

Differential Impact of Mental Health Multimorbidity on Healthcare Costs in Diabetes

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Diabetes mellitus (DM) is a global health problem that affected 285 million adults, or 6.4% of the worldwide adult population in 2010.¹ By 2030, DM prevalence is projected to increase by 69%, creating additional health burdens in both developing and developed countries.¹

The United States has been similarly affected by epidemic DM spread, with 25.8 million people affected in 2012 and a projected 29 million to be affected by 2050.² DM is a costly disease, with new estimates indicating that the total 2012 DM-related expenditures in the United States were \$245 billion³— a 41% increase over estimates from 2007—and costs are expected to continue to rise.^{3,4} The largest component of national DM-related expenditures is attributed to inpatient costs, with additional costs related to medication and physician office visits.³ Currently, more than 1 in 10 US healthcare dollars are spent directly on DM and its complications.⁵

Multimorbidity, defined as the coexistence of 2 or more chronic diseases in a given patient, has been found to be highly prevalent among primary care populations in recent years, and prevalence appears to be increasing as the worldwide population ages.^{6,7} A recent cross-sectional study of 1.7 million Scottish primary care patients found that 42% of subjects had 2 or more of 40 chronic conditions.⁸ Similarly, 35% of veterans in the US Veterans Health Administration (VHA) were reported to have 3 or more of 29 chronic conditions.⁹ Research indicates that certain common multimorbid disease clusters involve both somatic and psychiatric illnesses and are associated with increased healthcare utilization, increased costs, and worse health outcomes.^{8,10} Among these, DM is the most commonly cited chronic medical illness.⁶

Compared with the general population, rates of major depression are 60% higher and rates of generalized anxiety disorder are 123% higher among patients with DM.¹¹ Individuals with DM are also more likely to have schizophrenia and bipolar disorder than those without DM.^{12,13} Poor disease control in either DM or psychiatric disorders has been

ABSTRACT

Objectives: This study assessed the prevalence and specific costs associated with discrete multimorbid mental health disease clusters in adults with diabetes mellitus (DM).

Study Design: Longitudinal analysis of a retrospective cohort.

Methods: We performed a 5-year longitudinal analysis of a retrospective cohort of 733,071 patients with DM from the US Veterans Health Administration (VHA) between 2002 and 2006. The mental health comorbidities (MHCs) examined included depression, substance abuse, and psychosis. Our primary outcomes of interest were total inpatient, outpatient, and pharmacy costs measured in 2012 US\$ from the perspective of the VHA.

Results: DM was present with comorbid depression, substance abuse, and psychosis in 12.1%, 3.7%, and 4.2% of patients, respectively. Overall, 13.5% of patients had 1 MHC, 2.5% had 2 MHCs, and 0.5% had all MHCs. Total inpatient (\$1,435,651,415), outpatient (\$366,137,435), and pharmacy (\$90,064,725) costs were highest for patients with DM and comorbid depression alone. At the per-patient level, DM plus psychosis and substance abuse had the highest inpatient costs (\$35,518), DM plus all MHCs had the highest outpatient costs (\$6962), and DM plus depression and psychosis had the highest pharmacy costs (\$1753).

Conclusions: DM with comorbid depression is the most prevalent MHC combination and is associated with the highest total VHA healthcare costs. However, other comorbidity clusters are associated with higher mean per patient costs, and may therefore benefit from more intensive intervention. Analysis of healthcare expenditures by multimorbid disease clusters can be a useful tool for healthcare policy planning.

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Take-Away Points

This study assessed the prevalence and specific costs associated with discrete multimorbid mental health disease clusters in adults with diabetes mellitus using data from the Veterans Health Administration.

- Depression, substance use, and psychosis were highly prevalent in this population.
- Diabetes mellitus with comorbid depression was the most prevalent comorbid mental health condition and was associated with the highest total healthcare cost. However, other comorbidity clusters were also associated with higher mean per patient costs.
- Analysis of healthcare expenditures by multimorbid disease clusters may be a useful tool for healthcare policy planning.

shown to complicate and aggravate the other.¹⁴ The addition of comorbid mental health disorders to DM has been associated with poorer glycemic control, lower medication adherence, higher rates of diabetic complications, higher levels of disability, and diminished quality of life.^{12,15} Proposed mechanisms for these effects include altered physiological pathways and abnormal behavioral pathways that result in decreased self-care.¹⁴

Relatively few studies have examined the impact of different clusters of mental health comorbidities (MHCs) on healthcare utilization and costs among patients with DM. Most completed studies to date have focused solely on depression, have been limited by cross-sectional design, have had a relatively small sample size, or have used costing methodologies that failed to analyze costs in relevant categories.^{12,16-19} Most studies only analyzed total costs, or analyzed cost categories in separate models. The purpose of this study was to evaluate the impact of multiple combinations of psychiatric comorbidity on healthcare utilization and cost in adults with DM using a novel methodology that allows estimation of 3 categories of cost simultaneously.

We examined a national cohort of US veterans with DM cared for in the VHA— an integrated national healthcare system in the United States—over a 5-year period. Veterans have a high prevalence of chronic medical conditions as well as MHCs,²⁰ but rates of chronic conditions have increased over time in the general US population as well.²¹ Importantly, few data sources that are not from the VHA system have comprehensive information on inpatient, outpatient, and pharmacy costs across age ranges and insurance carriers.

METHODS

Data Source and Sample

The study involves 733,071 veterans from a national cohort of patients with DM cared for in the VHA from 2002 to 2006. The cohort was created by linking patient and administrative files from the VHA National Pa-

tient Care (NPC) and Pharmacy Benefits Management (PBM) databases. Veterans in the DM cohort were included in the study if they had: 1) DM defined by 2 or more *International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM)* codes for DM (250, 357.2, 362.0, and 366.41) in the previous 24 months (in 2000 and 2001); 2) *ICD-9-CM* codes for DM from inpatient stays and/or outpatient visits on separate days (excluding codes from lab tests and other nonclinician visits) in 2002; and 3) prescriptions for insulin or oral hypoglycemic agents in 2002 based on a previously validated algorithm.²² Veterans identified as having DM by *ICD-9-CM* codes were excluded from the cohort if they did not have prescriptions for DM medications in 2002 (see Egede et al [2012]).²³ The DM cohort included 740,195 veterans who were followed through December 2006 or until death or loss to follow-up. Data sets were linked using scrambled patient Social Security numbers, and annual patient-specific Veterans Administration (VA) healthcare costs were calculated through VA Decision Support System (DSS) data, which extract costs from the VA payroll and general ledger. Costs were then classified into inpatient, outpatient (including emergency department [ED]), and pharmacy categories. We excluded less than 1% of the patients (n = 7124) from the DM cohort because of missing data on all 3 cost outcomes, resulting in n = 733,071 subjects. Our statistical models account for patients with missing cost data, assuming they are missing at random. The study was approved by our Institutional Review Board and local VA Research and Development Committee.

Study Variables

Outcome variables. The primary outcome variables were 3 cost types (pharmacy, inpatient, and outpatient) measured in 2006 US\$, and the perspective was that of the federal payer. DSS cost data were applied to encounter codes (diagnosis or procedure) from the VA. Prescription drug costs were identified from the PBM system and summed from the price per dispensed unit. Costs for each study year were represented in person-years to account for censoring.

Covariates. The primary covariate was the number of MHCs modeled as continuous and categorical (0-1, 2, 3+). MHCs of interest included *ICD-9-CM* diagnosis of: substance abuse (292.0, 292.82-292.89, 292.9, 304.x, 305.2-305.9, 648.3); depression (300.4, 301.12, 309.0, 309.1, 311); or psychosis (295.x-298.x, 299.1), as defined by Elixhauser's Agency for Healthcare Research and Quality *ICD-9-*

CM coding algorithm, reported by Quan et al.²⁴ It was also modeled as MHC types (ie, none, depression, psychosis, substance abuse, and their 2-way and 3-way interactions). Other covariates included in the full model were age, gender, marital status, race/ethnicity, residence, region, and comorbidities. Marital status was defined as single or married. Race/ethnicity was classified as non-Hispanic white (NHW), non-Hispanic black (NHB), Hispanic, and other/unknown/missing. Location of residence was defined as urban and rural/highly rural, and hospital region was defined by the 5 geographic regions of the country based on VHA Veterans Integrated Service Networks (VISNs): northeast (VISNs 1, 2, 3), mid-Atlantic (VISNs 4, 5, 6, 9, 10), south (VISNs 7, 8, 16, 17), midwest (VISNs 11, 12, 15, 19, 23), and west (VISNs 18, 20, 21, 22).²⁵

Comorbidity variables included anemia, cancer, cerebrovascular disease, congestive heart failure, cardiovascular disease, fluid and electrolyte disorders, hypertension, hypothyroidism, liver disease, lung disease, obesity, peripheral vascular disease, and other diseases (ie, AIDS, rheumatoid arthritis, renal failure, peptic ulcer disease and bleeding, and weight loss), and were defined based on ICD-9-CM codes at entry into the cohort based on previously validated algorithms.²⁴

Statistical Analyses

Descriptive measures including mean and median costs were computed for each cost type for each MHC group. Preliminary analysis included plotting the unadjusted mean costs in each cost type (inpatient, outpatient, pharmacy) over time by MHC, with time on the x-axis and unadjusted mean cost on the y-axis. The plots helped to examine trends over time in each source of cost by MHC before adjusting for any other covariates. To model the relationship between the 3 cost categories and covariates, a joint model based on a multivariate generalized linear mixed model (mGLMM) approach with shared random intercept was used (see Gebregziabher et al).²⁶

Since the response variable is a vector of 3 correlated cost outcomes, mGLMM with a random intercept and slope was implemented in SAS Proc GLIMMIX (SAS Institute, Cary, North Carolina). To account for the skewness in the observed cost data, a log-normal distribution with an identity link was used. Therefore, the exponent of the parameter estimates can be interpreted as the percent change in each type of cost as a function of unit change in the covariates. Comparison with analysis results based on fitting separate models for each outcome was also performed. In the joint models, the random intercept shared by the 3 cost outcomes captures the associ-

ation in the natural heterogeneity among the individual subjects' baseline inpatient, outpatient, and pharmacy costs, while the random slope captures the correlation in the trajectory over time of cost outcomes. Goodness-of-fit of models was assessed using pseudo-AIC-type statistics and using residual plots.

Costs to the VHA of individual and combinations of MHCs were estimated by examining the adjusted 5-year mean least-square cost of each individual MHC and all possible combinations of MHCs by the number of veterans in every MHC category, and multiplying by the number of veterans diagnosed with each individual or combination of MHCs. The estimate of the medical component of the Consumer Price Index (CPI) from the Bureau of Labor Statistics (within the Department of Labor) was used to convert all 2002-2005 costs to 2006 US\$ prior to model estimation. The CPI was also used to convert total costs in the VHA from 2006 US\$ to December 31, 2012, dollar values using the 1.138856 multiplier. All statistical analyses were performed using SAS version 9.2 (SAS Institute, Cary, North Carolina).

RESULTS

Population Characteristics by Number of Mental Health Comorbidities

The final study sample consisted of 733,071 veterans with a diagnosis of DM during 2002 and followed through 2006 or until death or loss to follow-up (Table 1). The prevalence of depression, substance abuse, and psychosis were 12.1%, 3.7%, and 4.2%, respectively. Moreover, 13.5% had 1 MHC, 2.5% had 2 MHCs, and 0.5% had all 3 MHCs, while 83.5% had 0 MHCs. Across the 5 years studied, the mean number of mental health visits per year ranged from 26.6 in those with 3 MHCs to 0.9 in those without a MHC. Those who had at least 1 MHC were younger, more likely to be female, less likely to be married, and less likely to have a rural residence than those without a MHC.

Longitudinal Cost Associations With Mental Health Comorbidity Status

Table 2 highlights findings of significant ($P < .001$) cost associations with MHC status among veterans with DM between 2002 and 2006, after adjustment for demographics and medical comorbidities and accounting for the correlation of cost categories over time. Relative to the 0 MHC group, 1 MHC was associated with 28% higher inpatient, 42% higher outpatient, and 36% higher pharmacy costs between 2002 and 2006. Having 2 MHCs was associated with 57% higher inpatient, 78% higher outpa-

Table 1. Demographic and Clinical Characteristics of the Study Cohort by Number of Mental Health Comorbidities

Variable	All (n = 733,071)	MHC = 0 (n = 612,219)	MHC = 1 (n = 98,695)	MHCs = 2 (n = 18,427)	MHCs = 3 (n = 3730)
Mental health visits: mean (SD)					
2002	2.1 (12.1)	0.9 (6.9)	6.0 (20.6)	15.2 (33.6)	26.5 (46.5)
2003	1.7 (9.2)	0.9 (5.6)	4.7 (15.2)	10.7 (26.1)	15.7 (29.8)
2004	2.7 (14.9)	1.4 (9.2)	7.3 (25.3)	16.8 (39.9)	26.6 (51.3)
2005	2.0 (10.4)	1.1 (6.5)	5.1 (17.4)	11.3 (28.1)	17.6 (36.6)
2006	1.8 (9.8)	1.0 (6.2)	4.7 (16.9)	10.3 (26.3)	14.5 (31.3)
MHCs (%)					
Depression	12.1	0.0	70.1	84.6	100
Substance abuse	3.7	0.0	14.3	51.1	100
Psychosis	4.2	0.0	15.5	64.3	100
Age in years: mean (SD)	65.7 (11.1)	66.6 (10.8)	62.1 (11.4)	57.1 (10.6)	52.6 (8.0)
Male (%)	97.8	98.0	96.4	96.0	97.1
Race (%)					
NHW	69.2	69.6	68.9	62.0	51.6
NHB	12.4	11.7	14.1	22.2	31.7
Hispanic	5.8	5.6	6.4	7.7	9.2
Others	12.7	13.2	10.5	8.1	7.5
Married (%)	65.5	67.8	56.9	42.5	30.3
Rural (%)	38.7	39.0	38.6	32.5	27.3
Geographic region (%)					
Mid-Atlantic	22.5	22.6	22.5	21.2	20.1
West	15.0	14.7	16.6	17.5	18.0
Northeast	11.2	11.4	10.1	11.2	12.9
South	30.0	30.0	30.5	28.3	26.8
Midwest	21.0	21.2	19.7	20.9	21.2
Medical comorbidities (%)					
Anemia	7.2	6.6	10.2	11.6	11.2
Cancer	7.4	7.5	7.5	5.8	3.4
Cerebrovascular disease	11.3	10.2	16.7	18.0	16.9
Congestive heart failure	11.2	10.8	13.8	12.1	8.7
Cardiovascular disease	3.5	3.4	4.3	4.2	3.4
Fluid/electrolyte disorders	4.8	3.9	8.3	12.8	14.6
Hypertension	76.5	76.0	79.2	78.2	77.1
Hypothyroidism	6.0	5.8	7.2	7.4	6.4
Liver disease	3.1	2.3	5.7	11.5	21.3
Lung disease	13.6	12.4	18.9	22.3	24.5
Obesity	12.5	11.8	16.0	17.6	18.0
Other disease	3.6	3.2	5.3	6.9	8.2
Peripheral vascular disease	11.6	11.3	13.3	11.8	10.1

MHC indicates mental health comorbidity; NHB, non-Hispanic black; NHW, non-Hispanic white.

Table 2. Joint Equation With Random Intercept Estimates of Effect of Number of Mental Health Comorbidities on Cost

	Inpatient Cost		Outpatient Cost		Pharmacy Cost	
	Estimate	(95% CI)	Estimate	(95% CI)	Estimate	(95% CI)
Intercept	10,021	(9592-10,469)	7966	(7802, 8133)	1314	(1290-1338)
MHCs						
0 MHC	Ref		Ref		Ref	
1 MHC	1.281	(1.265-1.296)	1.423	(1.413-1.432)	1.364	(1.356-1.371)
2 MHCs	1.568	(1.535-1.601)	1.777	(1.752-1.802)	1.589	(1.569-1.608)
3 MHCs	1.853	(1.782-1.927)	1.922	(1.864-1.981)	1.716	(1.671-1.763)
Fiscal year	1.003	(0.999-1.006)	0.984	(0.983-0.985)	0.991	(0.991-0.992)
Age (years)	1.004	(1.004-1.004)	0.982	(0.982-0.983)	0.989	(0.988-0.989)
Male vs female	1.185	(1.150-1.221)	0.868	(0.855-0.881)	0.938	(0.926-0.950)
Married vs single	0.759	(0.751-0.766)	0.844	(0.840-0.848)	1.117	(1.113-1.122)
Rural vs urban	1.019	(1.009-1.030)	0.928	(0.924-0.932)	1.006	(1.002-1.010)
Race						
NHW	Ref		Ref		Ref	
NHB	1.121	(1.106-1.136)	1.361	(1.352-1.371)	0.885	(0.879-0.890)
Hispanic	1.025	(1.005-1.044)	1.241	(1.229-1.253)	0.845	(0.838-0.852)
Others	0.936	(0.921-0.951)	0.980	(0.973-0.986)	0.736	(0.732-0.741)
Geographic region						
Mid-Atlantic	Ref		Ref		Ref	
West	1.127	(1.110-1.144)	1.608	(1.596-1.619)	0.990	(0.984-0.997)
Northeast	1.127	(1.107-1.147)	1.124	(1.116-1.133)	1.046	(1.039-1.054)
South	0.932	(0.92-0.944)	1.016	(1.010-1.022)	1.051	(1.045-1.057)
Midwest	1.033	(1.019-1.048)	1.058	(1.052-1.065)	1.079	(1.072-1.085)
Medical comorbidities						
Anemia	1.276	(1.258-1.295)	1.406	(1.394-1.418)	1.217	(1.207-1.226)
Cancer	1.091	(1.073-1.110)	1.211	(1.201-1.221)	1.160	(1.151-1.169)
Cerebrovascular disease	1.315	(1.298-1.331)	1.235	(1.226-1.244)	1.264	(1.257-1.272)
Congestive heart failure	1.190	(1.174-1.205)	1.233	(1.224-1.242)	1.225	(1.217-1.233)
Cardiovascular disease	1.241	(1.217-1.266)	1.297	(1.282-1.313)	1.070	(1.058-1.081)
Fluid/electrolyte disorders	1.293	(1.272-1.313)	1.454	(1.438-1.469)	1.111	(1.101-1.122)
Hypertension	1.022	(1.009-1.034)	1.188	(1.182-1.194)	1.305	(1.299-1.311)
Hypothyroidism	0.995	(0.977-1.015)	1.060	(1.051-1.070)	1.141	(1.132-1.150)
Liver disease	1.210	(1.185-1.235)	1.286	(1.270-1.303)	1.052	(1.040-1.064)
Lung disease	1.132	(1.119-1.146)	1.330	(1.321-1.338)	1.319	(1.311-1.326)
Obesity	0.951	(0.938-0.965)	1.072	(1.065-1.079)	1.043	(1.037-1.049)
Other disease	1.290	(1.265-1.315)	1.377	(1.361-1.393)	1.416	(1.401-1.431)
Peripheral vascular disease	1.338	(1.321-1.355)	1.274	(1.266-1.283)	1.178	(1.170-1.185)

MHC indicates mental health comorbidity; NHB, non-Hispanic black; NHW, non-Hispanic white; Ref, reference.

tient, and 59% higher pharmacy costs. Having 3 MHCs was associated with 85% higher inpatient, 92% higher outpatient, and 72% higher pharmacy costs.

The joint model estimates with respect to the specific individual and combinations of MHCs relative to 0

MHCs are shown in [Table 3](#). Depression alone was associated with 16% higher inpatient, 45% higher outpatient, and 44% higher pharmacy costs. Substance abuse alone was associated with 30% higher inpatient, 9% higher outpatient, and 76% higher pharmacy costs. Psychosis alone

was associated with 63% higher inpatient, 68% higher outpatient, and 77% higher pharmacy costs. The combination of depression and psychosis was associated with 45% higher inpatient, 102% higher outpatient, and 94% higher pharmacy costs. The combination of psychosis and substance abuse was associated with 99% higher inpatient, 71% higher outpatient, and 66% higher pharmacy costs. The combination of all 3 comorbidities was associated with 89% higher inpatient, 90% higher outpatient, and 68% higher pharmacy costs.

Estimates of Mean and Total VHA Costs for Individual and Combinations of MHCs

Estimates of total VHA costs of individual and a combination of MHCs of interest based on December 31, 2012, value dollars are shown in **Table 4**. Over the 5-year period, mean inpatient (\$17,886) and outpatient (\$3659) costs were lowest in veterans without MHCs, while mean pharmacy costs were lowest in veterans with substance abuse only (\$689). Among veterans with MHCs, the mean inpatient cost was highest (\$35,518) for those diagnosed with psychosis and substance abuse, and lowest (\$20,737) for those diagnosed with depression alone. Veterans who also had a diagnosis of depression had lower (\$33,866) inpatient cost than those only diagnosed with psychosis and substance abuse (\$35,518). Among veterans with MHCs, mean outpatient cost was highest (\$7537) for those diagnosed with psychosis and depression, and lowest (\$3989) for those diagnosed with substance abuse only. Veterans who also had a diagnosis of substance abuse had lower (\$6962) outpatient cost than those only diagnosed with psychosis and depression (\$7397). Mean pharmacy cost was highest (\$1753) for veterans diagnosed with psychosis and depression and lowest (\$689) for those diagnosed with substance abuse only. Veterans who also had a diagnosis of substance abuse had lower pharmacy cost (\$1518) than those only diagnosed with depression and psychosis (\$1753).

Among veterans with MHCs, total estimated VHA inpatient cost burden was highest (\$1,435,651,415) for depression only, due to the high frequency ($n = 69,230$) of this MHC among veterans with DM. Total estimated VHA inpatient cost burden was lowest (\$100,765,641) among veterans diagnosed with psychosis and substance abuse due to the low frequency ($n = 2837$) of this MHC combination among those with DM. Total estimated VHA inpatient, outpatient, and pharmacy cost burden of all 3 MHCs combined were \$126,320,058, \$25,968,766, and \$5,660,328, respectively, for 3730 veterans.

DISCUSSION

We analyzed data from the US VHA, the largest integrated health system in the United States, which serves 8.3 million enrollees at 152 VA hospitals and 821 community-based outpatient clinics. Our cohort contained comprehensive demographic, clinical, pharmacy, and cost data on a national scale. We found that the presence of any MHC with DM is associated with significantly higher inpatient and outpatient costs compared with patients without MHCs. DM and comorbid depression was both the most frequent, and in aggregate, the most costly disease combination. However, at the patient level, several other disease combinations are associated with higher inpatient, outpatient, and pharmacy costs from the perspective of the federal payer. This was particularly true for disease clusters that included psychosis. These results are relevant for comprehensive healthcare systems as they plan interventions and programs for patients with DM and mental health multimorbidity.

Our results are consistent with prior research on healthcare costs associated with DM and depression, which has consistently found that costs are significantly higher even after adjustment for age, sex, race, insurance, and other chronic medical illnesses.^{12,17,19} For example, Kalsekar et al found that costs for Medicare patients with DM and depression were nearly 65% higher than those without depression.¹⁹ Similarly, Finkelstein et al found a 2-fold increase in total healthcare costs, which remained significant even after excluding non-mental health-related costs.¹⁸ Increasing depression severity has also been associated with significantly higher costs.^{16,27} A recent review on healthcare costs found inconsistent results, but noted that most studies suggest inpatient, outpatient, ED, and medications costs are all higher for those with comorbid mental health disorders than for those without.²⁸ Our analysis extends knowledge by estimating the specific inpatient, outpatient, and pharmacy expenditures for patients with DM, depression, substance abuse, and psychosis.

In our cohort, the observed prevalence of psychosis was 4.2%, which is significantly higher than that reported for the general population (approximately 0.4%).²⁹ However, among patients with schizophrenia receiving antipsychotic medications, DM prevalence rates as high as 23% have been reported.³⁰ High health services use among patients with psychosis are well documented,^{30,31} but with the exception of depression, less is known regarding healthcare utilization and costs associated with DM and MHCs. Jackson et al found that current alcohol use

Table 3. Joint Equation With Random Intercept Estimates of Effect of Individual and Combinations of Mental Health Comorbidities on Cost

	Inpatient Cost		Outpatient Cost		Pharmacy Cost	
	Estimate	(95% CI)	Estimate	(95% CI)	Estimate	(95% CI)
Intercept	9654	(9242-10,085)	7959	(7796-8125)	1310	(1287-1334)
MHCs						
No MHC		Ref		Ref		Ref
Depression only	1.159	(1.143-1.176)	1.445	(1.434-1.456)	1.441	(1.432-1.451)
Substance abuse only	1.297	(1.264-1.331)	1.090	(1.073-1.107)	0.763	(0.752-0.773)
Psychosis only	1.632	(1.592-1.673)	1.680	(1.655-1.706)	1.771	(1.747-1.795)
Depression & psychosis	1.448	(1.406-1.492)	2.021	(1.982, 2.061)	1.942	(1.909-1.976)
Depression & substance abuse	1.522	(1.472-1.573)	1.492	(1.458-1.526)	1.150	(1.127-1.173)
Psychosis & substance abuse	1.986	(1.896, 2.080)	1.709	(1.651-1.769)	1.662	(1.612-1.713)
All 3 MHCs	1.893	(1.821-1.969)	1.902	(1.846-1.961)	1.681	(1.637-1.727)
Fiscal year	1.004	(1.001-1.007)	0.984	(0.983-0.985)	0.991	(0.991-0.992)
Age (years)	1.005	(1.004-1.005)	0.982	(0.982-0.983)	0.988	(0.988-0.988)
Male vs female	1.159	(1.125-1.193)	0.880	(0.867-0.893)	0.965	(0.952-0.977)
Married vs single	0.770	(0.763-0.778)	0.841	(0.837-0.845)	1.109	(1.104-1.113)
Rural vs urban	1.023	(1.013-1.034)	0.927	(0.923-0.931)	1.004	(1.000-1.008)
Race						
NHW		Ref		Ref		Ref
NHB	1.096	(1.082-1.110)	1.370	(1.361-1.380)	0.897	(0.892-0.903)
Hispanic	1.014	(0.995-1.033)	1.244	(1.232-1.256)	0.850	(0.843-0.857)
Others	0.931	(0.916-0.946)	0.981	(0.975-0.988)	0.739	(0.735-0.744)
Geographic region						
Mid-Atlantic		Ref		Ref		Ref
West	1.131	(1.114-1.149)	1.609	(1.597-1.620)	0.992	(0.986-0.998)
Northeast	1.127	(1.108-1.147)	1.125	(1.116-1.134)	1.048	(1.040-1.055)
South	0.933	(0.921-0.946)	1.015	(1.009-1.021)	1.049	(1.043-1.054)
Midwest	1.032	(1.018-1.047)	1.059	(1.052-1.066)	1.080	(1.073-1.086)
Medical comorbidities						
Anemia	1.278	(1.259-1.297)	1.406	(1.394-1.418)	1.217	(1.208-1.226)
Cancer	1.095	(1.076-1.113)	1.211	(1.200-1.221)	1.159	(1.150-1.167)
Cerebrovascular disease	1.320	(1.303-1.337)	1.230	(1.221-1.238)	1.255	(1.247-1.263)
Congestive heart failure	1.197	(1.182-1.213)	1.231	(1.222-1.24)	1.220	(1.213-1.228)
Cardiovascular disease	1.244	(1.220-1.268)	1.297	(1.281-1.313)	1.069	(1.058-1.081)
Fluid/electrolyte disorders	1.290	(1.269-1.310)	1.459	(1.444-1.475)	1.122	(1.112-1.133)
Hypertension	1.030	(1.018-1.043)	1.188	(1.182-1.194)	1.305	(1.299-1.311)
Hypothyroidism	0.999	(0.981-1.019)	1.056	(1.046-1.065)	1.131	(1.122-1.140)
Liver disease	1.189	(1.165-1.213)	1.323	(1.306-1.340)	1.112	(1.099-1.124)
Lung disease	1.133	(1.119-1.146)	1.330	(1.322-1.339)	1.320	(1.312-1.327)
Obesity	0.960	(0.947-0.974)	1.069	(1.062-1.076)	1.036	(1.030-1.042)
Other disease	1.294	(1.269-1.319)	1.379	(1.362-1.395)	1.419	(1.404-1.434)
Peripheral vascular disease	1.346	(1.329-1.363)	1.275	(1.267-1.284)	1.179	(1.172-1.186)

MHC indicates mental health comorbidity; NHB, non-Hispanic black; NHW, non-Hispanic white; Ref, reference.

Table 4. Total Cost by Mental Health Disorder Over the 5-Year Period From Joint Model Least Square Estimates of Inpatient, Outpatient, and Pharmacy Costs in December 31, 2012 Values

	Mean Cost per Patient per Year (\$)	Veterans Impacted (n)	Total Cost (\$)
No MHCs			
Inpatient	\$17,886	612,219	\$10,950,149,034
Outpatient	\$3659	612,219	\$2,240,109,321
Pharmacy	\$902	612,219	\$552,221,538
Depression only			
Inpatient	\$20,737	69,230	\$1,435,651,415
Outpatient	\$5289	69,230	\$366,137,435
Pharmacy	\$1301	69,230	\$90,064,725
Substance abuse only			
Inpatient	\$23,208	14,152	\$328,438,253
Outpatient	\$3989	14,152	\$56,451,075
Pharmacy	\$689	14,152	\$9,741,653
Psychosis only			
Inpatient	\$29,197	15,313	\$477,090,163
Outpatient	\$6149	15,313	\$94,165,952
Pharmacy	\$1599	15,313	\$24,479,374
Depression & substance abuse			
Inpatient	\$27,219	6573	\$178,913,182
Outpatient	\$5460	6573	\$35,866,448
Pharmacy	\$1038	6573	\$6,820,371
Psychosis & substance abuse			
Inpatient	\$35,518	2837	\$100,765,641
Outpatient	\$6255	2837	\$17,744,486
Pharmacy	\$1500	2837	\$4,255,335
Depression & psychosis			
Inpatient	\$25,907	9017	\$233,604,993
Outpatient	\$7397	9017	\$66,697,369
Pharmacy	\$1753	9017	\$15,807,582
All 3 MHCs			
Inpatient	\$33,866	3730	\$126,320,058
Outpatient	\$6962	3730	\$25,968,766
Pharmacy	\$1518	3730	\$5,660,328

MHC indicates mental health comorbidity.

increased outpatient doctor visits whereas alcohol abuse decreased outpatient mental health visits.³² We also found patients with DM and comorbid substance abuse had the lowest outpatient and pharmacy costs of any MHC cluster; in fact, these patients had lower pharmacy costs than individuals without a MHC. However, concurrent high inpatient costs in this population emphasize the need for dual treatment of both disorders.

Implications

Our results have several clinical implications. First, it is of paramount importance that clinicians identify patients with comorbid DM and mental health conditions. Approaches to treating comorbid DM and mental health disorders include pharmacotherapy, nonpharmacological approaches, and health systems interventions such as collaborative care teams.³³ Using depression as an example,

multiple clinical trials of antidepressant medications in patients with comorbid DM and depression reported favorable trends in depression symptoms, though overall effects on glycated hemoglobin (A1C) were modest (-0.4% ; 95% CI, -0.6 to -0.1 ; $P = .002$; in 238 participants over 5 trials).³⁴ In addition, clinical trials have demonstrated modest effects of cognitive behavioral therapy on glycemic control among diabetics with depression.³⁵⁻³⁷ The VHA has actually led health systems innovation in this area by implementing co-located primary care and mental health services.³⁸⁻⁴¹ The VHA also extensively uses telemental health programs to increase access to mental healthcare^{40,42-45} and has improved outcomes for patients with the highest severity of mental illness through intensive case management strategies.⁴⁶ Similar strategies may be of interest to non-VA health administrators and policy makers.

Limitations

Our study should be interpreted in light of certain limitations. First, only 2.2% of our sample was female, which may limit the generalizability of our findings for women. However, our cohort did contain more than 16,000 women. Furthermore, the cohort consisted of veterans and may not be generalizable to the US general population. Second, our database did not contain information on self-care behaviors, disease knowledge, and health beliefs, which likely influence healthcare utilization and costs. Unfortunately, collecting these data was not feasible for such a large cohort. Our study lacked cost data from other payers such as Medicare, which may lead to underestimation of total costs if subjects tended to use large amounts of non-VHA care. However, our inclusion criteria likely yielded patients who utilize VHA for most of their healthcare.

We were also unable to collect information on out-of-pocket healthcare costs. If high, such out-of-pocket costs might decrease access to care and treatment-seeking behavior. The VHA tends to have lower medical co-payments than do private insurance companies in the United States, and almost a quarter of our cohort had high degrees of service-connected disability, indicating they are responsible for 0 co-payments for routine care.

Additionally, ED visits were bundled into outpatient visits for this study, which could be separated in other settings. Given that this analysis was primarily focused on depression, psychosis, and substance abuse, our results may not be generalizable to all MHCs. Moreover, because our data were administrative in nature and MHCs required report of only a single ICD-9-CM code, there is the potential for false positives. Finally, we were unable to

incorporate measures of severity of mental illness into our models. Future investigation should explore the impact of severity of mental health disorders on cost and outcomes that stratify costs by clinical outcomes in this population.

CONCLUSIONS

Analysis of a large national cohort of patients with DM with different combinations of mental health multimorbidity confirms prior research suggesting that such patients have higher healthcare costs than patients with DM without MHCs. The mGLMM technique used, a joint modeling with shared random intercept approach, enables us to overcome statistical challenges common in cost analyses including data skewness, heteroskedasticity, and variations in and correlations among cost outlays over time.²⁶ In summary, our study highlights important choices facing policy makers who must consider both health-system and patient-level impact of multimorbidity on healthcare utilization and costs.

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