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ORIGINAL ARTICLE

Disparities in Morbidity After Spinal Cord Injury Across Insurance Types in the United States

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Abstract

Objective: To compare the prevalence and incidence of, and adjusted hazards for comorbidities among adults with traumatic spinal cord injuries (TSCIs) across insurance types (private vs governmental insurance) in the United States.

Patients and Methods: Privately insured (N=9081) and Medicare (N=7645) beneficiaries with a diagnosis of TSCI were included. Prevalence and incidence estimates of common psychological, cardiometabolic, and musculoskeletal morbidities were compared at baseline and at 4-years after index diagnosis, respectively. Survival models were used to quantify hazard ratios (HRs) for outcomes, controlling for insurance type, sociodemographic characteristics, and other comorbidities. Sensitivity analyses were conducted to determine the effects of insurance and race/ethnicity.

Results: Adults with TSCIs on Medicare had a higher prevalence of any psychological (54.7% vs 35.4%), cardiometabolic (74.7% vs 70.1%), and musculoskeletal (72.8% vs 66.3%) morbidity than privately insured adults with TSCIs. Similarly, the 4-year incidences of most psychological (eg, depression: 37.6% [Medicare] vs 24.2% [private]), cardiometabolic (eg, type 2 diabetes: 22.5% [Medicare] vs 12.9% [private], and musculoskeletal (eg, osteoarthritis: 42.1% [Medicare] vs 34.6% [private]) morbidities were considerably higher among adults with TSCIs on Medicare. Adjusted survival models found that adults with TSCIs on Medicare had a greater hazard for developing psychological (HR, 1.40; 95% CI, 1.31-1.50) and cardiometabolic (HR, 1.21; 95% CI, 1.10-1.33) morbidities compared with privately insured adults with TSCI. There was evidence of both insurance and racial disparities.

Conclusion: Adults with TSCIs on Medicare had significantly higher prevalence and risk for developing common physical and mental health comorbidities, compared with privately insured adults with TSCIs.

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People living with traumatic spinal cord injuries (TSCIs) experience motor, sensory, and autonomic impairments that may result in the development of numerous secondary and comorbid conditions after TSCI onset. As of 2017, there were an estimated 296,000 people living with chronic TSCIs in the United States, with an age-standardized incidence rate of 21 per 100,000.[1,2] Health care professionals and policymakers at the national and state levels need to advance health care planning and resource allocation to prevent and reduce the burden of TSCI. Unfortunately, significant health care disparities exist in the treatment and outcomes of patients living with TSCIs in the United States.[3-5] These disparities could be related to health insurance access and supplementary needs that are not covered by the primary payor. The Centers for Medicaid and Medicare Services (CMS) usually sets coverage definitions for what is "reasonable and medical necessary"[6] for the diagnosis and treatment of a medical disease and its sequalae. Lack of insurance, coverage disruptions, and public insurance have been associated with worse outcomes across disease states, ranging from acute coronary disease to long-term health care management, such as cancer treatments.[7-10]

Therefore, it is possible that payor type is an important social determinant of health

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(SDoH) for those with a TSCI. A previous study has found that patients undergoing operation after TSCI with Medicaid or no insurance had significantly higher odds of in-hospital death and were less likely to receive early intervention.[11] Differences by coverage for individuals with TSCIs could also include variability in the coverage of length of hospitalization, number of rehabilitation therapy sessions per year, types of durable medical equipment covered, mental health provisions, bladder management interventions, prescription drug plan limitations, and residential home care, among other needs.[12-15] The World Health Organization defines SDoH as nonmedical factors that influence health outcomes.[16] Recently, there has been a shift to understand and acknowledge the critical thinking required for a provider to navigate these inequities. For example, in 2020, the outpatient billing and coding leveling set by CMS acknowledged that SDoH should be considered during medical decision-making for a patient for an encounter where the patient is deemed "moderate risk" (ie, 1 or more chronic illnesses with mild exacerbation, progression, or adverse effects of treatment; 2 or more stable chronic illnesses; undiagnosed new problem with uncertain prognosis; acute illness with systemic symptoms; acute complicated injury).[17] This shift credits that SDoH contribute to wide health disparities and inequities across diagnoses.[16] Insurance payor type is relevant to this because patients with TSCIs are not insured similarly.

The objective of this study was to compare the prevalence and incidence of, and adjusted hazards for common psychological, cardiometabolic, and musculoskeletal morbidities among adults with TSCIs across insurance types (ie, private vs governmental insurance) in the United States.

PATIENTS AND METHODS

Data Source

A retrospective cohort study of adults with TSCIs whose diagnoses could have existed across any patient care setting was conducted. This study used 2 sources of claims-based administrative data. First, patients with TSCIs were obtained from a national, private insurance claims database, Clinformatics DataMart Database (OptumInsight). This is a deidentified administrative claims database of more than 80 million adults and children with commercial insurance representing those on a single, large US private payer who had both medical and pharmacy coverage throughout the enrollment. Second, we included patients with TSCIs enrolled exclusively in Medicare. All Medicare claims data of our patient cohort related to office visits, outpatient's emergency department, and inpatient encounters were used for this analysis. We included data regarding patient sociodemographic information that were equivalent across the 2 claims data sets.

Sample Selection

All individuals 18 years of age and older at the time of enrollment were eligible for this analysis. Enrollment years included 2007-2013, with data for examining outcomes spanning 2007-2018. We excluded individuals with less than 5 years of continuous enrollment. All medical claims, excluding laboratory and outpatient pharmacy, were considered to identify the incidence or prevalence of these conditions during the enrollment period.

Identification of Patients With a TSCI. All members with a diagnosis of TSCI were identified using the *International Classification of Diseases, Ninth Revision, Clinical Modification*, as previously described.[18] Members with spinal cord injuries before 2007 were excluded because of poorer coverage of diagnosis codes during 2001-2006 in the database. To allow adequate longitudinal follow-up for all patients with TSCIs, only those who had 5 or more continuous years of enrollment after their starting date of enrollment within the study period were included (Figure 1).

Psychological Morbidities, Cardiometabolic Diseases, and Musculoskeletal Disorders. Physician-diagnosed physical and mental health disorders were identified on the basis of a single encounter that included at least 1 of the pertinent *International Classification of Diseases, Ninth Revision* or *International Statistical Classification of Diseases, Tenth Revision* codes, as previously described.[19-21] All physical and mental health disorders were chosen on the basis of established categories through

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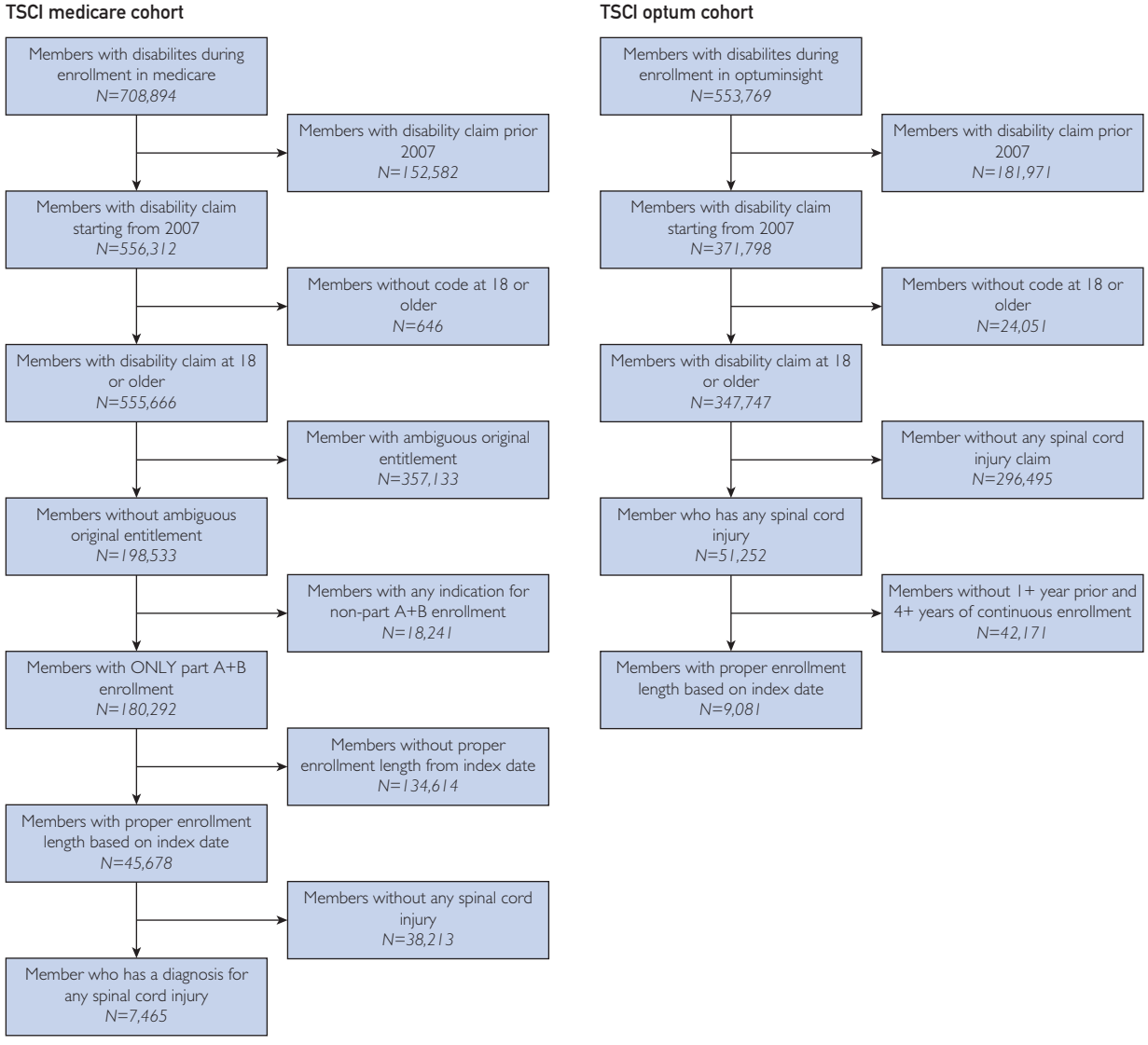

FIGURE 1. Flow chart of participants' inclusion and exclusion for patients with TSCI on Medicare and patients with TSCI on private insurance. TSCI = traumatic spinal cord injury.

the Agency for Healthcare Research and Quality's indicators of clinical classification software.[22] Clinical classification software is a software tool that aggregates *International Classification of Diseases, Ninth Revision, Clinical Modification* diagnoses codes into higher levels of clinical classifications. The decision to follow the Agency for Healthcare Research and Quality's clinical definitions was made a priori to provide uniformity.

Component psychological morbidities included the following: (1) insomnia, (2) adjustment disorders, (3) anxiety disorders, (4) posttraumatic stress disorder, (5) delirium/dementia/amnesia, (6) impulse control disorders, (7) mood disorders, (8) personality disorders, (9) alcohol-related disorders, and (10) substance-related disorders.

Component cardiometabolic diseases included the following: (1) cardiac dysrhythmias, (2) heart failure, (3) atherosclerosis, (4) nonalcoholic fatty liver disease, (5) chronic kidney disease, (6) type 2 diabetes, (7) hypercholesterolemia, and (8) hypertension.

Component musculoskeletal disorders included the following: (1) rheumatoid arthritis; (2) osteoarthritis; (3) osteoporosis; (4) pathologic fracture; (5) other connective tissue disease (eg, upper extremity tendonitis), synovitis and tenosynovitis, other disorders of synovium and tendon (eg, synovial hypertrophy), bursitis, enthesopathies-lower limb (eg, hip tendonitis), other enthesopathies (eg, lateral epicondylitis), other and unspecified soft tissue disorders, not elsewhere classified (eg, panniculitis), calcification and ossification of muscle; (6) sarcopenia; and (7) myalgia.

Covariates. Explanatory covariates included age, sex, race/ethnicity, and a modified Elixhauser comorbidity index that was specific to the dependent variables. The Elixhauser comorbidity index was modified to remove conditions that would be correlated with incident psychological morbidities, cardiometabolic diseases, and musculoskeletal disorders, as previously described.[23]

Statistical Analyses

Bivariate analyses of baseline demographic characteristics between patients with TSCIs on Medicare vs Optum were examined (Table 1). For categorical variables, column percentages were compared between both groups using the effect size calculations with Cohen *h*. The Cohen *h* effect size calculation was used as, due to large sample sizes, being statistically overpowered would not provide clinically meaningful differences in proportions between groups. For continuous variables, means and standard deviations as well as medians with upper and lower bounds on interquartile ranges were calculated. Cohen *d* standardized mean differences (SMDs) were calculated for continuous variables to ascertain clinically meaningful differences between groups.

To capture the full comorbidity history within the study period, all eligible beneficiaries with sufficient continuous enrollment of 5 total years were retained to enable sufficient lookback and follow-up. Specifically, all individuals with sufficient continuous enrollment within the study period were randomly assigned a time zero to begin a 4-year follow-up. The selection of the randomly assigned date required 1 year of enrollment (ie, the "lookback period") to collect comorbidity history and 4 years of postindex date follow-up to measure the first diagnosis of incident psychological, cardiometabolic, or musculoskeletal. The lookback period was used to examine if any prevalent psychological, cardiometabolic, or musculoskeletal outcomes existed. The prevalence of all comorbidities is reported in Table 2.

To examine disease-free survival of individuals with TSCIs who were covered with Medicare compared with private insurance, we used Kaplan-Meier product-limit survival curves when modeling for unadjusted psychological morbidities, cardiometabolic diseases, and musculoskeletal disorders. To establish incidence in claims, we used a 1-year lookback period from the index date in each group to obtain evidence of any service use with a diagnosis of any psychological morbidity, cardiometabolic disease, and musculoskeletal disorders. Patients with any evidence of prior diagnosis of the above conditions during the lookback period were excluded from the product-limit survival curves and other subsequent analyses.

Similarly, to estimate the unadjusted and adjusted hazards of the composite and each psychological morbidity, cardiometabolic disease, and musculoskeletal disorder, a series of survival models were developed. For each outcome, all patients who had evidence of the specific psychological morbidity, cardiometabolic disease, and musculoskeletal disorder at baseline were excluded from the model. For example, if type 2 diabetes was being considered the incident outcome, all patients with prevalent type 2 diabetes in the lookback period were excluded from the longitudinal model. Therefore, sample sizes of patients included for each outcome varied on the basis of evidence of prevalent disease in the 1 year before the index date. Survival models were then used to quantify unadjusted and adjusted hazard ratios (HRs) for each incident psychological morbidity, cardiometabolic disease, and musculoskeletal disorder. Appropriate survival models were based on distributional assumptions that included testing Weibull, lognormal, exponential, gamma, logistic, loglog, and normal distributions with respect to the follow-up in days by minimizing critical model fit statistics.

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Critical assessment of Akaike Information Criterion was used as a basis for minimization among all candidate distributions. Parametric Weibull regression was applied stepwise for incident outcome. To examine the effects of incremental adjustment on the exposure variable (ie, individuals with TSCIs on Medicare vs privately insured beneficiaries with TSCIs [reference]), a series of sensitivity analyses for each outcome was performed. Finally, to examine the marginal association of race/ethnicity and insurance type, we examined outcomes within and across all combinations of insurance type and races/ethnicities. All patients were right censored if they did not experience the outcome in the follow-up period or were disenrolled from the plan. Both unadjusted and all adjusted HRs and 95% CIs for the exposure to being insured on Medicare were calculated.

All analyses were conducted using SAS 9.4 (SAS Institute). Statistical testing was 2-tailed with a significance level of .05 and effect sizes (Cohen *d* SMD) of 0.2 to reflect clinically meaningful difference cutoff.

RESULTS

The median time in the plan for eligible enrollees was 9.0 (25th Percentile: 8.9; 75th Percentile: 9.0) and 10.3 (25th Percentile: 8.0; 75th Percentile: 13.0) years for individuals with TSCIs on Medicare vs privately insured beneficiaries with TSCIs. There was a greater proportion of women in the privately insured beneficiaries with TSCIs (57.8%) compared with individuals with TSCIs on Medicare (49.2%) (Table 1).

TABLE 1. Descriptive Characteristics of Medicare Beneficiaries With TSCI and Privately Insured Beneficiaries With TSCI

Spinal cord injury	TSCI Medicare cohort	TSCI optum cohort
Overall	7465 (100%)	9081 (100%)
Full enrollment length		
Mean (SD)	8.6 (0.8)	10.8 (3.4)
Median (Q1-Q3)	9.0 (8.9-9.0)	10.3 (8.0-13.0)
Years after eligibility start date		
Mean (SD)	4.8 (1.1)	5.0 (1.7)
Median (Q1-Q3)	4.7 (3.8-5.8)	4.6 (3.7-6.0)
Age group (y)		
18-44	1297 (17.4%)	1384 (15.2%)
45-64	3759 (50.4%)	2547 (28.0%)
≥65	2409 (32.3%)	5150 (56.7%)
Sex		
Female	3672 (49.2%)	5252 (57.8%)
Male	3793 (50.8%)	3829 (42.2%)
Race		
Black	1122 (15.0%)	637 (7.0%)
Hispanic	625 (8.4%)	718 (7.9%)
White	5487 (73.5%)	5705 (62.8%)
Unknown	231 (3.1%)	2021 (22.3%)
Census division		
East North Central	1167 (15.6%)	875 (9.6%)
East South Central	688 (9.2%)	336 (3.7%)
Middle Atlantic	940 (12.6%)	410 (4.5%)
Mountain	410 (5.5%)	1232 (13.6%)
New England	525 (7.0%)	478 (5.3%)
Pacific	792 (10.6%)	1680 (18.5%)
South Atlantic	1568 (21.0%)	1815 (20.0%)
West North Central	420 (5.6%)	788 (8.7%)
West South Central	904 (12.1%)	1366 (15.0%)
Unknown	51 (0.7%)	101 (1.1%)

TSCI = traumatic spinal cord injury.

Psychological Morbidities

Individuals with TSCIs on Medicare had a higher baseline prevalence of any (54.7% vs 35.4%) and most (all except adjustment disorders, delirium/dementia/amnesia, and impulse control disorders) of the psychological morbidities compared with privately insured beneficiaries with TSCIs, and differences were to a clinically meaningful extent ($P<.01$ and SMD of ≥0.2). Moreover, individuals with TSCIs on Medicare had a significantly higher 4-year incidence of any (60.7% vs 48.3%) and all but 2 (impulse control and alcohol-related disorders) of the psychological outcomes, including insomnia (19.2% vs 12.1%), adjustment disorders (9.1% vs 6.2%), anxiety disorders (33.6% vs 21.4%), posttraumatic stress disorder (3.4% vs 1.4%), delirium/amnesia (17.1% vs 13.2%), mood disorders (37.6% vs 24.2%), and substance-related disorders (11.0% vs 7.5%), compared with privately insured beneficiaries with TSCIs (all $P<.01$ and SMD of ≥0.2) (Table 2).

Cardiometabolic Diseases

Individuals with TSCIs on Medicare had a higher baseline prevalence of any (74.7% vs 70.1%) and most (all except chronic kidney disease) of the cardiometabolic diseases compared with privately insured beneficiaries with TSCIs, and differences were again to a

TABLE 2. Baseline Prevalence and 4-Year Incidence (With 1-Year Clean Enrollment Period) of Any and All Cardiometabolic Diseases, Musculoskeletal Disorders, and Psychological Morbidities Among Medicare Beneficiaries With TSCI or Privately Insured Beneficiaries With TSCIs[a]

	Prevalent only		Incident only	
	Full		No outcome prior baseline	
	TSCI Medicare cohort	TSCI optum cohort	TSCI Medicare cohort/denominator	TSCI optum cohort/denominator
Overall	N=7465	N=9081		
Psychological				
Any psychological	4087 (54.7%)[b]	3214 (35.4%)	2050/3378 (60.7%)[b]	2833/5867 (48.3%)
Insomnia	728 (10.0%)[b]	549 (6.0%)	1292/6737 (19.2%)[b]	1035/8532 (12.1%)
Adjustment disorders	304 (4.1%)	245 (2.7%)	649/7161 (9.1%)[b]	547/8836 (6.2%)
Anxiety disorders	1965 (26.3%)[b]	1230 (13.5%)	1849/5500 (33.6%)[b]	1680/7851 (21.4%)
PTSD	208 (2.8%)[b]	50 (0.6%)	250/7257 (3.4%)[b]	122/9031 (1.4%)
Delirium/dementia/amnesia	650 (8.7%)	696 (7.7%)	1165/6815 (17.1%)[b]	1107/8385 (13.2%)
Impulse control disorders	38 (0.5%)	8 (0.1%)	99/7427 (1.3%)	13/9073 (0.1%)
Mood disorders	2931 (39.3%)[b]	1713 (18.9%)	1703/4534 (37.6%)[b]	1783/7368 (24.2%)
Personality disorders	206 (2.8%)[b]	33 (0.4%)	247/7259 (3.4%)[b]	64/9048 (0.7%)
Alcohol-related disorders	487 (6.5%)[b]	304 (3.3%)	393/6978 (5.6%)	403/8777 (4.6%)
Substance-related disorders	790 (10.6%)[b]	308 (3.4%)	737/6675 (11.0%)[b]	659/8773 (7.5%)
Cardiometabolic				
Any cardiometabolic	5580 (74.7%)[b]	6363 (70.1%)	1157/1885 (61.4%)[b]	1389/2718 (51.1%)
Cardiac dysrhythmias	1932 (25.9%)[b]	1969 (21.7%)	1983/5533 (35.8%)[b]	2090/7112 (29.4%)
Heart failure	1047 (14.0%)[b]	822 (9.1%)	1130/6418 (17.6%)[b]	1148/8259 (13.9%)
Atherosclerosis	1229 (16.5%)[b]	983 (10.8%)	1458/6236 (23.4%)[b]	1612/8098 (19.9%)
Nonalcoholic fatty liver disease	259 (3.5%)[b]	142 (1.6%)	446/7206 (6.2%)[b]	332/8938 (3.7%)
Chronic kidney disease	664 (8.9%)	812 (8.9%)	841/6801 (12.4%)	1062/8269 (12.8%)
Type 2 diabetes	2469 (33.1%)[b]	2049 (22.6%)	1126/4996 (22.5%)[b]	907/7032 (12.9%)
Hypercholesterolemia	1824 (24.4%)[b]	1933 (21.3%)	1451/5641 (25.7%)[b]	1551/7148 (21.7%)
Hypertension	4687 (62.8%)[b]	5340 (58.8%)	1341/2778 (48.3%)[b]	1462/3741 (39.1%)
Musculoskeletal				
Any musculoskeletal	5434 (72.8%)[b]	6024 (66.3%)	1589/2031 (78.2%)	2409/3057 (78.8%)
Rheumatoid arthritis	55 (0.7%)	357 (3.9%)[b]	473/6912 (6.8%)[b]	342/8724 (3.9%)
Osteoarthritis	2537 (34.0%)[b]	2461 (27.1%)	2076/4928 (42.1%)[b]	2289/6620 (34.6%)
Osteoporosis	1201 (16.1%)	1743 (19.2%)[b]	1188/6264 (19.0%)	1593/7338 (21.7%)
Pathological fracture	848 (11.4%)	1433 (15.8%)[b]	897/6617 (13.6%)	1410/7648 (18.4%)[b]
Other connective tissue disease	4766 (63.8%)[b]	4699 (51.7%)	2002/2699 (74.2%)	3162/4382 (72.2%)
Sarcopenia	968 (13.0%)[b]	904 (10.0%)	1941/6497 (29.9%)[b]	2168/8177 (26.5%)
Myalgia	1158 (15.5%)[b]	770 (8.5%)	1161/6307 (18.4%)[b]	1101/8311 (13.2%)

[a]PTSD = posttraumatic stress disorder; TSCI = traumatic spinal cord injury.
[b]$P<.01$ and standard mean difference of ≥ 0.2.

clinically meaningful extent ($P<.01$ and SMD of ≥ 0.2). Moreover, individuals with TSCIs on Medicare had a significantly higher 4-year incidence of any (61.4% vs 51.1%) and all but one (chronic kidney disease) of the cardiometabolic diseases, including cardiac dysrhythmias (35.8% vs 29.4%), heart failure (17.6% vs 13.9%), atherosclerosis (23.4% vs 19.9%), nonalcoholic fatty liver disease (6.2% vs 3.7%), type 2 diabetes (22.5% vs 12.9%), hypercholesterolemia (25.7% vs 21.7%), and hypertension (48.3% vs 39.1%), compared with privately insured beneficiaries with TSCIs (all $P<.01$ and SMD of ≥ 0.2) (Table 2).

Musculoskeletal Disorders

Individuals with TSCIs on Medicare had a higher baseline prevalence of any (72.8% vs 66.3%) and most (all except rheumatoid

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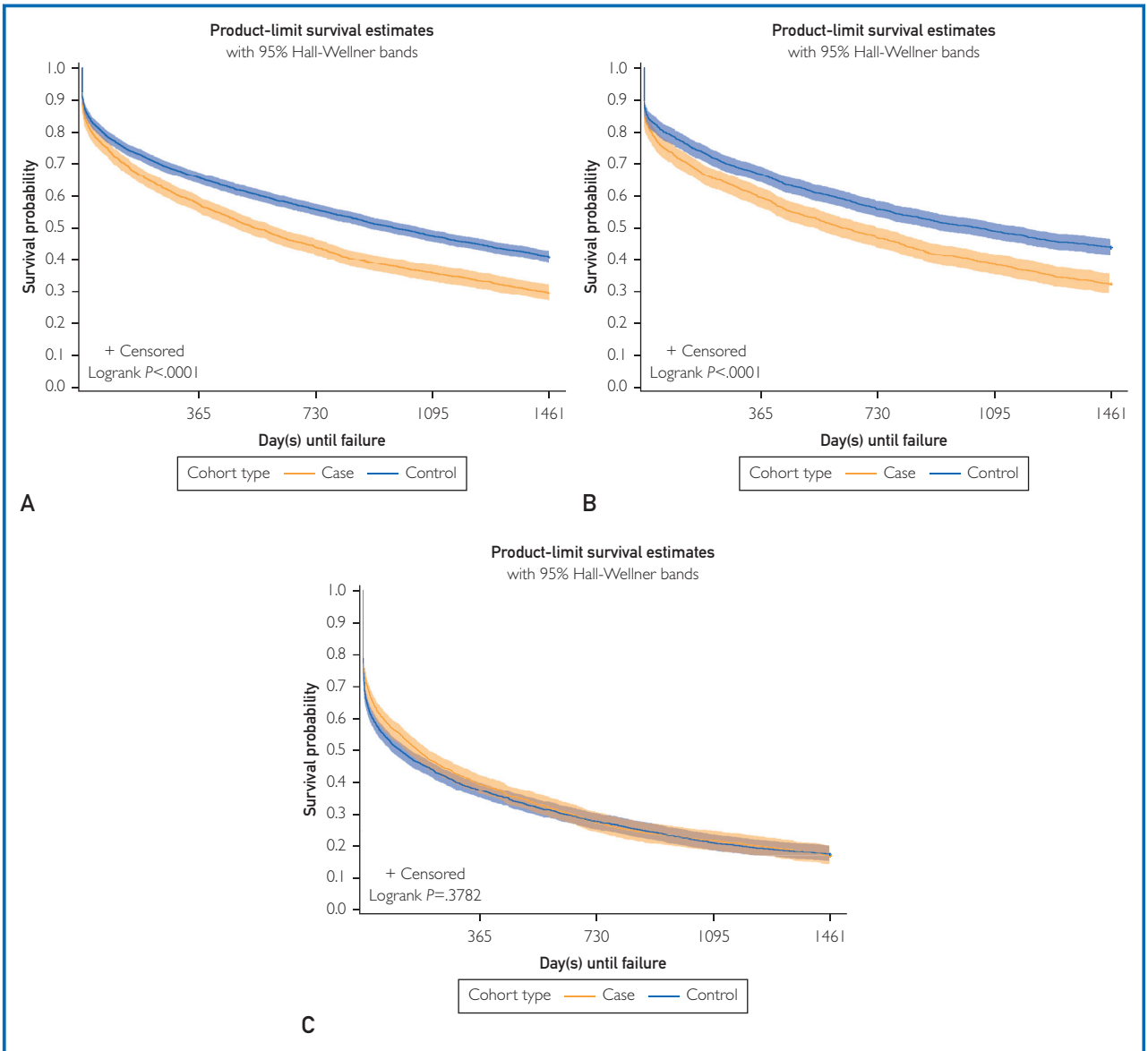

FIGURE 2. Disease-free survival and Kaplan-Meier product-limit survival curves (3-year) for Medicare beneficiaries with TSCIs (blue) and privately insured beneficiaries with TSCIs (red), for any (A) psychological morbidity, (B) cardiometabolic disease, and (C) musculoskeletal disorder. TSCI = traumatic spinal cord injury.

arthritis, osteoporosis, pathological fractures) of the musculoskeletal disorders compared with privately insured beneficiaries with TSCIs, and differences were to a clinically meaningful extent ($P<.01$ and SMD of ≥ 0.2). Individuals with TSCIs on Medicare also had significantly higher incidence of rheumatoid arthritis (6.8% vs 3.9%), osteoarthritis (42.1% vs 34.6%), sarcopenia (29.9% vs 26.5%), and myalgia (18.4% vs 13.2%), compared with privately insured beneficiaries with TSCIs (all $P<.01$ and SMD of ≥ 0.2) (Table 2).

Kaplan-Meier curves for the unadjusted disease-free survival for any psychological morbidity, cardiometabolic disease, and musculoskeletal disorder in individuals with TSCIs on Medicare vs privately insured beneficiaries with TSCIs are shown in Figure 2.

Unadjusted survival models found a robust increased HR for each of the incident

TABLE 3. Survival Models With Parametric Weibull Regression Was Completed Stepwise for Each Incident Psychological Outcome to Examine the Effects of Incremental Adjustment on the Exposure Variable (Medicare Beneficiaries With TSCI) Compared With the reference (Privately Insured Beneficiaries With TSCIs)[a,b]

Parametric: Weibull	Model 1[c]	Model 2[d]	Model 3[e]	Model 4[f]
Any psychological outcome	1.39 (1.31-1.48)[g]	1.51 (1.42-1.62)[g]	1.42 (1.33-1.52)[g]	1.40 (1.31-1.49)[g]
Insomnia	1.62 (1.50-1.74)[g]	1.76 (1.62-1.92)[g]	1.61 (1.47-1.75)[g]	1.52 (1.40-1.66)[g]
Adjustment disorders	1.50 (1.35-1.67)[g]	1.41 (1.25-1.59)[g]	1.24 (1.10-1.40)[g]	1.18 (1.04-1.33)[g]
Anxiety disorders	1.74 (1.63-1.85)[g]	1.80 (1.68-1.93)[g]	1.67 (1.55-1.79)[g]	1.60 (1.49-1.72)[g]
PTSD	2.78 (2.24-3.46)[g]	2.28 (1.82-2.87)[g]	2.13 (1.69-2.68)[g]	1.91 (1.51-2.41)[g]
Delirium/dementia/amnesia	1.27 (1.18-1.38)[g]	1.65 (1.51-1.80)[g]	1.45 (1.33-1.59)[g]	1.43 (1.31-1.56)[g]
Impulse control disorders	7.91 (4.38-14.28)[g]	6.01 (3.32-10.89)[g]	4.93 (2.74-8.86)[g]	4.81 (2.68-8.65)[g]
Mood disorders	1.64 (1.54-1.75)[g]	1.79 (1.66-1.92)[g]	1.65 (1.54-1.78)[g]	1.61 (1.49-1.73)[g]
Personality disorders	4.54 (3.40-6.07)[g]	4.22 (3.11-5.74)[g]	3.57 (2.64-4.85)[g]	3.29 (2.43-4.46)[g]
Alcohol-related disorders	1.43 (1.23-1.66)[g]	1.23 (1.04-1.44)[h]	1.18 (1.00-1.40)[h]	1.14 (0.96-1.34)
Substance-related disorders	1.73 (1.57-1.90)[g]	1.57 (1.42-1.73)[g]	1.40 (1.26-1.55)[g]	1.26 (1.14-1.40)[g]

[a]PTSD = posttraumatic stress disorder; TSCI = traumatic spinal cord injury.
[b]Results are presented as hazard ratios and 95% CIs. As with incidence estimates, all survival models used cases (Medicare beneficiaries with TSCI) and control cohorts (privately insured beneficiaries with TSCIs) consistent with Table 2, which required a 1-year clean period with no evidence of the cardiometabolic disease being modeled.
[c]Model 1: unadjusted.
[d]Model 2: model 1 + demographic variables (age, sex, race, geographic region).
[e]Model 3: model 1 + model 2 + modified Elixhauser comorbidity index.
[f]Model 4: model 1 + model 2 + model 3 + education + income.
[g]$P<.001$.
[h]$P<.05$.

psychological morbidities, cardiometabolic diseases (except chronic kidney disease), and musculoskeletal disorders among individuals with TSCIs on Medicare vs privately insured beneficiaries with TSCIs (Tables 3, 4, and 5) (all $P<.001$). Fully adjusted survival models revealed that individuals with TSCIs on Medicare had a greater hazard for any psychological morbidity (HR, 1.40; 95% CI, 1.31-1.49) and cardiometabolic diseases (HR, 1.21; 95% CI, 1.10-1.33) (Supplemental Tables 1, 2, and 3, available online at http://www.mcpiqojournal.org) and nearly all individual component psychological morbidities, cardiometabolic diseases, and musculoskeletal disorders than privately insured individuals with TSCIs (Tables 3, 4, and 5).

Sensitivity analyses revealed evidence of both insurance and racial disparities. Specifically, when examining within-race disparities across insurance types, we found that White individuals with TSCIs on Medicare had a significantly higher risk for developing any psychological (HR, 1.43; 95% CI, 1.34-1.54) and cardiometabolic (HR, 1.26; 95% CI, 1.15-1.39) outcome, compared with privately insured White beneficiaries with TSCIs. Similarly, Black individuals with TSCIs on Medicare had a significantly higher risk for developing any psychological (HR, 1.36; 95% CI, 1.15-1.62) and cardiometabolic (HR, 1.52; 95% CI, 1.17-1.96) outcome, compared with privately insured Black individuals with TSCIs. Further, when examining between-insurance type across race, we found that Black individuals with TSCIs on Medicare had a significantly higher risk for developing any psychological (HR, 1.15; 95% CI, 1.02-1.29) and cardiometabolic (HR, 1.65; 95% CI: 1.39-1.95) outcome compared with privately insured White individuals with TSCIs. Similarly, Hispanic individuals with TSCIs on Medicare had a significantly higher risk for developing any cardiometabolic (HR, 1.43; 95% CI, 1.15-1.77) disease compared with privately insured White beneficiaries.

DISCUSSION

The principal findings of this study were that individuals living with TSCIs on Medicare had a higher baseline prevalence of and risk for developing common psychological, cardiometabolic, and musculoskeletal morbidities compared with privately insured adults with TSCIs. More research is needed to examine why mental and physical comorbidities are

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TABLE 4. Survival Models With Parametric Weibull Regression Was Completed Stepwise for Each Incident Cardiometabolic Outcome to Examine the Effects of Incremental Adjustment on the Exposure Variable (Medicare Beneficiaries With TSCI) Compared With the Reference (Privately Insured Beneficiaries With TSCIs)[a,b]

	Model 1[c]	Model 2[d]	Model 3[e]	Model 4[f]
Any cardiometabolic outcome	1.34 (1.23-1.45)[g]	1.33 (1.22-1.46)[g]	1.22 (1.11-1.34)[g]	1.21 (1.10-1.33)[g]
Cardiac dysrhythmias	1.30 (1.23-1.39)[g]	1.42 (1.33-1.52)[g]	1.23 (1.15-1.32)[g]	1.22 (1.14-1.31)[g]
Heart failure	1.30 (1.20-1.40)[g]	1.61 (1.48-1.76)[g]	1.39 (1.27-1.52)[g]	1.38 (1.26-1.51)[g]
Atherosclerosis	1.17 (1.09-1.25)[g]	1.48 (1.37-1.59)[g]	1.29 (1.20-1.39)[g]	1.28 (1.18-1.38)[g]
Nonalcoholic fatty liver disease	1.60 (1.41-1.81)[g]	1.48 (1.29-1.71)[g]	1.25 (1.08-1.44)	1.21 (1.05-1.40)[g]
Chronic kidney disease	0.96 (0.89-1.05)	1.23 (1.12-1.34)[g]	1.06 (0.97-1.17)	1.06 (0.96-1.16)
Type 2 diabetes	1.81 (1.66-1.97)[g]	1.85 (1.68-2.03)[g]	1.61 (1.46-1.77)[g]	1.60 (1.45-1.76)[g]
Hypercholesterolemia	1.20 (1.12-1.29)[g]	1.20 (1.11-1.29)[g]	1.13 (1.04-1.22)[g]	1.13 (1.04-1.22)[g]
Hypertension	1.36 (1.26-1.47)[g]	1.46 (1.34-1.58)[g]	1.31 (1.21-1.43)[g]	1.31 (1.20-1.43)[g]

[a]TSCI = traumatic spinal cord injury.
[b]Results are presented as hazard ratios and 95% CIs. As with incidence estimates, all survival models used cases (Medicare beneficiaries with TSCI) and control cohorts (privately insured beneficiaries with TSCIs) consistent with Table 2, which required a 1-year clean period with no evidence of the cardiometabolic disease being modeled.
[c]Model 1: unadjusted.
[d]Model 2: model 1 + demographic variables (age, sex, race, geographic region).
[e]Model 3: model 1 + model 2 + modified Elixhauser comorbidity index.
[f]Model 4: model 1 + model 2 + model 3 + education + income.
[g]$P<.001$.

higher among people with TSCIs who were covered by governmental vs private insurance. It is plausible that privately insured individuals may have better access to higher quality care; however, access to preventive screening and health care should be equitable across insurance types. Providers who care for patients with TSCIs should consider applying risk stratification techniques to categorize patient morbidity and outcomes.

Known examples of risk stratification in the TSCI population include fragility fracture risk[24] and psychometric properties of pressure ulcer scales,[25] among others. This study is unique in that, to our knowledge, it is the first and largest to date to account for public vs private insurance in comparing health outcomes across several distinct chronic diseases and in providing disparity data. In addition to differences in health outcomes across insurance types, we found significant racial disparities within and across insurance types. Black and White individuals with TSCIs had higher risk for developing psychological morbidities and cardiometabolic diseases if they were on Medicare (vs private insurance). Furthermore, both Black and Hispanic individuals with TSCIs on Medicare had higher risk of developing cardiometabolic diseases compared with privately insured beneficiaries with TSCIs who were White. These findings are extremely important to inform clinical screening algorithms for mental health and cardiometabolic disease risk factors in this higher-risk population and in the design of policy and care coordination with an emphasis on reducing health care disparities across Medicare beneficiaries, particularly among racial/ethnic minorities.

Psychological disease sequalae after TSCI has been associated with several risk factors and is predictive of mortality, even after controlling for injury severity and other health-related variables.[26] The impact of depression has been linked to urinary tract infections and pressure ulcers, lower self-appraised health, poor community access and mobility, poor social integration, and chronic pain.[20,27] The clinical evaluation of the risks of developing mood disorders after TSCI should include assessment of posttraumatic stress disorder, pain, metabolic and nutritional evaluations, as well as other common clinical pearls. The results of this study revealed that public insurance is associated with worse mental health outcomes/comorbidities. Screening for and offering psychological counseling, family therapy, intervention with medications, as well as constant and strict

TABLE 5. Survival Models With Parametric Weibull Regression Was Completed Stepwise for Each Incident Musculoskeletal Outcome to Examine the Effects of Incremental Adjustment on the Exposure Variable (Medicare beneficiaries with TSCI) Compared With the Reference (Privately Insured Beneficiaries With TSCIs)[a,b]

	Model 1[c]	Model 2[d]	Model 3[e]	Model 4[f]
Any musculoskeletal outcome	0.96 (0.89-1.03)	1.00 (0.92-1.08)	0.95 (0.88-1.03)	0.94 (0.87-1.01)
Rheumatoid Arthritis	1.75 (1.53-2.00)[g]	1.80 (1.55-2.10)[g]	1.61 (1.38-1.87)[g]	1.59 (1.36-1.85)[g]
Osteoarthritis	1.30 (1.23-1.38)[g]	1.51 (1.42-1.61)[g]	1.39 (1.30-1.48)[g]	1.36 (1.27-1.45)[g]
Osteoporosis	0.91 (0.84-0.98)[h]	1.20 (1.11-1.31)[g]	1.14 (1.05-1.24)	1.13 (1.04-1.23)[g]
Pathological fracture	0.72 (0.66-0.79)[g]	0.96 (0.87-1.06)	0.91 (0.83-1.01)	0.90 (0.82-1.00)
Other connective tissue disease	1.07 (1.01-1.14)[h]	1.11 (1.04-1.19)[h]	1.04 (0.97-1.11)	1.03 (0.96-1.10)
Sarcopenia	1.13 (1.07-1.20)[g]	1.35 (1.26-1.44)[g]	1.15 (1.08-1.23)[g]	1.14 (1.06-1.22)[g]
Myalgia	1.45 (1.34-1.57)[g]	1.40 (1.29-1.53)[g]	1.27 (1.16-1.39)[g]	1.21 (1.10-1.32)[g]

[a]TSCI = traumatic spinal cord injury.
[b]Results are presented as hazard ratios and 95% CIs. As with incidence estimates, all survival models used cases (Medicare beneficiaries with TSCI) and control cohorts (privately insured beneficiaries with TSCIs), consistent with Table 2, which required a 1-year clean period with no evidence of the cardiometabolic disease being modeled.
[c]Model 1: unadjusted.
[d]Model 2: model 1 + demographic variables (age, sex, race, geographic region).
[e]Model 3: model 1 + model 2 + modified Elixhauser comorbidity index.
[f]Model 4: model 1 + model 2 + model 3 + education + income.
[g]$P<.001$.
[h]$P<.05$.

monitoring in the outpatient setting for treatment should be available to publicly insured beneficiaries. This is more pronounced knowing that the 4-year incidence of depression and anxiety are higher among Medicare beneficiaries with TSCIs compared with their privately insured counterparts.

Similarly, risks of cardiometabolic diseases are a known hallmark that individuals face after TSCIs. Our findings corroborate with those of other studies, demonstrating that among both Medicare and privately insured individuals with TSCIs, there is a high prevalence (>70%) and incidence (>50%) for any cardiometabolic disease. Unlike neurogenic bowel and bladder, secondary cardiometabolic complications after TSCI typically develop without overt symptoms. Younger people with TSCIs are at moderate-to-high risk of long-term cardiac events with obesity, dyslipidemia, and carbohydrate metabolism dysfunction.[28] Moreover, these cardiac events preferentially affect those with cervical neurological level of injury, indicating a need for lifelong chronic impairment risk assessment that is also semi-specific.[28] Given the dramatic increases in physical inactivity and sedentary behavior, there is also a strong association between TSCI and type 2 diabetes and metabolic syndrome.[29,30] Future efforts should advocate for the economic health care burden associated with poor screening methods across insurance types and for the development and implementations of early behavioral interventions and treatments that reduce the risk of cardiometabolic morbidities.[31-33]

The results of this study echo the need for all providers to continue to think about payor type, practice management limitations, inequities of outcomes in TSCI disease sequalae, and to be mindful of legislation and advocacy for medically necessary services and treatments set by the CMS. For example, the implementation of policies regarding single payor discourse or Medicare expansion would be completed at the federal/congressional level.[34] Studies such as this may help provide insight into the interventions needed to reduce the risk of morbidity onset/progression as well as efforts to reduce disparities found across insurance types and among racial/ethnic minorities. There should be continued work toward equitable access to health care and improved outcomes regardless of race/ethnicity and insurance types.

This study has several limitations that should be acknowledged. First, the *International Classification of Diseases, Ninth Revision* codes for the diagnosis of TSCI do not differentiate between a complete and incomplete spinal

cord injury as defined by the International Standards for Neurological Classification of Spinal Cord injury. This is significant because the completeness of TSCI has a pathophysiological difference relating to the functioning balance of the cardiovascular and endocrine system.[35,36] Being able to code for the completeness of injury and then using only the incomplete TSCI codes against the control cohort may be of more accurate comparison for the HRs for each of the incident cardiometabolic morbidities, as an incomplete TSCI may be less effected by autonomic dysfunction. Private health insurance is typically offered through employment, through employment of a spouse, or if they are a dependent. The beneficiaries of commercial payor insurance can be traced back to both higher income level and possibility more family support in the home setting. Finally, a limitation of this database is the lack of information regarding time since injury for this population with TSCI. The effect of length or duration of TSCI on disease is thus unknown for either cohort of patients.

A major strength of this study is the length of the study period. All patients with sufficient continuous enrollment within the period of 4 years were retained. This period length is important because it ensures that the TSCI cohort is not a mixture of acute and chronic TSCIs, but only chronic TSCIs. Moreover, we were able to merge longitudinal private and public claims data to compare health outcomes among people with TSCI across different insurance types (public vs private). Health insurance is an enabling factor, but it is not a dichotomous risk factor. Depth and generosity of coverage matter and would influence health outcomes, particularly among high-need populations.

CONCLUSION

Adults with TSCIs on Medicare have a significantly higher prevalence of and risk for developing common psychological, cardio metabolic, and musculoskeletal morbidities, compared with privately insured adults with TSCI. In addition, we found both within- and between-race disparities across and within different insurance types. There are no known risk stratification tools that account for payor type in decision-making protocols for providers that see patients with TSCIs. These findings are extremely important to inform clinical screening algorithms for mental and physical health risk factors in this higher-risk population and in the design of policy and care coordination with an emphasis on reducing of health care disparities associated with insurance types, particularly among racial/ethnic minorities.

POTENTIAL COMPETING INTERESTS

The authors report no competing interests.

SUPPLEMENTAL ONLINE MATERIAL

Supplemental material can be found online at http://www.mcpiqojournal.org. Supplemental material attached to journal articles has not been edited, and the authors take responsibility for the accuracy of all data.

Abbreviations and Acronyms: **CMS,** Centers for Medicaid and Medicare Services; **HR,** hazard ratio; **SDoH,** social determinants of health; **SMD,** standardized mean difference; **TSCI,** traumatic spinal cord injury

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