ comorbidities were nearly fourfold greater in patients 75 years and older relative to patients younger than 50 years (OR=3.95 [95% CI: 3.84, 4.06]). Compared to non-Hispanic whites, the odds of 3+ comorbidities among non-Hispanic blacks were 1.67 times greater (95% CI: 1.63, 1.71). Hispanics were more likely to have a mental health comorbidity alone (OR=1.20 [95% CI: 1.13, 1.28]) than non-Hispanic whites. For patients living in rural areas, the odds were higher of having 3+ comorbidities (OR=1.21 [95% CI: 1.19, 1.23]) and of having both medical and mental health comorbidities (OR=1.15 [95% CI: 1.13, 1.17]) compared to urban dwellers.

CONCLUSIONS: Among individuals with diabetes, traditionally disadvantaged groups, including non-Hispanic blacks and rural patients, appear to bear the greatest burden and risk of multimorbidity. Significantly greater odds with increasing number of comorbidities were seen by race/ethnicity, rural residence, and geographic region.

KEYWORDS: multimorbidity; racial/ethnic; rural residence; pattern; veterans.

J Gen Intern Med 30(1):25–32

DOI: 10.1007/s11606-014-2990-y

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INTRODUCTION

Diabetes is one of the most commonly measured diseases in studies of multimorbidity,¹ as well as one of the most frequently detected disorders in multimorbid disease clusters,^{2–5} due to its major contribution to the development of heart disease, stroke, kidney failure, non-traumatic lower limb amputations, blindness, and depression.⁶ The multimorbidity that typically accompanies diabetes has prompted numerous studies with regard to its prevalence, patterns, and associated health and healthcare outcomes.

Multimorbidity, or the co-existence of multiple chronic diseases in the same individual, is increasingly recognized as a significant global public health challenge.^{2,7,8} Multimorbidity increases with age, and is associated with a variety of untoward health outcomes, including poor functional status, lower quality of life, higher healthcare utilization, and higher mortality.^{2,9–12} It is conceptualized not simply as a list of diseases conferring varying degrees of health risk, but as non-randomly occurring clusters of diseases within populations. Moreover, multimorbidity has been shown to vary widely in different settings based on socioeconomic status and race/ethnicity.^{13,14}

Racial/ethnic, regional, and rural/urban differences in diabetes control, medication adherence, and mortality are well-documented among individuals with diabetes.^{15–18} Given the prevalence of comorbid mental health disorders, it is also of particular interest to examine variations in psychiatric versus somatic disorders in patients with diabetes. Mental health disorders, particularly mood spectrum disorders, are strongly linked to worse health outcomes, with higher degrees of overall morbidity, in patients with diabetes.^{13,19} The association of diabetes with physical and psychological problems, and the strength of evidence for significant disparities among veterans with diabetes, warrants further investigation of concurrent physical and mental health conditions that likely

Received May 1, 2014

Revised July 11, 2014

Accepted July 25, 2014

Published online August 16, 2014

contribute to health inequity in this high-risk population. This project was designed to describe patterns of multimorbidity and to measure regional, rural/urban, and racial/ethnic variation in multimorbidity in a large national cohort of patients with type 2 diabetes mellitus. We also present information on multimorbidity grouped by mental versus physical disorders.

METHODS

Source of data

Multiple patient and administrative files from the Veterans Health Administration (VHA) National Patient Care (NPCD) and Pharmacy Benefits Management (PBM) databases were linked to create a national cohort of veterans with type 2 diabetes. Diabetes was defined by two or more International Classification of Diseases, Ninth Revision (ICD-9) codes for diabetes (250, 357.2, 362.0, and 366.41) in the previous 24 months (2000 and 2001) and during 2002 from inpatient stays and/or outpatient visits on separate days, using a previously validated algorithm.²⁰ The NPCD is the source for the VHA Medical SAS data sets used to analyze veteran clinical data such as diagnosis and procedure codes for outpatient visits and inpatient admissions. The PBM database includes utilization information for every prescription filled in the VA, with the Outpatient Pharmacy Package for individual prescriptions dispensed at the site's pharmacy, either as a new fill or a refill. All prescriptions filled by a Consolidated Mail Outpatient Pharmacy are included. The data sets were linked using scrambled patient Social Security numbers.

Study population

Veterans were followed from time of entry into the study in 2002 through December 2006, loss to follow-up, or until death. The cohort included a total of 892,223 veterans with type 2 diabetes, of which 61.51% were non-Hispanic white, 12.14% were non-Hispanic black, and 13.86% were Hispanic. There were also 12.48% of veterans with either missing or unknown race/ethnicity information. The study was approved by our Institutional Review Board (IRB) and local VA Research and Development committee.

Primary covariates

The primary covariates were race/ethnicity and location of residence. Race/ethnicity was retrieved from the 2002 outpatient and inpatient Medical SAS data sets. When missing or unknown, the variable was supplemented using fields for race from the inpatient 2003 Medical SAS data set, the outpatient 2004 Medical SAS data set, or the VA Vital Status Files from the Centers for Medicare and Medicaid Services. Patient residence was classified as urban or rural; with highly rural

categorized as rural as defined by the VA definition of rurality.²¹ Other covariates included in the study were age (categorized into four groups: <50, 50–64, 64–74, and 75 years and older), gender, marital status (married or unmarried), and region, classified based on the five geographic regions of the country according to the Veterans Integrated Service Networks (VISN): Northeast (VISNs 1, 2, and 3), Mid-Atlantic (VISNs 4, 5, 6, 9, and 10), South (VISNs 7, 8, 16, and 17), Midwest (VISNs 11, 12, 15, 19, and 23), and West (VISNs 18, 20, 21, and 22).²² We also considered medication status (receipt versus non-receipt of prescription for diabetes medication during the study period) and service-connected disability as a dichotomous (<50%, ≥50%) proxy variable to measure copay status, as has been done in multiple prior studies.^{17,23–25}

Outcome measure

The main outcome was multimorbidity, which was operationally defined based on the count of 16 common medical and mental health comorbidities^{12,26} including cancer, cardiovascular disease (CVD), cerebrovascular disease, congestive heart failure, peripheral vascular disease, liver disease, lung disease, fluid and electrolyte disorders, anemia, hypothyroidism, hypertension, obesity, substance abuse (alcohol and drug), psychoses, and depression. Comorbidities were defined based on ICD-9 codes as a history of disease at entry into the cohort, and were dichotomized (present/absent) using a previously validated algorithm.²⁷ Moreover, to examine comorbidity burden, individuals were grouped by number of comorbidities into the following four groups: 0, 1, 2, and 3+ comorbidities. We also defined a categorical outcome indicating the pattern of multimorbidity defined as medical comorbidity only, mental health comorbidity only, both medical and mental health comorbidities, and no comorbidity (diabetes alone).

Statistical analysis

Poisson regression was used to model the count data (comorbidities), adjusted for covariates. For each covariate, rate ratios and corresponding 95% confidence intervals (CI) were estimated via maximum likelihood using PROC GENMOD in SAS. Similarly, logistic regression was used to model the association between the categorical outcomes and the covariates, and estimates of odds ratios and 95% CI are reported. We examined the count model for overdispersion using the ratio of deviance to degrees-of-freedom and for zero-inflation by comparing models that assume zero-inflation versus no zero-inflation.²⁸ We did not observe any significant degree of overdispersion or zero-inflation in any of the models, indicating good fit and no excess of zeros (i.e., no comorbidity) in the model. Additionally, we used residual analysis to assess goodness-of-fit for each of the models. All data analyses were conducted using SAS 9.3. (Cary, North Carolina).

RESULTS

The study population comprised 892,223 veterans with diabetes in 2002. The mean number of medical and mental health comorbidities combined was 1.86. Table 1 shows the combined medical and mental health multimorbidity count stratified by demographics, geographic region, residence, service-connected disability, and use of any diabetes medication. Comorbidity type is also categorized into patients with diabetes alone and those with medical comorbidity only, mental health comorbidity only, and combined medical and mental health comorbidities, stratified by the same characteristics. The proportion of high-level (3+) multimorbidity increased with increasing age, and was more prevalent in females, non-Hispanic blacks, and individuals with $\geq 50\%$ service-connected disability or taking any diabetes medication. Among patients with any comorbidity, the majority (70.2%) had only medical comorbidities, 13.9% had both types of comorbidities, and 1.5% had only mental health comorbidities.

Table 2 shows the rate ratio for comorbidity count for the full model (gender, age, race/ethnicity, marital status, geographic region, rural/urban residence, level of service-connected disability, and use of diabetes medication). The number of comorbidities, including both medical and mental health, was slightly (5%) higher in women than men, and substantially increased with increasing age. Comorbidity count was 1.11 times higher in non-Hispanic blacks than non-Hispanic whites (95% CI: 1.11, 1.12), but only slightly higher (2%) in Hispanics. Married status appeared to be protective, with a 12% lower rate ratio for comorbidity count compared to unmarried patients. Total comorbidity burden was similar across geographic regions, with rate ratios ranging from 0.98 to 1.02, but higher in rural than urban areas (RR=1.04 [95% CI: 1.04, 1.05]). Patients with $\geq 50\%$ service-connected disability had 1.26 times the number of comorbidities as those with $<50\%$ service-connected disability (95% CI: 1.26, 1.27). Finally, patients not using medication to treat their diabetes had fewer comorbidities than those taking medication (RR=0.83 [95% CI: 0.82, 0.83]).

Table 3 shows the OR and corresponding 95% CI for the association between various patient-related characteristics in the full model and the likelihood of having 1, 2, or 3+ comorbidities relative to patients with no comorbidity. Focusing on number of comorbidities, women were less likely to have a single comorbidity (OR=0.83 [95% CI: 0.80, 0.87]) but more likely to have 3+ comorbidities (OR=1.08 [95% CI: 1.03, 1.12]) than men. As age increased, the odds of having 1, 2, or 3+ comorbidities increased, with the odds of having 3+ comorbidities almost fourfold higher in patients 75 years and older compared to patients younger than 50 years (OR=3.95 [95% CI: 3.84, 4.06]). Although non-Hispanic blacks had higher odds of having 1 (OR=1.35 [95% CI: 1.31, 1.38]), 2 (OR=1.47 [95% CI: 1.43, 1.50]), or 3+ (OR=1.67 [95% CI: 1.63, 1.71]) comorbidities than non-Hispanic whites,

Hispanics had lower odds of 1 (OR=0.90 [95% CI: 0.88, 0.92]) or 2 (OR=0.92 [95% CI: 0.90, 0.94]) comorbidities than non-Hispanic whites, and similar odds of having 3+ comorbidities. Relative to geography, patients living in the Mid-Atlantic, Midwest, and South had 9% or 10% higher odds of having 3+ comorbidities, and those living in the Northeast had 7% lower odds of having 3+ comorbidities than those living in the West. Finally, patients living in rural versus urban areas had higher odds of 1 (OR=1.07 [95% CI: 1.06, 1.09]), 2 (OR=1.15 [95% CI: 1.13, 1.17]) or 3+ (OR=1.21 [95% CI: 1.19, 1.23]) comorbidities.

Table 4 shows the OR and corresponding 95% CI for the association between various patient-related characteristics and having medical only, mental health only, and both medical and mental health comorbidities, relative to those with diabetes alone. Patterns similar to comorbidity count occurred by demographic characteristics. With regard to gender, women were more likely to have greater comorbidity burden (both medical and mental health comorbidities combined) (OR=1.16 [95% CI: 1.11, 1.22]) than men. As age increased, the odds of having only medical comorbidities increased, with nearly fourfold greater odds in patients 75 years and older than those younger than 50 years (OR=3.98 [95% CI: 3.88, 4.07]). This pattern was reversed, with increasing age associated with lower odds of having only a mental health comorbidity, with 73% lower odds in patients 75 years and older relative to patients younger than 50 years (OR=0.27 [95% CI: 0.25, 0.29]). With regard to race/ethnicity, non-Hispanic blacks had higher odds of medical comorbidity only (OR=1.49 [95% CI: 1.46, 1.53]), mental health comorbidity only (OR=1.25 [95% CI: 1.18, 1.33]), and combined medical and mental health comorbidities (OR=1.45 [95% CI: 1.41, 1.49]) than non-Hispanic whites. However, Hispanics had 8% lower odds of medical comorbidity only than those without comorbidity, but 20% higher odds of mental health comorbidity only and similar odds of combined medical and mental health comorbidities. Married patients were less likely to have medical or mental health comorbidities compared to unmarried patients. With regard to geography, patients in the Mid-Atlantic, Midwest, and South regions had 12%, 10%, and 17% higher odds, respectively, of having medical comorbidity only than those in the West. Finally, patients living in rural versus urban areas had higher odds of medical comorbidity only (OR=1.14 [95% CI: 1.12, 1.15]), mental health comorbidity only (OR=1.12 [95% CI: 1.08, 1.16]), and both medical and mental health comorbidities (OR=1.15 [95% CI: 1.13, 1.17]).

DISCUSSION

Among individuals with diabetes, traditionally disadvantaged groups, including non-Hispanic blacks and rural patients, had the greatest burden and risk of multimorbidity. With an

Table 1. Sample characteristics by multimorbidity count and type of multimorbidity (n=892,223)

Sample Characteristic (%)		Number of Comorbidities Mean (SD)	Number of Comorbidities (%)				Comorbidity Type (%)			
			0	1	2	3+	None	Medical Only	Mental Health Only	Medical and Mental Health
All Patients	(n=892,223)	1.86 (1.45)	14.33	33.45	25.70	26.52	14.33	70.25	1.50	13.92
Gender										
Male	(97.6)	1.86 (1.45)	14.23	33.58	25.73	26.45	14.23	70.55	1.47	13.75
Female	(2.4)	1.89 (1.55)	18.30	28.15	24.42	29.13	18.30	58.04	2.54	21.12
Age										
<50	(7.5)	1.55 (1.43)	24.87	32.33	22.01	20.79	24.87	47.03	5.22	22.88
50–64	(32.0)	1.81 (1.44)	15.57	34.17	25.03	25.23	15.57	62.25	2.40	19.77
65–74	(33.5)	1.87 (1.42)	12.65	34.91	26.36	26.09	12.65	76.95	0.59	9.81
75+	(27.0)	2.00 (1.48)	12.01	31.13	26.71	30.15	12.01	77.86	0.52	9.61
Race/Ethnicity										
Non-Hispanic White	(61.5)	1.93 (1.45)	12.10	33.38	26.74	27.78	12.10	72.65	1.26	13.99
Non-Hispanic Black	(12.1)	2.09 (1.53)	10.59	30.92	26.45	32.04	10.59	69.50	1.85	18.07
Hispanic	(13.9)	1.77 (1.49)	20.68	29.91	22.91	26.51	20.68	64.84	1.66	12.82
Other/	(12.5)	1.40 (1.19)	21.88	40.21	22.98	14.93	21.88	65.21	2.14	10.78
Missing										
Marital Status										
Married	(64.4)	1.79 (1.39)	14.38	35.22	26.02	24.37	14.38	73.05	1.09	11.48
Unmarried	(35.6)	1.99 (1.54)	14.23	30.26	25.12	30.39	14.23	65.21	2.23	18.33
Region										
Northeast	(11.5)	1.82 (1.43)	15.45	33.21	25.76	25.58	15.45	70.32	1.47	12.75
Mid-Atlantic	(22.5)	1.87 (1.45)	13.87	33.68	25.63	26.82	13.87	70.92	1.37	13.84
Midwest	(20.8)	1.89 (1.47)	13.76	33.31	25.70	27.23	13.76	71.34	1.45	13.46
South	(29.8)	1.86 (1.43)	13.69	33.83	26.18	26.30	13.69	70.89	1.38	14.04
West	(15.4)	1.82 (1.47)	16.24	32.91	24.75	26.10	16.24	66.72	1.90	15.14
Residence										
Urban	(61.6)	1.84 (1.46)	14.94	33.66	25.37	26.03	14.94	69.39	1.57	14.10
Rural	(38.4)	1.89 (1.44)	13.35	33.12	26.23	27.30	13.35	71.64	1.38	13.63
Service-Connected Disability										
<50% disabled	(89.8)	1.81 (1.42)	14.71	34.39	25.70	25.20	14.71	71.75	1.34	12.20
≥50% disabled	(10.2)	2.29 (1.65)	10.93	25.23	25.71	38.14	10.93	57.08	2.91	29.09
Diabetes Medication										
Yes	(83.0)	1.91 (1.44)	12.11	34.14	26.59	27.16	12.11	71.47	1.55	14.88
No	(17.0)	1.61 (1.45)	25.14	30.11	21.36	23.39	25.14	64.33	1.25	9.27

increasing number of comorbidities, as well as medical and combined comorbidity types, significantly greater odds were seen with non-Hispanic black race/ethnicity (35–67%), rural residence (7–21%), and Mid-Atlantic, Midwest, and South geographic regions (9–10%). Similar to other studies, older age (77–78% of this cohort 65+ years old) showed the highest odds of medical comorbidity.^{8,14,27} However, among those with at least 50% service-connected disability, the highest odds of comorbidity type were driven by mental health.

Few studies indicate the co-occurrence of physical and mental health conditions when examining population-based disparities in the veteran population.⁵ An important finding by gender showed that women had 8% higher odds of 3+ comorbidities and 16% higher odds of both medical and mental health comorbidities than men. Studies have also shown greater CVD risk burden²⁹ and mental health disorders in women,³⁰ who represent a growing population of veterans. The significantly lower multimorbidity among married veterans resonates with other studies showing this finding as an important

support mechanism for male versus female veterans.³¹ Prior studies of racial/ethnic, regional, and rural/urban differences in diabetes outcomes^{14–18} demonstrated a twofold higher potential for physical multimorbidity in non-Hispanic black patients due to poorer control of CVD risk factors and a lower rate of medication adherence. This study found that non-Hispanic black patients had 25–67% greater risk of medical, mental health, and combined comorbidities. The synergistic effect of the greater number of medical and mental health comorbidities present in more disadvantaged populations is a contributing factor to the gap in health equity evidenced in the literature.^{7–9,13–18}

The prevalence of coexisting medical and mental health conditions is clear among disadvantaged populations, with a convincing base of evidence. One study in a Scottish population (1.75 million) found that individuals in the most socio-economically deprived areas had 10–15 years' earlier onset of multimorbidity and 11-fold higher odds of both physical and mental health disorders than their wealthier counterparts.¹³

Table 2. Rate ratios for comorbidity count by sample characteristic

Characteristic	Rate Ratio	95% Confidence Interval
Gender		
Male (reference)	1.00	—
Female	1.05	(1.04, 1.06)
Age		
<50 (reference)	1.00	—
50–64	1.18	(1.18, 1.19)
65–74	1.26	(1.25, 1.27)
75+	1.36	(1.35, 1.37)
Race/Ethnicity		
Non-Hispanic White (reference)	1.00	—
Non-Hispanic Black	1.11	(1.11, 1.12)
Hispanic	1.02	(1.02, 1.03)
Other/Missing	0.77	(0.77, 0.78)
Marital Status		
Unmarried (reference)	1.00	—
Married	0.88	(0.87, 0.88)
Region		
West (reference)	1.00	—
Northeast	0.98	(0.97, 0.99)
Mid-Atlantic	1.01	(1.00, 1.02)
Midwest	1.02	(1.02, 1.03)
South	1.01	(1.00, 1.01)
Residence		
Urban (reference)	1.00	—
Rural	1.04	(1.04, 1.05)
Service-Connected Disability		
<50% disabled (reference)	1.00	—
≥50% disabled	1.26	(1.26, 1.27)
Diabetes Medication		
Yes (reference)	1.00	—
No	0.83	(0.82, 0.83)

Medical and mental health multimorbidity also increases likely utilization of healthcare, with two- and fivefold greater odds, respectively, of unplanned hospitalization.¹² These findings necessitate the development of interventions that use a multifaceted approach in patients with multimorbidity in order to improve equity in health and healthcare, which will likely be facilitated through health information technology.³²

It is clear from this analysis that location of residence is also both a statistically and clinically important factor as a measure of health, and can be a powerful predictor of health outcomes and disparities. Rural veterans were more likely to have 3+ comorbidities (OR 1.21). They were also more likely to have medical only, mental health only, or both comorbidity types than those living in urban areas. Recent studies conducted to improve health services utilization through an understanding of predictors of poor uptake for invited diabetes screening found that those deemed socioeconomically deprived^{33,34} were approximately 20% more likely not to participate, and that lack of participation was threefold greater for younger people.³⁴ Interventions that use telemonitoring combined with another supportive strategy (such as active case management or care coordination) to improve glycemic control show higher potential for sustained post-intervention effect.^{35–38} While there has been a growing number of such behavioral randomized trials or comprehensive multifaceted interventions, few have presented longitudinal outcomes data for improved health equity in disadvantaged populations with type 2 diabetes.

Table 3. Odds ratios for patients with one, two, three, or more comorbidities compared to diabetes only by sample characteristic

Characteristic	Odds Ratio (95% Confidence Interval)		
	1 vs. None	2 vs. None	3+ vs. None
Gender			
Male (reference)	1.00	1.00	1.00
Female	0.83 (0.80, 0.87)	0.96 (0.92, 1.00)	1.08 (1.03, 1.12)
Age			
<50 (reference)	1.00	1.00	1.00
50–64	1.72 (1.68, 1.76)	1.89 (1.84, 1.94)	2.11 (2.06, 2.17)
65–74	2.27 (2.22, 2.33)	2.62 (2.55, 2.69)	3.01 (2.93, 3.10)
75+	2.31 (2.25, 2.37)	3.04 (2.96, 3.12)	3.95 (3.84, 4.06)
Race/Ethnicity			
Non-Hispanic White (reference)	1.00	1.00	1.00
Non-Hispanic Black	1.35 (1.31, 1.38)	1.47 (1.43, 1.50)	1.67 (1.63, 1.71)
Hispanic	0.90 (0.88, 0.92)	0.92 (0.90, 0.94)	1.01 (0.99, 1.04)
Other/Missing	0.84 (0.83, 0.86)	0.63 (0.62, 0.64)	0.40 (0.40, 0.41)
Marital Status			
Unmarried (reference)	1.00	1.00	1.00
Married	1.02 (1.00, 1.03)	0.88 (0.87, 0.89)	0.67 (0.66, 0.68)
Region			
West (reference)	1.00	1.00	1.00
Northeast	0.98 (0.96, 1.01)	1.00 (0.97, 1.02)	0.93 (0.91, 0.96)
Mid-Atlantic	1.11 (1.08, 1.13)	1.10 (1.07, 1.13)	1.09 (1.07, 1.12)
Midwest	1.08 (1.06, 1.11)	1.09 (1.06, 1.11)	1.11 (1.08, 1.13)
South	1.15 (1.13, 1.17)	1.16 (1.14, 1.19)	1.10 (1.08, 1.13)
Residence			
Urban (reference)	1.00	1.00	1.00
Rural	1.07 (1.06, 1.09)	1.15 (1.13, 1.17)	1.21 (1.19, 1.23)
Service-Connected Disability			
<50% disabled (reference)	1.00	1.00	1.00
≥50% disabled	0.94 (0.92, 0.97)	1.30 (1.27, 1.33)	2.03 (1.98, 2.08)
Diabetes Medication			
Yes (reference)	1.00	1.00	1.00
No	0.41 (0.41, 0.42)	0.37 (0.36, 0.38)	0.38 (0.37, 0.38)

Table 4. Odds ratios for patients with medical and/or mental health comorbidity types compared to those having diabetes only by sample characteristic

Characteristic	Odds Ratio (95% Confidence Interval)		
	Medical Only vs. None	Mental Health Only vs. None	Both Medical and Mental Health vs. None
<i>Gender</i>			
Male (reference)	1.00	1.00	1.00
Female	0.88 (0.85, 0.91)	0.95 (0.87, 1.04)	1.16 (1.11, 1.22)
<i>Age</i>			
<50 (reference)	1.00	1.00	1.00
50–64	2.17 (2.12, 2.21)	0.79 (0.76, 0.83)	1.49 (1.45, 1.53)
65–74	3.45 (3.37, 3.53)	0.28 (0.27, 0.30)	1.06 (1.03, 1.09)
75+	3.98 (3.88, 4.07)	0.27 (0.25, 0.29)	1.16 (1.13, 1.20)
<i>Race/Ethnicity</i>			
Non-Hispanic White (reference)	1.00	1.00	1.00
Non-Hispanic Black	1.49 (1.46, 1.53)	1.25 (1.18, 1.33)	1.45 (1.41, 1.49)
Hispanic	0.92 (0.90, 0.94)	1.20 (1.13, 1.28)	1.03 (1.00, 1.06)
Other/Missing	0.70 (0.68, 0.71)	0.73 (0.70, 0.77)	0.45 (0.43, 0.46)
<i>Marital Status</i>			
Unmarried (reference)	1.00	1.00	1.00
Married	0.95 (0.93, 0.96)	0.55 (0.53, 0.57)	0.58 (0.57, 0.59)
<i>Region</i>			
West (reference)	1.00	1.00	1.00
Northeast	0.98 (0.96, 1.00)	1.00 (0.93, 1.06)	0.92 (0.90, 0.95)
Mid-Atlantic	1.12 (1.10, 1.14)	0.91 (0.86, 0.96)	1.05 (1.02, 1.08)
Midwest	1.10 (1.08, 1.12)	1.02 (0.96, 1.08)	1.06 (1.03, 1.09)
South	1.17 (1.14, 1.19)	0.89 (0.84, 0.94)	1.06 (1.03, 1.08)
<i>Residence</i>			
Urban (reference)	1.00	1.00	1.00
Rural	1.14 (1.12, 1.15)	1.12 (1.08, 1.16)	1.15 (1.13, 1.17)
<i>Service-Connected Disability</i>			
<50% disabled (reference)	1.00	1.00	1.00
≥50% disabled	1.04 (1.02, 1.06)	2.40 (2.28, 2.51)	2.71 (2.65, 2.78)
<i>Diabetes Medication</i>			
Yes (reference)	1.00	1.00	1.00
No	0.40 (0.39, 0.41)	0.45 (0.42, 0.48)	0.31 (0.31, 0.32)

Collectively, such studies will lead toward a better understanding of some of the root causes and variations of health equity, as well as potential interventions for improving equity in healthcare across different populations. The challenge inherent in achieving parity in care is in devising effective strategies that effect more coordinated multifaceted management of clinical care, while simultaneously addressing social elements in the context of limited resources so that the unseen daily management occurs at the same level of intensity.

There are important advantages in showing the pattern of multimorbidity in a very large population of patients who have similar access to healthcare, such as in the VA healthcare system. The paradigm shift in the focus of care toward patients rather than their disease, combined with provisions from the Affordable Care Act that increase access to healthcare across the broader U.S. population, should enhance the ability of various healthcare systems to improve the management of multimorbidity. However, the shifting demographic toward racial/ethnic minorities who bear a heavier burden and higher risk of chronic disease, with poorer control, calls for greater focus on comprehensive patient-focused interventions that empower patients for greater self-management. These study findings must be applied in the appropriate context. This study is limited by a lack of information on disease severity, chronological development of comorbid conditions, and clusters (combinations) of chronic conditions in specific demographic

groups.³⁹ Another limitation is generalizability to the larger U.S. population with diabetes. However, our findings can be generalized to older adults in large healthcare systems such as the Geisinger Health System, Group Health, or Kaiser Permanente. Similarly, while the proportion of women in our study is relatively low, the absolute number of women and greater multimorbidity among them¹³ strongly indicates the need for further investigation of gender differences.

These findings provide better characterization of disparities in multimorbidity patterns, information that can be used by frontline clinicians to assist with coordinated management of diabetes. As an increasing number of studies examine shared etiologies and risk factors for disease clusters, clinical services and health policies must set targets toward management efforts that shape guidelines for best practices in multimorbidity,³⁹ but also cannot ignore patient-specific needs. This study will also aid in understanding patterns of multimorbidity in a way that facilitates planning and coordination of health services to align well with the needs of diverse groups of individuals with diabetes and heavy comorbidity burden. Beyond the recognition of distribution of chronic diseases (e.g., co-occurring diabetes, hypertension, stroke, obesity, and depression), the development and execution of a multifaceted, culturally congruent approach to managing chronic disease clusters is most likely to have a powerful impact on patient care and health outcomes for individuals with diabetes.

ACKNOWLEDGMENT: 1. This study was supported by grant #IIR-06-219 funded by the VHA Health Services Research and Development (HSR&D) program. The funding agency did not participate in the design or conduct of the study; collection, management, analysis, and interpretation of the data; or preparation, review, or approval of the manuscript. The manuscript represents the views of the authors and does not reflect those of the VA or HSR&D.

2. Drs. Leonard E Egede and Mulugeta Gebregziabher are the guarantors of this work, and as such, had full access to all data in the study, and take responsibility for the integrity of the data and the accuracy of the data analysis.

3. This work has not previously been presented.

Conflict of Interest: The authors each declare that they have no conflict of interest.

Authors' Contributions: Study concept and design: Egede, Gebregziabher, Axon, Hunt, Lynch

Acquisition of data: Egede

Analysis and interpretation of data: Gebregziabher, Hunt, Payne, Egede

Drafting of the manuscript: Egede, Lynch, Gebregziabher, Axon, Hunt, Payne

Critical revision of the manuscript for important intellectual content: Lynch, Gebregziabher, Axon, Hunt, Payne, Egede

Final approval of manuscript: Lynch, Axon, Gebregziabher, Hunt, Egede, Payne

Corresponding Author: Leonard E. Egede, MD, MS; Center for Health Disparities Research, Division of General Internal Medicine Medical University of South Carolina, 135 Rutledge Avenue, MSC 593, Charleston, SC 29425-0593, USA (e-mail: egedel@muscc.edu).

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