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ORIGINAL RESEARCH

Influence of Comorbidities on Healthcare Expenditures and Perceived Physical and Mental Health Status Among Adults with Multiple Sclerosis: A Propensity Score-Matched US National-Level Study

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Objective: To evaluate the effect of comorbidities on healthcare expenditures and perceived physical and mental health status among adults with multiple sclerosis (MS) compared to propensity score-matched non-MS controls.

Methods: A retrospective, cross-sectional, matched cohort study was conducted using Medical Expenditure Panel Survey (2005–2015) data. The base study sample consisted of adults (age ≥18 years) who were alive and had positive total healthcare expenditures during the survey calendar year. Adults with MS were propensity-matched (1:1) to non-MS controls based on age, gender, and race/ethnicity using greedy matching algorithm. Healthcare expenditures consisted of total and subtypes of expenditures. Health status consisted of perceived physical and mental health status. Comorbidities were identified using ICD-9-CM and Clinical Classification System codes. Ordinary least squares regression and multinomial logistic regression were used to analyze the healthcare expenditures and health status variables, respectively.

Results: Final study sample consisted of 541 adults in each MS and non-MS control groups after propensity score matching. After adjusting for potential confounders, individuals with MS had greater total and subtypes of expenditures compared to non-MS controls, and several comorbidities (eg, depression, hypertension) were significantly associated with increased healthcare expenditures. Yearly average total expenditures (expressed in 2018 US$) were significantly ($p<0.001$) higher for adults with MS ($29,396) than propensity score-matched non-MS adults ($7875). Moreover, after adjusting for all individual-level factors, adults with MS experienced 363% ($p<0.001$) higher total expenditures compared to propensity score-matched non-MS controls. Individuals with MS were more likely to report poorer physical and good mental health status compared to propensity score-matched non-MS controls, and several comorbidities (eg, anxiety, depression) were significant independent predictors of poorer health status. For example, adults with MS were four times more likely (OR: 4.10, 95% CI: 2.42–6.96) to report fair/poor physical health status compared to excellent/very good physical health status compared with non-MS controls. Adults with MS were 42% (OR: 1.42, 95% CI: 1.01–1.99) more likely than propensity score-matched non-MS controls to report good rather than very good or excellent mental health status. However, there was no difference between adults with MS and propensity score-matched non-MS controls in terms of reporting fair or poor than very good or excellent mental health status.

Conclusion: Findings from this study indicate substantial economic and health status burdens among adults with MS at the US national-level that are significantly influenced by comorbidities.

Keywords: multiple sclerosis, comorbidities, expenditures, physical health status, mental health status, propensity score matching

Introduction

Multiple Sclerosis (MS) is a disabling central nervous system disease affecting nearly a million individuals in the United States (US), nearly doubling from previous estimates, and approximately 2.3 million individuals globally.[1] Individuals with MS suffer from a wide array of physical and psychiatric comorbidities[2] and existing literature suggests comorbidities among individuals with MS lead to diagnostic delays,[3] elevated risk of relapse,[4] higher chances of disability progression,[5] as well as reduced health-related quality of life.[6] Moreover, presence of comorbidities not only negatively influences the initiation of disease-modifying therapy (DMT) among individuals with MS but also affects the adherence to DMT.[7,8] Hence, understanding the comorbidity burden among individuals with MS has the long-term potential to improve the available clinical support, proper allocation of scarce healthcare resources, and quality of life among individuals with MS and their caregivers.

In recent times, comorbidity burden among individuals with MS has received significant attention, and recognizing the negative influence of comorbidities among individuals with MS, an international initiative was launched by the National Multiple Sclerosis Society (NMSS) to characterize the types and frequencies of comorbidities in this vulnerable population. In a series of articles,[2,9–15] the common comorbidities among individuals with MS have been described. While the systematic reviews published from this initiative provided a good understanding of the prevalent comorbidities, these studies were not specific to the US population. Only a handful of studies are available that have examined comorbidity burden among individuals with MS in the US. A study by Capkun et al (2015) using the US Department of Defense (DoD) database showed that rates of mortality and several comorbidities such as infections, cardiovascular diseases, and depression were more common among individuals with MS compared to a matched non-MS cohort.[16] Another study using the North American Research Committee on Multiple Sclerosis (NARCOMS) Registry with 16,141 participants (8983 responded) found that the most frequently reported comorbidities were hypercholesterolemia, hypertension, and arthritis.[17] Newland et al (2015) conducted a cross-sectional web-based survey among members of the greater Midwest MS society chapter and observed that individuals with MS reported higher rates of depression, arthritis, diabetes, coronary artery disease, migraine headaches, and cancer than the normative population.[18] Another study examining the important comorbidities in the US from 1990 to 2001 found that the odds of pressure ulcers, urinary tract infections, and pneumonia/influenza being reported on the death certificate were higher in MS-related deaths than in matched controls.[19]

Existing studies on MS comorbidity in the US are older,[19] lack generalizability,[16–18] and do not focus on some of the important issues such as healthcare resource use and expenditures and health status. Moreover, while a couple of existing studies[20,21] using the Medical Expenditures Panel Survey (MEPS) data examined the healthcare expenditures among individuals with MS, they did not examine the effect of specific comorbidities on healthcare expenditure burden and also did not use a robust study design (example – propensity score matching). To address the gaps in the existing literature, we examined the prevalence and patterns of comorbidities, healthcare expenditures, and health status (physical and mental) among adults with MS compared to a propensity score-matched non-MS control group using a US nationally representative sample.

Methods

Study Design

Utilizing pooled data from nationally representative Medical Expenditures Panel Survey (MEPS) from 2005 to 2015, a retrospective, cross-sectional, matched cohort study was conducted. As per the recommendation of the MEPS survey designers, pooled data from multiple years of the survey were utilized to obtain adequate sample size.[22] MEPS complies with relevant data protection and privacy regulations, details of which can be found elsewhere.[23] The University of Arizona Institutional Review Board determined that this study did not require human subject review and approved it as such.

Data Source

The Agency for Healthcare Research and Quality (AHRQ) collects the ongoing MEPS data. Several important information of the US civilian, non-institutionalized individuals as well as their families, their healthcare providers and employers are recorded in MEPS. Health-related data such

as the physical and mental health conditions, along with the different types of healthcare service utilization (eg – outpatient services) and treatments (eg – prescription medications) of MEPS participants are collected during the surveys using the original National Health Interview Survey (NHIS) framework. While MEPS consists of several different data files, the household component (MEPS-HC) and the medical conditions (MEPS-MC) were utilized for the purposes of this study. MEPS-HC questionnaire amass data on a wide range of factors such as socio-demographic characteristics, health status, income, as well as healthcare resource use and expenditures. Self-reported medical conditions are recorded in the MEPS-MC files utilizing either International Classification of Diseases, 9th Edition, Clinical Modification (ICD-9-CM) codes or Clinical Classification System (CCS) codes that provide comorbidity data. According to an existing study, a median sensitivity of 70% was observed in terms of consistency between the self-reported and healthcare provider reported chronic conditions (eg – hypertension, mental health, diabetes).[24]

Study Sample

The study sample consisted of adults (i) age ≥18 years; (ii) who were alive during the specific calendar year of survey; and (iii) reported positive total healthcare expenditures. Adults with MS, identified using AHRQ CCS code of "80", comprised the case group.[25] Adults with MS were propensity-matched (1:1) to non-MS controls based on age, gender, and race/ethnicity using a greedy matching algorithm (8:1-digit match). Algorithm for greedy matching technique randomly selects a case (adults with MS) and subsequently selects the control (non-MS adults) whose propensity score is closest to the selected case. Utilizing a similar repetitious process, the greedy matching algorithm continues to match the case and control subjects until all the cases have been matched to appropriate controls. The term "greedy" is used for this algorithm because the closest control is selected to match with a case subject even though this control subject may have the potential to serve as a better match for a later/different case subject.[26] Healthcare expenditures consisted of total and subtypes (inpatient, outpatient, emergency room, prescription drugs, home health agency, dental care, and other expenditures) of healthcare expenditures. Health status consisted of perceived physical and mental health status.

Measures

The primary dependent variables included healthcare expenditures and health status. Healthcare expenditures included total as well as subtypes of costs (such as inpatient, outpatient, emergency room, home health agency). Healthcare expenditures for specific service user refer to the MEPS respondents in the study sample who reported using any of the specific services such as inpatient, outpatient, home healthcare, etc. All expenditures were expressed in 2018 US dollar values utilizing the medical care services portion of the consumer price index available in the Bureau of Labor Statistics website.[27] Health status consisted of perceived physical and mental health status, both of which were categorized as excellent/very good, good, and fair/poor. During the interview rounds, the perceived physical and mental health statuses of MEPS participants were collected on rating scale ranging from excellent to poor (excellent, very good, good, fair, and poor).

The Andersen's Behavioral Model (ABM) of Health Services Use was utilized in this study as the conceptual framework. Using the ABM, the association of predisposing, enabling, need, external environmental, and personal health practices factors with the study outcomes (healthcare expenditures, perceived physical and mental health status) were examined. Age, gender, and race/ethnicity were included as predisposing factors whereas education, marital status, poverty status, and insurance type were a part of the enabling factors. Activities of daily living (ADL) limitations, instrumental activities of daily living (IADL) limitations, functional activities limitations, activities limitations in work/housework, comorbidities and pain were considered to be part of need factor. In terms of the personal health behavior, the current study included body mass index (BMI) and smoking status, while region and metropolitan residence status were part of external environmental factor. MEPS respondents who reported need of help or supervision for any ADL (eg – eating, dressing) or IADL (eg – taking medications, using telephone) were categorized as "yes" for limitations in these activities. If the MEPS respondents reported any limitations in terms of work, housework or school, they were coded as having activities limitations. The pain variable was developed by using the following question: "During past 4 weeks, pain interfered with normal work outside the home and housework".[28] This question for pain assessment was self-reported on a 5-point scale: (i) not at all; (ii)

a little bit; (iii) moderately; (iv) quite a bit; and (v) extremely. For the purpose of this study, the pain variable was classified into the following three categories: (i) quite a bit/extreme pain; (ii) a little bit or moderate pain; and (iii) no pain.

Specific comorbidities examined in this study included anemia, anxiety, arthritis, chronic obstructive pulmonary disease (COPD), depression, type 2 diabetes (henceforth referred to as diabetes), cancer, eye problems, gastroesophageal reflux disease (GERD), heart diseases, hyperlipidemia, hypertension, osteoporosis, stroke, and thyroid disease. We identified clusters of comorbidities by grouping diseases according to organ-specific domains.[29] Comorbidities were organized into six major clusters: (1) cardio-metabolic (presence of hypertension or heart disease or diabetes), (2) musculoskeletal (arthritis or osteoporosis), (3) psychiatric (anxiety, depression) (4) respiratory (asthma or emphysema), (5) cancers, and (6) other comorbidities (GERD, thyroid disease). Existing studies have used such clustering of chronic conditions, citing evidence of synergistic treatment and management approaches.[30,31]

Statistical Analyses

Comparison of the distribution of the five ABM factor sets prior and subsequent to propensity score matching was conducted using chi-square tests. Propensity score matching was achieved by utilizing an 8 to 1 greedy matching algorithm to exactly match cases to control (1:1) to obtain the final study sample. Survey procedures in SAS version 9.4 (Cary, NC, USA) were used to accommodate for the complex MEPS design and generate national-level estimates. An a-priori alpha of <0.05 was considered to be statistically significant for all analyses. Healthcare expenditures and health status variables were analyzed using Ordinary Least Squares (OLS) regression and multinomial logistic regression, respectively. We examined the Variance Inflation Factor (VIF) for multicollinearity and a VIF value of <5 was considered to demonstrate that there was no sign of multicollinearity.[32]

Results

Sample Characteristics

The final study sample consisted of 541 adults with Multiple Sclerosis (MS) and 541 non-MS controls after propensity score matching. Table 1 shows the distribution of patient-level characteristics prior and subsequent to matching between adults with MS and non-MS controls. Several patient-level characteristics were statistically significantly different between the case and control group. After matching, adults with MS were higher likely to be non-white, married, poor, unemployed, have public insurance coverage, and a current smoker compared with matched controls. Balance between the case and control group can be observed from Figures 1 and 2.

Comorbidities

Individuals with MS were significantly more likely than propensity score-matched non-MS controls to experience musculoskeletal (46.3% vs 31.0%) and psychiatric comorbidities (41.2% vs 19.0%). Comorbidities that were observed to be significantly different between adults with MS and propensity score-matched non-MS controls, respectively, include anemia (5.5% vs 1.8%), anxiety (17.1% vs 8.5%), arthritis (42.1% vs 30.1%), depression (29.7% vs 13.3%), and osteoporosis (5.7% vs 2.4%). Further details regarding the comorbidities can be found in Table 1.

Unadjusted Incremental Health Expenditures

Table 2 displays the unadjusted incremental health expenditures. Yearly average total expenditures (expressed in 2018 US$) were significantly ($p<0.001$) higher for adults with MS ($29,396) than propensity score-matched non-MS adults ($7875) (Table 2). Emergency room ($718 vs $226), outpatient ($5754 vs $2749), prescription ($15,533 vs $1620), and home health agency ($1989 vs $218) expenditures were also statistically significantly different between adults with MS compared to propensity score-matched non-MS controls.

Unadjusted Total Health Expenditures for Individuals with MS by Comorbidities

Table 3 presents unadjusted total expenditures among adults with MS compared to propensity score-matched non-MS controls in the presence of comorbidities. Individuals with MS and co-occurring arthritis ($33,700 vs $12,345), asthma ($36,147 vs $10,079), cancer ($44,954 vs $22,542), COPD ($31,871 vs $8967), diabetes ($39,579 vs $17,900), eye problems ($36,999 vs $16,092), GERD ($48,536 vs $17,106), heart disease ($40,389 vs $21,148), hyperlipidemia ($34,430 vs $15,393), hypertension ($35,924 vs $12,271), depression ($36,380 vs

Table 1 Distribution of Characteristics Between MS and Non-MS Controls MEPS 2005–2015

	Before Matching						After Matching					
	MS		Non-MS				MS		Non-MS			
	Unwt. N	Wt.%	Unwt. N	Wt.%	p-value	Sig	Unwt. N	Wt.%	Unwt. N	Wt.%	p-value	Sig
Age group												
18–64	470	85.4	165,000	79.9	0.05	*	470	85.4	470	84.4	0.70	
65,+	71	14.6	39,230	20.1			71	14.6	71	15.6		
Gender												
Female	402	73.1	118,000	55.1	0.00	***	402	73.1	402	72.2	0.82	
Men	139	26.9	85,807	44.9			139	26.9	139	27.8		
Race/Ethnicity												
White	366	79.8	104,000	70.8	0.00	**	366	79.8	366	85.1	0.03	*
Other	175	20.2	99,762	29.2			175	20.2	175	14.9		
Marital status												
Married	303	60.7	108,000	55.6	0.13		303	60.7	271	50.1	0.01	**
Other	238	39.3	95,969	44.4			238	39.3	270	49.9		
Education												
LT HS	49	9.3	36,911	15.6	0.07		49	9.3	85	12.1	0.58	
HS	130	28.0	48,179	28.4			130	28.0	126	28.3		
> HS	260	62.7	80,080	56.1			260	62.7	238	59.6		
Region												
Northeast	103	23.6	33,417	18.7	0.11		103	23.6	109	21.7	0.92	
Mid-west	150	24.2	42,190	22.6			150	24.2	122	25.0		
South	164	28.9	75,396	36.1			164	28.9	175	30.8		
West	124	23.3	52,936	22.6			124	23.3	135	22.6		
Poverty status												
Poor	100	15.0	33,787	10.8	0.09		100	15.0	71	7.5	0.00	**
Near Poor	110	17.0	42,127	16.4			110	17.0	115	17.2		
Middle Income	153	27.9	60,308	29.5			153	27.9	170	30.7		
High Income	178	40.1	67,717	43.3			178	40.1	185	44.5		
Employment status												
Employed	205	40.3	127,000	65.7	0.00	***	205	40.3	347	66.1	0.00	***
Not employed	336	59.7	76,722	34.3			336	59.7	194	33.9		
Insurance coverage												
Private	338	68.0	130,000	72.5	0.00	***	338	68.0	371	79.0	0.00	***
Public	179	28.4	49,178	18.3			179	28.4	110	13.7		
Uninsured	24	3.6	25,169	9.3			24	3.6	60	7.3		
Physical health status												
Ex/vgood	100	22.2	107,000	57.3	0.00	***	100	22.2	282	57.5	0.00	***
Good	168	28.9	61,937	28.5			168	28.9	164	28.6		
Fair/poor	273	48.9	35,083	14.2			273	48.9	95	13.9		
Mental health status												
Ex/vgood	229	42.2	129,000	66.4	0.00	***	229	42.2	332	65.2	0.00	***
Good	195	38.1	56,072	25.5			195	38.1	157	26.4		
Fair/poor	117	19.7	19,267	8.2			117	19.7	52	8.4		
BMI status												
Under/Normal	204	39.6	67,400	35.2	0.14		204	39.6	205	39.7	0.96	
Overweight	324	57.5	132,000	62.9			324	57.5	321	57.7		
Obese	13	2.9	4375	1.9			13	2.9	15	2.6		

(*Continued*)

Table 1 (Continued).

	Before Matching						After Matching					
	MS		Non-MS				MS		Non-MS			
	Unwt. N	Wt.%	Unwt. N	Wt.%	p-value	Sig	Unwt. N	Wt.%	Unwt. N	Wt.%	p-value	Sig
Smoking status												
Current smoker	128	23.8	32,217	17.0	0.00	**	128	23.8	79	14.3	0.00	***
Other	373	76.2	155,000	83.0			373	76.2	421	85.7		
Pain group												
Quite/Extreme	170	30.6	26,077	12.2	0.00	***	170	30.6	52	10.1	0.00	***
Little/Moderate	203	42.2	68,409	36.6			203	42.2	198	38.6		
No pain	130	27.2	93,998	51.2			130	27.2	255	51.3		
ADL Limitations												
Yes	137	24.0	7129	3.0	0.00	***	137	24.0	16	3.3	0.00	***
No	403	76.0	196,000	97.0			403	76.0	523	96.7		
IADL Limitations												
Yes	188	33.2	13,006	5.6	0.00	***	188	33.2	32	6.0	0.00	***
No	352	66.8	191,000	94.4			352	66.8	509	94.0		
Activities disability												
Yes	337	61.2	31,945	14.2	0.00	***	337	61.2	85	13.4	0.00	***
No	203	38.8	171,000	85.8			203	38.8	455	86.6		
Comorbidities												
Anemia	28	5.5	4224	1.7	0.00	***	28	5.5	13	1.8	0.00	**
Anxiety	89	17.1	21,075	11.2	0.01	*	89	17.1	51	8.5	0.00	***
Arthritis	212	42.1	52,100	25.9	0.00	***	212	42.1	155	30.1	0.00	***
Asthma	59	10.5	13,860	6.6	0.04	*	59	10.5	46	9.1	0.55	
Cancer	41	8.1	13,858	8.0	0.96		41	8.1	42	9.7	0.43	
COPD	80	14.9	22,801	11.5	0.13		80	14.9	68	13.5	0.58	
Diabetes	69	12.2	26,604	11.3	0.70		69	12.2	58	8.7	0.07	
Eye problems	18	3.7	8430	4.4	0.62		18	3.7	17	4.7	0.49	
GERD	60	11.3	15,677	8.3	0.11		60	11.3	50	8.2	0.17	
Heart Disease	69	13.2	24,430	12.3	0.67		69	13.2	55	10.7	0.32	
Hyperlipidemia	143	25.0	47,146	23.8	0.66		143	25.0	107	20.7	0.16	
Hypertension	180	29.5	63,525	29.8	0.90		180	29.5	156	30.7	0.73	
Depression	162	29.7	23,331	11.8	0.00	***	162	29.7	72	13.3	0.00	***
Osteoporosis	31	5.7	3654	1.9	0.00	***	31	5.7	12	2.4	0.00	***
Stroke	17	3.1	3880	1.9	0.15		17	3.1	11	2.5	0.54	
Thyroid	54	10.8	15,288	8.4	0.24		54	10.8	57	11.5	0.79	
Cardio-metabolic	251	41.9	88,259	42.5	0.85		251	41.9	215	41.2	0.86	
Respiratory	80	14.9	22,801	11.5	0.13		80	14.9	68	13.5	0.58	
Musculo-skeletal	235	46.3	53,919	26.8	0.00	***	235	46.3	159	31.0	0.00	***
Psychiatric	218	41.2	37,093	19.3	0.00	***	218	41.2	104	19.0	0.00	***
Other comorbidities	148	28.8	39,783	20.5	0.00	**	148	28.8	123	23.8	0.11	

Notes: Based on 541 adults (age ≥ 18 years) with Multiple Sclerosis (MS) and 203,939 adults without MS before matching; and 541 adults with and without MS after matching. The two groups were matched on age, gender, and race/ethnicity. Asterisks represent statistical significance between the two groups based on chi-square tests. Asterisks represent statistical significance between the two groups based on chi-square tests. ***p< 0.001; **0.001 ≤p< 0.01; *0.01 ≤p<0.05.

Abbreviations: MEPS, Medical Expenditure Panel Survey; Unwt, unweighted; Wt%, weighted percentage; Sig, significant difference; Ex/vgood, excellent or very good; LT HS, less than high school; HS, high school; ADL, activity of daily living; IADL, instrumental activity of daily living; COPD, chronic obstructive pulmonary disease; GERD, gastroesophageal reflux disorder.

$17,868), osteoporosis ($37,002 vs $9926), and thyroid disease ($37,196 vs $17,401), had significantly higher total healthcare expenditures than propensity score-matched non-MS controls. Supplementary Tables 1–6 present the differences in subtypes of expenditures among adults with MS and propensity score-matched non-MS

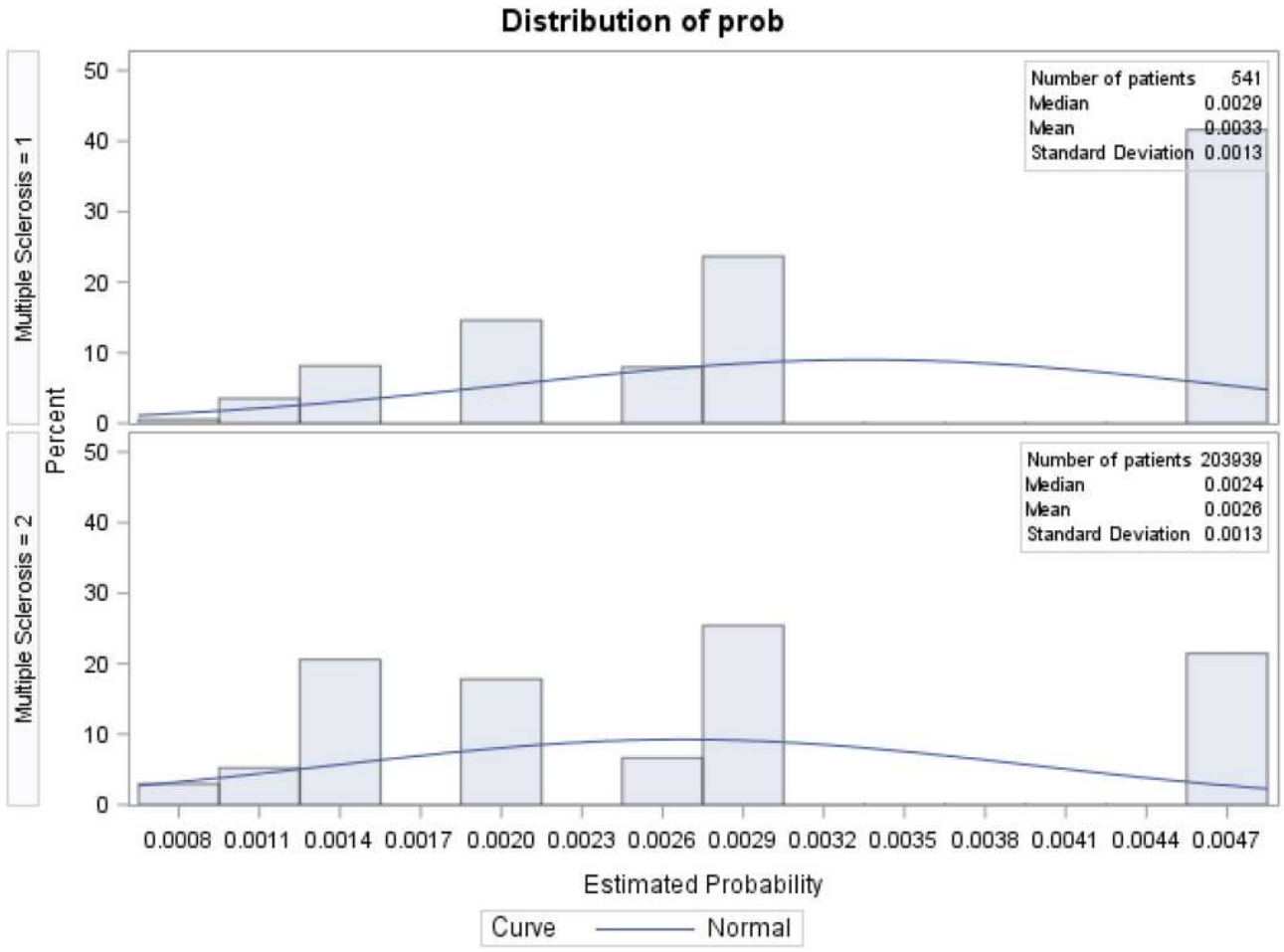

Figure 1 Propensity score distribution before matching.
Notes: Multiple sclerosis = 1 denotes the case group (individuals with MS); multiple sclerosis = 2 denotes the control group (individuals without MS).

controls in the presence of comorbidities. It is noteworthy that the unadjusted health expenditures by comorbidities differed mainly between older adults with MS and propensity score-matched non-MS controls in terms of outpatient (Supplemental Table 3), prescription (Supplemental Table 4), and home healthcare (Supplemental Table 5) expenditures.

Adjusted Incremental Health Expenditures

Table 4 presents the findings from OLS regression analysis of logged healthcare expenditures (total, inpatient, emergency room, outpatient, prescription drugs, home healthcare, and other). After adjusting for all individual-level factors, adults with MS experienced 363% ($p<0.001$) higher total expenditures compared to propensity score-matched non-MS controls. Similar observations were noted for inpatient, outpatient, and prescription expenditures. Of particular note, prescription expenditures were 1372% ($p<0.001$) higher among adults with MS compared to propensity score-matched non-MS adults, which probably imply high MS disease-modifying treatment costs in the US. Examination of VIF revealed no sign of multicollinearity in the OLS models (all VIFs were <5).

Physical and Mental Health Status for Individuals with MS

From Table 5, it can be seen that adults with MS were four times more likely (OR: 4.10, 95% CI: 2.42–6.96) to report fair/poor physical health status compared to excellent/very good physical health status compared with non-MS controls. Presence of depression (OR: 4.81, 95% CI: 2.46–-9.42) and anxiety (OR: 2.73, 95% CI: 1.25–5.98) were associated, respectively, with nearly five- and three-fold higher likelihood of reporting fair/poor physical health status compared to excellent/very good physical health

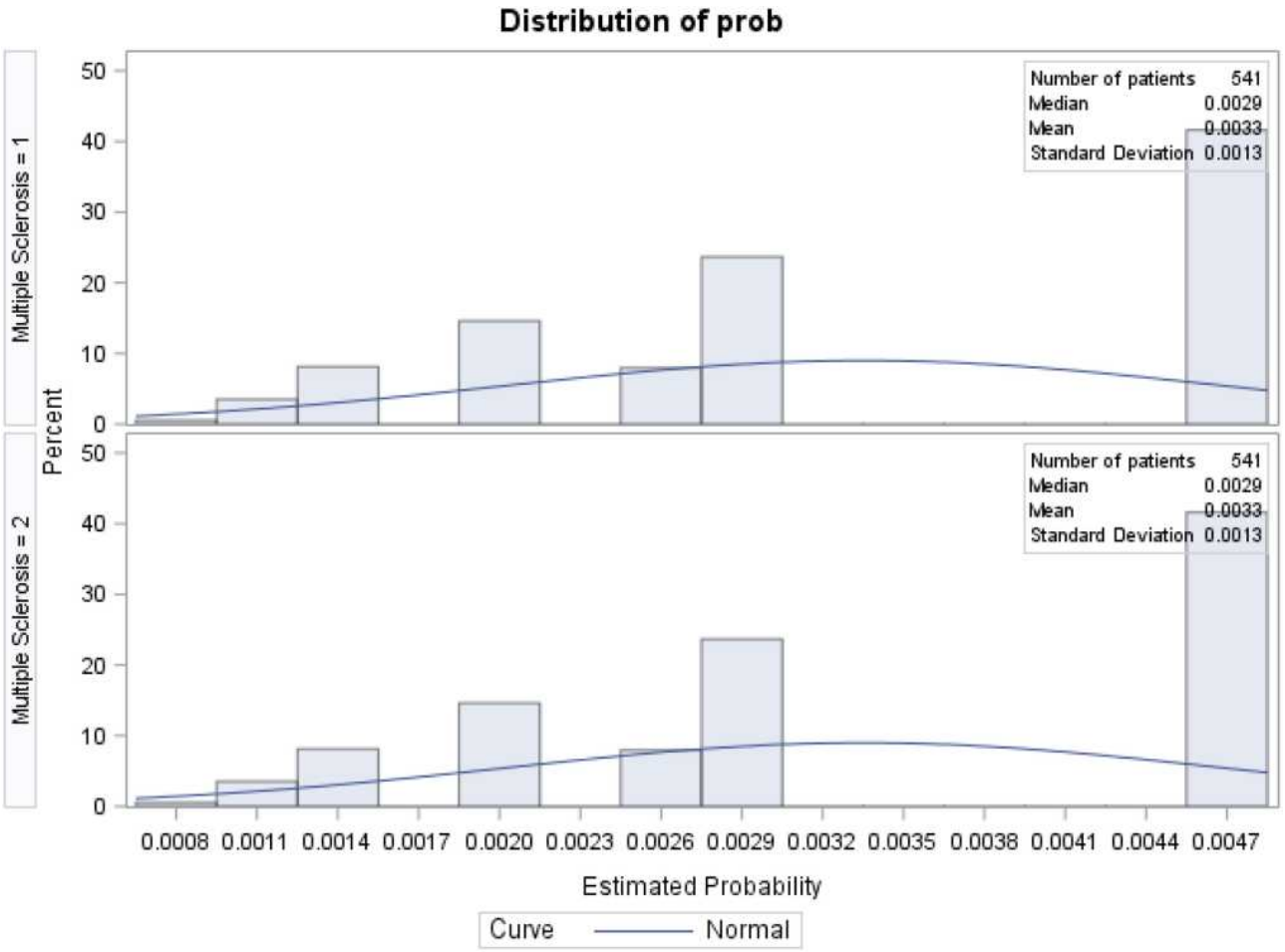

Figure 2 Propensity score distribution after matching.
Notes: Multiple sclerosis = 1 denotes the case group (individuals with MS); multiple sclerosis = 2 denotes the control group (individuals without MS).

status in our study sample. Individuals with MS and co-occurring depression were nearly five times more likely to report fair/poor physical health status than excellent/very good physical health status compared with non-MS controls. Individuals with MS and co-occurring anxiety were nearly three times more likely to report fair/poor physical health status than excellent/very good physical health status compared with non-MS controls. Similar findings were observed for some comorbidities such as heart disease, hyperlipidemia, and COPD.

Table 6 shows the findings from multinomial logistic regression analyses for mental health status. Adults with MS were 42% (OR: 1.42, 95% CI: 1.01–1.99) more likely than propensity score-matched non-MS controls to report good rather than very good or excellent mental health status. However, there was no difference between adults with MS and propensity score-matched non-MS controls in terms of reporting fair or poor than very good or excellent mental health status. Several comorbidities such as cancer, diabetes, hyperlipidemia, hypertension, and depression were significant correlates of fair or poor mental health status. For example, presence of depression was associated with five times more likelihood (OR: 5.01, 95% CI: 2.69–9.31) of report fair/poor mental health status rather than excellent/very good mental health status in our study sample.

Discussion

Findings from this US national-level study indicate that comorbidities significantly influence economic and health status burden among adults with MS. The contribution of this study is significant because it is one of the first steps in a continuum of research that is expected to inform the development of appropriate interventions (such as team-based holistic care approach to MS treatment) to minimize the comorbidity burden among individuals with MS,

which has the potential to improve quality of life as well as achieve other improved health outcomes.

Comorbidities

Musculoskeletal and psychiatric comorbidities were most commonly reported among individuals with MS compared to non-MS controls. Specifically, anemia, arthritis, osteoporosis, anxiety, and depression were more commonly reported among individuals with MS. With respect to arthritis and depression, our study is consistent with existing literature that found depression and arthritis to be higher among individuals with MS than the rest of the population.[18] According to a European cross-sectional database analysis, those with MS showed a higher prevalence of any mental health (40.3% in MS vs 17.9% in non-MS) and physical (64.7% in MS vs 47.3% in non-MS) comorbidities compared to non-MS controls.[33] Another study examining comorbidity incident rates among MS patients before and after diagnosis found a significantly increased incidence rates of osteoporosis and fractures after diagnosis of MS.[34] Anxiety and depression are the most commonly cited psychiatric comorbidities found in MS patients.[35–46] Thus, our study findings are consistent with these existing studies.

Expenditures

Previous studies about the economic impact of MS on affected individuals showed increased mean annual costs in inpatient services, radiology services, emergency room, office visit, and therapies compared to non-MS controls.[20,21,47] However, none of these studies examined the influence of comorbidities on healthcare expenditures among adults with MS. According to a retrospective discharge-level cohort study using hospital data, researchers found a significantly higher mean adjusted cost and incremental cost per hospitalization day in hospitalized MS patients with cardiac conditions compared to MS patients without cardiac conditions.[48] However, the study by Franklin et al[48] only examined the cardiac comorbidities and their study sample was limited to hospitalized individuals with MS. The current study provides national-level cost information related to a comprehensive list of comorbidities among community-dwelling adults with MS patients and thus more generalizable.

Our study found that several co-occurring chronic conditions contributed to incremental costs differently across different types of expenditures. Total expenditures were higher among individuals with MS when they concurrently had arthritis, asthma, cancer, COPD, diabetes, eye problems, GERD, heart disease, hyperlipidemia, hypertension, depression, osteoporosis, or thyroid disease in comparison to non-MS matched controls. Co-occurring GERD and osteoporosis added the greatest total expenditure among individuals with MS. Asthma and COPD added the third and fourth greatest cost total expenditure among individuals with MS, respectively. Total expenditures were the greatest among individuals with MS when they concurrently had the following comorbidity categories: 1. Other, 2. Cardio-metabolic, or 3. Respiratory compared to non-MS matched controls. Individuals with co-occurring MS and arthritis or any other disease within the musculoskeletal category have significantly higher emergency room expenditures compared with non-MS controls. Individuals with co-occurring MS and asthma or COPD or any other disease within the respiratory category have the greatest outpatient expenditures compared with non-MS controls. While co-occurring osteoporosis and thyroid disease added the greatest prescription expenditures compared with non-MS controls, individuals with a comorbid disease within the respiratory or other category showed the greatest overall prescription expenditures.

Individuals with co-occurring hyperlipidemia have significantly greater home healthcare and other expenditures compared with non-MS controls. Individuals with co-occurring MS and hypertension or hyperlipidemia or any other disease within the cardio-metabolic category have the greatest home healthcare expenditures compared with non-MS controls. Co-occurring osteoporosis or any other disease within the musculoskeletal category added the second greatest home healthcare expenditures compared with non-MS controls. Total expenditures were higher among individuals with MS when they concurrently had arthritis, asthma, cancer, COPD, diabetes, eye problems, GERD, heart disease, hyperlipidemia, hypertension, depression, osteoporosis, or thyroid disease in comparison to matched controls. Co-occurring GERD and osteoporosis added the greatest total expenditure among individuals with MS.

Health Status

Comorbidities in MS can have a variety of effects on health outcomes and clinical decision-making. Existing evidence suggests comorbidities in MS affect treatment decision-making. For example, the more comorbidities that are present among individuals with MS, the less likely healthcare providers are to recommend initiating MS

Table 2 Total and Subtypes of Costs Among Any Users (2018 US$)

	MS			Non-MS		
	N	Mean	Std Err	N	Mean	Std Err
Total***	541	29,396	1794	541	7875	755
Inpatient	541	4356	883	541	2432	315
ER**	541	718	298	541	226	35
Outpatient**	541	5754	507	541	2749	409
Prescription***	541	15,533	1236	541	1620	152
HHA**	541	1989	344	541	218	70
Other	541	1045	209	541	629	43
Subtypes of costs among Specific Service Users[a]						
Inpatient	94	23,237	2376	56	25,592	2013
ER	125	3033	1222	88	1555	187
Outpatient**	517	6015	520	473	3060	452
Prescription***	520	16,024	1260	429	2020	176
HHA**	98	12,073	1534	14	7973	1527
Other	356	1506	290	333	955	61

Notes: Based on 541 individuals with MS and 541 matched controls without MS, aged 18 years or older and were alive during particular calendar year. Asterisks represent significant group differences by the presence of MS using *t*-tests. Asterisks represent statistical significance between the two groups based on chi-square tests. ***p< 0.001; **0.001 ≤p< 0.01. [a]Specific service user refer to the MEPS respondents in the study sample who reported using any of the specific services such as inpatient, outpatient, home healthcare etc. Type of expenditures among users will not add to average total expenditure because of the denominators.

Abbreviations: Std Err, standard error; ER, emergency room; HHA, Home Health Agency.

Table 3 Unadjusted Total Expenditures by Comorbidities

	MS	Non MS	P-value	Sig	Cost Ratio
Anemia	34,877	17,371	0.06		2.01
Anxiety	28,288	16,738	0.18		1.69
Arthritis	33,700	12,345	0.00	***	2.73
Asthma	36,147	10,079	0.00	***	3.59
Cancer	44,954	22,542	0.02	*	1.99
COPD	31,871	8967	0.00	***	3.55
Diabetes	39,579	17,900	0.01	*	2.21
Eye problems	36,999	16,092	0.02	*	2.30
GERD	48,536	17,106	0.00	***	2.84
Heart disease	40,389	21,148	0.00	***	1.91
Hyperlipidemia	34,430	15,393	0.00	***	2.24
Hypertension	35,924	12,271	0.00	***	2.93
Depression	36,380	17,868	0.00	***	2.04
Osteoporosis	37,002	9926	0.00	***	3.73
Stroke	29,178	48,300	0.37		0.60
Thyroid	37,196	17,401	0.03	*	2.14
Cardio-metabolic	35,164	12,245	0.00	***	2.87
Respiratory	31,871	8967	0.00	***	3.55
Musculoskeletal	32,912	12,174	0.00	***	2.70
Psychiatric	31,692	15,112	0.00	***	2.10
Other comorbidities	40,145	15,782	0.00	***	2.54

Notes: Based on 541 individuals with MS and 541 matched controls without MS, aged 18 years or older and were alive during particular calendar year. Asterisks represent significant group differences by the presence of MS using *t*-tests. Medical Expenditure Panel Survey 2005–2015. Asterisks represent significant group differences by the presence of MS using *t*-tests. ***p < 0.001; *0.01 ≤ p < 0.05. Annual mean MS and non-MS costs are presented in 2018 US$.

Abbreviations: COPD, chronic obstructive pulmonary disease; GERD, gastroesophageal reflux disorder.

disease-modifying therapies.[7] Individuals with MS were significantly more likely to report fair/poor physical and mental health status compared to excellent/very good physical health status compared with non-MS controls. Additionally, the current study found that comorbidities such as the presence of depression negatively affects both physical and mental health status. This is consistent with existing literature that found comorbidities in MS to worsen baseline functional status.[49] Depression has been shown to have a greater impact on functional status[50,51] and is greatly impacted by modifiable factors[52] like diet and exercise. With respect to physical and mental functioning, certain disease combinations have been found to have synergistic, negative additive, or positive effects.[53]

Co-occurring diabetes, cardiovascular disease, and/or chronic respiratory disease have been found to be synergistically linked with worsening physical functioning in combination.[53] Presence of co-occurring depression, anxiety, heart disease, hyperlipidemia, and COPD were associated with higher likelihood of reporting of fair/poor physical health status compared to excellent/very good physical health status. Our findings of co-occurring depression worsening physical health status are consistent with existing literature about the significant impact of depression on functional status among individuals with MS.[50,51] Surprisingly, presence of comorbid diabetes or thyroid disease did not show significant differences in physical health status. This conflicts with existing literature that observed diabetes and thyroid disease being synergistic and the most "favorable" or positive chronic diseases with respect to physical functioning, assuming self-perceived physical health status was worse across all chronic diseases.[53] Findings from the present study observed that co-occurring heart disease is associated with higher likelihood of reporting fair/poor physical health status, indicating heart disease to have a negative effect on physical health status. This is inconsistent with existing literature that found cardiovascular disease to have a relatively neutral effect on physical functioning. Association of co-occurring COPD with increased

Table 4 Intercepts and Parameter Estimates for MS vs Non-MS Groups from Separate OLS Regression Analyses on Logged Healthcare Expenditures (2018 US$)

		Beta	SE	Sig	% Diff
Total expenditures	Intercept	6.634	0.337	***	
MS	Yes	1.532	0.108	***	363
	No	Ref	–		
Inpatient expenditures	Intercept	−0.350	0.601		
MS	Yes	0.545	0.212	*	72
	No	Ref	–		
Emergency expenditures	Intercept	1.359	0.623	*	
MS	Yes	0.259	0.238		30
	No	Ref	–		
Outpatient expenditures	Intercept	4.367	0.545	***	
MS	Yes	0.867	0.154	***	138
	No	Ref	–		
Prescription expenditures	Intercept	2.866	0.614	***	
MS	Yes	2.689	0.199	***	1372
	No	Ref	–		
HHA expenditures	Intercept	−0.162	0.467		
MS	Yes	0.207	0.117		23
	No	Ref	–		
Other expenditures	Intercept	1.366	0.676	*	
MS	Yes	0.215	0.218		24
	No	Ref	–		

Notes: Based on 541 individuals with MS and 541 matched controls without MS, aged 18 years or older and were alive during particular calendar year. Medical Expenditure Panel Survey 2005–2015. Asterisks represent statistical significance between the two groups based on chi-square tests. ***p< 0.001; *0.01 ≤p<0.05. OLS regression model included MS and propensity score-matched non-MS group; race/ethnicity; marital status; education; region; poverty status; employment status; health insurance status; physical health status; mental health status; BMI; smoking status; pain; MEPS year; activities of daily living; instrumental activities of daily living; activities disability; anemia; anxiety; arthritis; cancer; COPD; diabetes; eye problems; GERD; heart disease; hyperlipidemia; hypertension; depression; osteoporosis; stroke; and thyroid disorder as independent variables.

Abbreviations: OLS, ordinary least squares; S.E., standard error; Sig, significant difference; COPD, chronic obstructive pulmonary disease; GERD, gastroesophageal reflux disorder. % Diff, Percent difference between MS and propensity score-matched non-MS groups. The percent difference in expenditures between the two groups were calculated using semi-logarithmic equation ($e^{\beta} - 1$).

likelihood of reporting fair/poor physical health status was consistent with existing literature that found chronic respiratory disease and arthritis to have a relatively negative or unfavorable effect on physical functioning.[53]

Individuals with co-occurring diabetes, hyperlipidemia, cancer, depression and anxiety were more likely to report fair/poor mental health status compared to excellent/very good mental health status. However, presence of co-occurring thyroid disease did not show significant differences in mental health status. This conflicts with existing literature that observed thyroid disease, across all chronic diseases, having a negative effect with respect to worsening mental functioning.[29,53,54] Despite thyroid disease not being found to be a significant predictor of lower mental health status in our study, the negative effect of thyroid disease has been shown to be partly due to gender being a negative effect on mental functions.[53] It has been shown that women and those younger in age with a chronic disease generally have a lower mental health status than men and older individuals.[53] Although the effect of gender and age on mental functioning was not explored in our study, individuals with MS were more likely to be women and younger in age (18–64 age group) compared to non-MS controls before matching. Future considerations may explore whether age and gender have a negative effect on mental functioning specifically in the context of MS. Similar to that of physical health status, mental health status was determined based on self-perceived health status in our study rather than objective measurement of health status which were used in the existing literature.

Although our findings are not consistent with the health status trends among certain comorbid chronic diseases with respect to their positive, negative, or neutral effects, the nature of these relationships in the context of MS still remains unclear. Despite the clinical manifestation of MS being unique from other chronic diseases, our findings will add to the knowledge base of this disease state and encourage future considerations in areas where information is limited.

While work has been done on the effects of comorbid chronic disease and quality of life, there is still little known about the impacts of comorbidities among individuals with MS. As the aging population and the prevalence of MS grows in the US, preventative measures can be improved upon as the knowledge base about the effects of certain comorbid conditions in MS become clearer. Our study provides a nationwide representation of the

Table 5 Multinomial Logistic Regression Analysis Physical Health Status

	Good			Fair/Poor		
	OR	**95% CI**	**Sig**	**OR**	**95% CI**	**Sig**
Multiple Sclerosis						
Yes vs No	2.31	[1.50,3.56]	***	4.10	[2.42,6.96]	***
Race/Ethnicity						
Others vs White	1.37	[0.79,2.38]		2.51	[1.30,4.83]	**
Marital status						
Others vs Married	0.73	[0.40,1.33]		0.50	[0.27,0.95]	*
Education						
<High School vs High School	0.97	[0.42,2.26]		1.73	[0.65,4.62]	
> High School vs High School	1.20	[0.72,2.01]		0.86	[0.47,1.58]	
Region						
Mid-west vs Northeast	1.93	[0.95,3.95]		1.20	[0.61,2.39]	
South vs Northeast	1.60	[0.85,3.03]		0.78	[0.43,1.41]	
West vs Northeast	2.02	[0.92,4.44]		0.77	[0.37,1.59]	
Poverty status						
Near Poor vs Poor	0.43	[0.19,0.99]	*	0.58	[0.23,1.43]	
Middle Income vs Poor	0.65	[0.28,1.52]		0.45	[0.18,1.16]	
High Income vs Poor	0.31	[0.12,0.78]	*	0.27	[0.11,0.68]	**
Employment status						
Not employed vs Employed	0.96	[0.58,1.60]		1.38	[0.64,2.94]	
Insurance coverage						
Private vs Uninsured	0.56	[0.24,1.30]		0.28	[0.07,1.06]	
Public vs Uninsured	0.79	[0.29,2.14]		0.38	[0.10,1.49]	
BMI status						
Overweight/Obese vs Under/Normal Weight	1.07	[0.63,1.81]		1.26	[0.67,2.36]	
Missing vs Under/Normal Weight	1.17	[0.30,4.61]		0.37	[0.11,1.28]	
Smoking status						
Current smoker vs Other	2.20	[1.20,4.02]	*	3.14	[1.66,5.94]	***
Pain						
Quite/Extreme vs No pain	5.38	[2.28,12.6]	***	18.00	[7.60,42.6]	***
Little/Moderate vs No pain	3.28	[2.28,4.73]	***	7.08	[4.11,12.2]	***
ADL Limitations						
Yes vs No	0.65	[0.16,2.71]		0.95	[0.22,4.02]	
IADL Limitations						
Yes vs No	0.84	[0.21,3.44]		2.14	[0.57,8.03]	
Activities disability						
Yes vs No	1.39	[0.52,3.71]		3.63	[1.57,8.38]	**
Comorbidities						
Anemia						
Yes vs No	1.05	[0.36,3.05]		2.80	[0.80,9.78]	
Anxiety						
Yes vs No	1.89	[0.84,4.25]		2.73	[1.25,5.98]	*

(*Continued*)

Table 5 (Continued).

	Good			Fair/Poor		
	OR	**95% CI**	**Sig**	**OR**	**95% CI**	**Sig**
Arthritis						
Yes vs No	0.69	[0.38,1.24]		0.60	[0.30,1.23]	
Cancer						
Yes vs No	1.52	[0.71,3.25]		1.24	[0.51,3.00]	
COPD						
Yes vs No	1.90	[0.99,3.65]		3.09	[1.62,5.89]	***
Diabetes						
Yes vs No	1.90	[0.84,4.31]		2.51	[0.91,6.91]	
Eye problems						
Yes vs No	0.89	[0.26,2.99]		1.46	[0.28,7.55]	
GERD						
Yes vs No	3.20	[1.33,7.69]	**	2.57	[0.84,7.89]	
Heart disease						
Yes vs No	2.57	[1.09,6.06]	*	5.39	[2.16,13.4]	***
Hyperlipidemia						
Yes vs No	1.67	[0.95,2.93]		4.10	[1.99,8.44]	***
Hypertension						
Yes vs No	1.25	[0.72,2.15]		0.62	[0.35,1.10]	
Depression						
Yes vs No	3.56	[1.87,6.80]	***	4.81	[2.46,9.42]	***
Osteoporosis						
Yes vs No	0.51	[0.25,1.03]		0.45	[0.15,1.33]	
Stroke						
Yes vs No	0.69	[0.09,5.27]		1.26	[0.22,7.11]	
Thyroid disorder						
Yes vs No	1.25	[0.70,2.26]		1.39	[0.50,3.88]	
MEPS year						
2006 vs 2005	0.64	[0.34,1.20]		0.54	[0.27,1.08]	
2007 vs 2005	1.04	[0.47,2.32]		0.51	[0.23,1.17]	
2008 vs 2005	0.43	[0.21,0.88]	*	0.44	[0.18,1.06]	
2009 vs 2005	0.54	[0.24,1.21]		0.37	[0.13,1.04]	
2010 vs 2005	0.58	[0.26,1.30]		0.70	[0.27,1.84]	
2011 vs 2005	1.02	[0.38,2.76]		0.47	[0.14,1.57]	
2012 vs 2005	0.77	[0.23,2.59]		0.50	[0.16,1.62]	
2013 vs 2005	0.67	[0.28,1.64]		0.28	[0.11,0.71]	**
2015 vs 2005	1.79	[0.81,3.93]		0.98	[0.32,3.01]	

Notes: Based on 541 individuals with MS and 541 matched controls without MS, aged 18 years or older and were alive during particular calendar year. Medical Expenditure Panel Survey 2005–2015. Asterisks represent statistical significance between the two groups based on chi-square tests. ***p< 0.001; **0.001 ≤p< 0.01; *0.01 ≤p<0.05.
Abbreviations: MEPS, Medical Expenditure Panel Survey; OR, odds ratio; CI, confidence interval; Sig, significant difference; BMI, body mass index; ADL, activity of daily living; IADL, instrumental activity of daily living; COPD, chronic obstructive pulmonary disease; GERD, gastroesophageal reflux disorder.

Table 6 Multinomial Logistic Regression Analysis Mental Health Status

	Good			Fair/Poor		
	OR	**95% CI**	**Sig**	**OR**	**95% CI**	**Sig**
Multiple Sclerosis						
Yes vs No	1.42	[1.01,1.99]	*	1.26	[0.58,2.76]	
Race/Ethnicity						
Others vs White	0.98	[0.54,1.77]		0.95	[0.47,1.91]	
Marital status						
Others vs Married	0.90	[0.63,1.29]		1.14	[0.60,2.16]	
Education						
<High School vs High School	2.44	[1.45,4.10]	***	5.77	[2.81,11.8]	***
> High School vs High School	1.21	[0.83,1.75]		1.32	[0.75,2.29]	
Region						
Mid-west vs Northeast	1.12	[0.73,1.72]		0.58	[0.26,1.27]	
South vs Northeast	1.06	[0.67,1.66]		0.70	[0.35,1.39]	
West vs Northeast	1.31	[0.81,2.10]		0.78	[0.36,1.71]	
Poverty status						
Near Poor vs Poor	0.77	[0.39,1.52]		0.76	[0.38,1.55]	
Middle Income vs Poor	1.07	[0.54,2.12]		0.71	[0.32,1.58]	
High Income vs Poor	0.78	[0.36,1.68]		0.50	[0.21,1.15]	
Employment status						
Not employed vs Employed	1.49	[0.95,2.33]		1.19	[0.59,2.41]	
Insurance coverage						
Private vs Uninsured	0.72	[0.37,1.38]		0.66	[0.17,2.55]	
Public vs Uninsured	1.06	[0.49,2.30]		0.70	[0.17,2.85]	
BMI status						
Overweight/Obese vs Under/Normal Weight	1.08	[0.73,1.59]		0.65	[0.37,1.15]	
Missing vs Under/Normal Weight	1.01	[0.28,3.63]		0.68	[0.15,3.20]	
Smoking status						
Current smoker vs Other	1.67	[1.10,2.55]	*	2.52	[1.47,4.34]	***
Pain						
Quite/Extreme vs No pain	2.08	[1.19,3.64]	*	2.60	[1.20,5.65]	*
Little/Moderate vs No pain	2.54	[1.72,3.74]	***	2.10	[1.15,3.82]	*
ADL Limitations						
Yes vs No	0.45	[0.20,1.01]		0.72	[0.23,2.29]	
IADL Limitations						
Yes vs No	1.46	[0.70,3.05]		4.52	[1.61,12.7]	**
Activities disability						
Yes vs No	1.37	[0.82,2.30]		2.10	[0.97,4.57]	
Comorbidities						
Anemia						
Yes vs No	2.11	[1.05,4.23]	*	0.67	[0.23,1.97]	
Anxiety						
Yes vs No	1.15	[0.60,2.20]		3.99	[2.13,7.49]	***

(*Continued*)

Table 6 (Continued).

	Good			Fair/Poor		
	OR	**95% CI**	**Sig**	**OR**	**95% CI**	**Sig**
Arthritis						
Yes vs No	0.64	[0.44,0.93]	*	0.54	[0.30,0.97]	*
Cancer						
Yes vs No	0.97	[0.46,2.05]		2.69	[1.03,6.99]	*
COPD						
Yes vs No	1.33	[0.81,2.18]		1.65	[0.88,3.09]	
Diabetes						
Yes vs No	1.33	[0.71,2.50]		2.46	[1.07,5.64]	*
Eye problems						
Yes vs No	1.49	[0.54,4.10]		0.11	[0.01,1.02]	
GERD						
Yes vs No	1.17	[0.51,2.66]		2.42	[0.87,6.72]	
Heart disease						
Yes vs No	1.31	[0.68,2.55]		0.96	[0.35,2.59]	
Hyperlipidemia						
Yes vs No	1.50	[0.88,2.56]		2.31	[1.13,4.69]	*
Hypertension						
Yes vs No	0.70	[0.47,1.03]		0.37	[0.20,0.66]	***
Depression						
Yes vs No	3.32	[2.13,5.16]	***	5.01	[2.69,9.31]	***
Osteoporosis						
Yes vs No	0.59	[0.23,1.51]		0.40	[0.10,1.51]	
Stroke						
Yes vs No	0.50	[0.18,1.42]		1.95	[0.55,6.95]	
Thyroid disorder						
Yes vs No	0.59	[0.34,1.03]		0.93	[0.41,2.13]	
MEPS year						
2006 vs 2005	0.68	[0.43,1.08]		0.46	[0.22,0.94]	*
2007 vs 2005	0.60	[0.32,1.13]		0.80	[0.32,1.98]	
2008 vs 2005	0.38	[0.22,0.68]	**	0.34	[0.16,0.74]	**
2009 vs 2005	0.74	[0.40,1.40]		0.78	[0.33,1.85]	
2010 vs 2005	1.00	[0.51,1.96]		0.49	[0.18,1.36]	
2011 vs 2005	1.51	[0.76,2.97]		1.42	[0.53,3.79]	
2012 vs 2005	0.73	[0.33,1.62]		0.53	[0.14,1.97]	
2013 vs 2005	0.69	[0.36,1.34]		0.51	[0.17,1.50]	
2015 vs 2005	0.95	[0.46,1.95]		0.39	[0.12,1.23]	

Notes: Based on 541 individuals with MS and 541 matched controls without MS, aged 18 years or older and were alive during particular calendar year. Medical Expenditure Panel Survey 2005–2015. Asterisks represent statistical significance between the two groups based on chi-square tests. ***p< 0.001; **0.001 ≤p< 0.01; *0.01 ≤p<0.05.
Abbreviations: MEPS, Medical Expenditure Panel Survey; OR, odds ratio; CI, confidence interval; Sig, significant difference; BMI, body mass index; ADL, activity of daily living; IADL, instrumental activity of daily living; COPD, chronic obstructive pulmonary disease; GERD, gastroesophageal reflux disorder.

prevalence, economic, and health status burden among individuals with MS compared to propensity score-matched non-MS controls.

Strengths of this study are as follows: (i) use of a nationally representative sample of community-dwelling adults and (ii) use of a broad set of individual-level variables including pain. However, limitations of this study are as follows: (i) potential of recall bias as MEPS uses self-reported data; (ii) sequence of comorbidities cannot be obtained; (iii) severity and types of MS (such as Relapsing-Remitting MS) information unavailable; and (iv) inability of establishing cause–effect relationships. However, in order to minimize recall bias, interviews are conducted at regular intervals of 4–5 months by MEPS.[24] And lastly, availability of only 3-digit ICD-9-CM codes in the publicly available MEPS dataset may have limited the identification of some specific comorbidities.

Conclusions

Comorbidities among individuals with MS are important considerations as they negatively impact those living with the disease. Despite the importance of understanding comorbidity burden among individuals with MS, only a few studies have been conducted to examine the comorbidity burden among those in the US. Findings from this study indicate substantial economic and health status burden among adults with MS at the US national-level that are significantly influenced by comorbidities.

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Disclosure

Z Yegezu, K Kollecas, K Duhrkopf served as a contact between Sanofi Genzyme and University of Arizona. K Kollecas, K Duhrkopf, and N Greene are employees and shareholders of Sanofi Genzyme. L Hashemi was an employee of Sanofi Genzyme at the time this article was written. The authors report no other conflicts of interest in this work.

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