Neurologist-associated reduction in PD-related hospitalizations and health care expenditures

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ABSTRACT

Objective: To investigate the impact of neurologist care on Parkinson disease (PD)-related hospitalizations. Recent data indicate that neurologist treatment in PD may be associated with improved survival, yet is underutilized. Factors contributing to this improved survival remain unknown, but may be due in part to optimal disease treatment or avoidance of disease-related complications.

Methods: This was a retrospective cohort study of Medicare beneficiaries diagnosed with PD in 2002 and still living in 2006. Hospitalization for PD-related (neurodegenerative disease, psychosis, depression, urinary tract infection, and traumatic injury) and general medical (hypertension, diabetes, congestive heart failure, angina, and gastrointestinal obstruction) illnesses was compared by PD treating physician specialty using Cox proportional hazard models, adjusting for confounders. Secondary analyses included PD-related rehospitalization and cost stratified by frequency of neurologist care.

Results: We identified 24,929 eligible incident PD cases; 13,489 had neurologist care. There were 9,112 PD-related hospitalizations, and these occurred and recurred less often among neurologist-treated patients. Neurologist PD care was associated with lower adjusted odds of both initial and repeat hospitalization for psychosis (hazard ratio [HR] 0.71, 95% confidence interval [CI] 0.59–0.86), urinary tract infection (HR 0.74, 0.63–0.87), and traumatic injury (HR 0.56, 0.40–0.78). PD-related outcomes improved with frequency of neurologist care in a step-wise manner. Odds of general illness hospitalization or hospitalization did not differ by neurologist involvement.

Conclusions: Regular neurologist care in PD is specifically associated with lower risk of hospitalization and rehospitalization for several PD-related illnesses. This may reflect an improved ability of neurologists to prevent, recognize, or treat PD complications. *Neurology*® 2012;79:1774–1780

GLOSSARY

BASF = Beneficiary Annual Summary File; **CCI** = Charlson comorbidity index; **CI** = confidence interval; **DRG** = diagnosis-related group; **HR** = hazard ratio; **PD** = Parkinson disease; **SNF** = skilled nursing facility.

In the United States, 98% of office visits for evaluation and management of elderly patients with Parkinson disease (PD) are performed by physicians with specialist training in internal medicine, family practice, geriatric medicine, or neurology.¹ We recently reported that only 48% of patients with incident PD had a neurologist involved in their PD care over the initial 48-month postdiagnosis period, and that those who had neurologist care had a lower 1-year risk of hip fracture or skilled nursing facility (SNF) care and were less likely to die over a 6-year observation period.¹ Although survival is a tangible and unequivocal outcome measure for PD, other PD-related events lead to reductions in quality of life and need for long-term care. Morbidity and mortality in PD are not solely associated with the dopa-responsive motor

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Study funding: Supported primarily by the National Center for Research Resources and National Institutes of Health Roadmap for Medical Research (UL1RR024992, KL2RR024994). Other support: National Institute of Neurological Disorders and Stroke at the National Institutes of Health (5T32NS007205–27); the St. Louis Chapter of the American Parkinson Disease Association; the American Parkinson Disease Association, Walter and Connie Donius; and the Robert Renschen Fund.

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manifestations. Nonmotor manifestations such as cognitive impairment/dementia, depression, psychosis, and dysautonomia (which predisposes to urinary tract infection and syncope) contribute to morbidity, pose challenges for clinicians, and can be made worse by the medication regimen. Cardiovascular disease and infection are the most common reasons for hospitalization of patients with terminal PD.² Yet falls with injury, infection, depression, and psychosis also contribute to acute hospitalization in PD.^{3–6} We have used Medicare data to investigate these intermediate outcomes, and examined the potential impact of neurologist care on hospital admissions for PD-related conditions. We hypothesized that greater familiarity with neurologic disease gained from specialty training would result in reduced disease-related morbidity and improved outcomes.

METHODS **Standard protocol approvals, registrations, and patient consents.** This study was approved by the Human Research Protection Office at Washington University School of Medicine.

Study population. The study population was derived from 100% Medicare part A and B outpatient and carrier claims data from the year 2002. All beneficiaries with a claim containing the International Classification of Diseases–9 code “332.0” were extracted for further analysis. Incident cases were identified using previously published methods.⁷ Beneficiaries who had concurrent diagnostic claims for “Secondary Parkinsonism” (332.1) or “Other Degenerative Diseases of the Basal Ganglia” (333.0), beneficiaries who were nursing home residents at the time of initial diagnosis (as indicated in the “place of service” variable),^{8,9} and those who died prior to January 1, 2006, were excluded.

Individual demographic, comorbidity, and residential data were extracted from Medicare Beneficiary Annual Summary Files (BASFs). Demographic data included subject race, sex, and date of birth. Baseline clinical data on comorbid illness, defined as the presence of diabetes, dementia, malignant solid tumor (lung, colon/rectum, breast, prostate, uterine), ischemic heart disease, chronic obstructive pulmonary disease, cerebrovascular disease, acute myocardial infarction, chronic kidney disease, or congestive heart failure, were used to calculate an age-weighted Charlson comorbidity score.¹⁰ County of residence was linked to a previously developed socioeconomic deprivation score, comprised of census-based socioeconomic data: % high school graduate, % population unemployed, % population living in a crowded house, % population without a car, % population without a telephone, and % population below the federal poverty rate, weighted to reflect the community-level factors that may impact access to specialty care.¹¹

PD physician specialty. We used provider identification codes to determine the treating physician specialty for each medical claim. Three neurologist involvement categories—“infrequent” (no outpatient neurologist PD visits), “intermediate”

(1–5 neurologist outpatient PD visits), and “frequent” (more than 5 outpatient neurologist PD visits)—were created based on tertiles of the natural distribution of care over the 48-month observation period. The total number of outpatient PD visits, regardless of provider specialty, was calculated and included as a covariate in all analyses.

Hospitalization patterns according to neurologist frequency of care. We hypothesized that persons with PD who received regular neurologist care would be less likely to be hospitalized for PD-related conditions compared to those who saw a neurologist infrequently for PD care. Hospitalization data were extracted for all patients from 2002 until December 31, 2005, using BASFs, which also contain diagnosis-related group (DRG) codes for each of the first 10 hospitalizations per year for each beneficiary. DRG codes are used to identify the principal diagnosis for a hospitalization for the purpose of standardizing billing and payments nationwide. We created DRG-based categories for hospitalization, choosing to examine 5 commonly reported disease-mediated or related medical conditions (referred to as “PD-related”) that may require hospitalization: psychosis, neurodegenerative disease, urinary tract infection, traumatic injury, and depression. These conditions were chosen a priori based on a review of the literature and our team’s extensive clinical experience managing PD. The inclusion of hospitalization for depressive neuroses, the most commonly reported psychiatric illness in PD,^{12–16} is straightforward. The other PD-related outcomes chosen deserve further explanation. Dysautonomia commonly produces bladder and bowel symptoms in PD (often prior to the classic tremor, slowness, shuffling, and poverty of movement), predisposing those with PD to urinary tract infection. Moreover, urinary tract infection has been shown to have an atypical presentation in PD: symptoms such as acute change in motor benefit from medications, confusion, and worsening of motor symptoms are common, as opposed to the urinary urgency, urinary frequency, and dysuria which are reported in typical urinary tract infections.^{3–5,17} Psychosis in PD may be due to the disease itself, and occurs with increasing frequency as the disease progresses.^{18–23} In a newly diagnosed patient with PD, however, psychosis is more likely secondary to PD medication regimen or polypharmacy. Therefore, we hypothesized that in this incident cohort, hospitalization patterns for psychosis may provide information on both adverse drug events risk and allow us to indirectly assess the baseline distribution of disease severity by physician specialty. Traumatic injury in the elderly, similar to hip fracture, is most likely due to falls. Fall prevention in PD relies on optimal motor management as well as appropriate use of physiatrist and rehabilitation services. We included the DRG code for “neurodegenerative disease” to determine if DRG coding for PD-related hospitalizations differed by physician specialty; i.e., if neurologist-treated patients were assigned a hospitalization code for “neurodegenerative disease” by default. For comparison, we extracted hospitalization data for 5 common general medical conditions that would trigger a hospitalization not likely to be prevented by neurologist care: angina pectoralis, diabetes mellitus, hypertension, gastrointestinal obstruction, and congestive heart failure.

Because initial hospitalization for a complication may be in part due to baseline patient health or disease severity rather than physician knowledge, training, or skill, we further hypothesized that neurologist care would also be associated with a lower likelihood of repeat hospitalization for PD-related illnesses, and compared the risk of additional hospitalization by neurologist treatment category, adjusting for the same confounders.

Table 1 Study cohort baseline characteristics

Characteristics	Frequency of neurologist care ^a			
	Infrequent (n = 11,440)	Intermediate (n = 5,409)	Frequent (n = 8,085)	Total (n = 24,929)
Race, n (%)				
White	10,097 (88.3)	4,909 (90.7)	7,597 (94.0)	22,598 (90.6)
Black	851 (7.4)	297 (5.5)	251 (3.1)	1,399 (5.6)
Hispanic	329 (2.9)	145 (2.7)	164 (2.0)	638 (2.6)
Asian	163 (1.4)	58 (1.1)	73 (0.9)	294 (1.2)
% Male	38.0	41.3	49.5	42.5
Age, y, mean (SD)	78.3 (6.2)	76.8 (5.7)	75.9 (5.4)	77.2 (5.9)
Charlson comorbidity score, mean (SD)	3.36 (0.70)	3.23 (0.66)	3.13 (0.67)	3.26 (0.67)
Socioeconomic				
% With bachelor degree or higher ^b	22.4	23.1	23.8	22.9
Median household income (2000 dollars) ^b	\$41,859.32	\$42,545.22	\$43,606.80	\$42,576.10
% Urban = population >250,000 ^c	75.7	78.4	81.0	76.5

^a Infrequent = 0 outpatient neurologist visits for Parkinson disease over 4 years; intermediate = 1–4 outpatient neurologist visits for Parkinson disease over 4 years; frequent = 5 or more outpatient neurologic visits for Parkinson disease over 4 years.

^b Based on US Census 2000 county-level data.

^c Based on the United States Department of Agriculture's Rural-Urban Continuum Classification system.

Finally, BASFs also contain cost data grouped by service type (outpatient, physician, inpatient, SNF, durable medical equipment, and home health) and yearly utilization data (number of hospitalizations, physician office visits, and covered SNF days). Total and subcategory cost and utilization data for 2002–2005 were extracted from these files for this cohort and compared by neurologist treatment category.

Statistical analyses. Descriptive analyses performed on the cohort included the following: race, sex, age, physician specialty, and urban/rural residence classification. Cox proportional hazard models were used to explore the association of neurologist care frequency with the likelihood of PD-related and general medical illness hospitalizations. The time-to-event variable for each outcome was from the beginning of the study in 2002 until the first event occurrence (measured in years). Patients with no events were censored at the end of calendar year in 2005. Covariates included race, sex, age, socioeconomic deprivation, modified Charlson comorbidity index (CCI) score, and total number of outpatient PD visits. Primary models compared the “frequent” neurologist care category to the reference “infrequent” category. Additional analyses to evaluate for a dose-dependent reduction in PD-related hospitalization included the intermediate category of neurologic PD care in the Cox model. Finally, the risk of repeat hospitalization for each PD-related outcome was compared across neurologist treatment categories using logistic regression, adjusting for all previously indicated covariates. Means of continuous variables were compared by *t* test or analysis of variance. Proportions were evaluated using χ^2 tests. Logistic regression coefficients were converted to odds ratios with 95% confidence intervals (CIs) using standard methods. All statistical tests were 2-sided, with the statistical significance level set

at 0.05, and with 95% CIs where appropriate. Statistical analyses were performed using SAS v.9.2, PASW v.16 and 17.

RESULTS Subject demographics and baseline characteristics. We identified 24,929 independently living beneficiaries with an incident PD diagnosis in 2002 who were still living on January 1, 2006. A greater proportion of Medicare recipients with PD who received frequent neurologist services were white or male and were slightly younger than Medicare recipients with PD who had infrequent neurologist care. The mean age-weighted modified Charlson comorbidity score differed slightly between those with infrequent and frequent neurologist PD care, 3.36 ± 0.70 vs 3.13 ± 0.67 . The absolute differences in individual socioeconomic and geographic variables between those with frequent, intermediate, and infrequent neurologist care were also small (table 1).

Hospitalization patterns. During the 48-month observation period, 5,318 (21.3%) patients with PD had at least 1 hospitalization for a PD-related illness. Adjusting for patient race, age, sex, modified Charlson comorbidity score, and socioeconomic deprivation, those with regular neurologist care had lower adjusted odds of being hospitalized for some PD-related illnesses: psychosis (hazard ratio [HR] 0.71, 95% CI 0.59–0.86), traumatic injury (HR 0.56, 95% CI 0.40–0.78), and urinary tract infection (HR 0.74, 95% CI 0.63–0.87) (table 2). There was no compensatory increased risk of hospitalization for neurodegenerative disease, nor was there an increase in risk of hospitalization for depression. The association between neurologist care and reduced risk of hospitalization appeared to be specific for PD-related comorbidities, as there was no difference in likelihood of hospitalization for the following common medical conditions across neurologist frequency groups: diabetes (HR 0.76, 95% CI 0.53–1.08), hypertension (HR 1.02, 95% CI 0.70–1.5), gastrointestinal obstruction (HR 1.01, 95% CI 0.76–1.30), congestive heart failure (HR 1.05, 95% CI 0.86–1.28), or angina (HR 1.10, 95% CI 0.75–1.62). Sensitivity analyses which included only those who had seen a neurologist at least once (for diagnosis confirmation) produced very similar results for both PD-related and general medical illnesses, without change in direction or magnitude of the observed associations.

Repeat hospitalization. There were 1,433 repeat hospitalizations for PD-related illnesses in our cohort. Regular neurologist care was associated with a reduction in the likelihood that a person with PD would undergo more than 1 hospitalization for psychosis (adjusted odds ratio [OR] 0.41, 95% CI 0.33–0.51). The reduction in risk for repeat hospitalization for urinary tract infection (ad-

Table 2 Odds of hospitalization according to frequency of neurologist care

DRG-based illness category	No. (%) of hospitalizations according to neurologist frequency				Adjusted odds of hospitalization with increasing outpatient neurologist care, HR (95% CI) ^a	
	Infrequent	Intermediate	Frequent	Total	Intermediate	Frequent
PD-related						
Neurodegenerative disease	1,234 (3.4)	639 (3.8)	1074 (4.9)	2,947	1.09 (0.98–1.22)	0.96 (0.85–1.08)
Psychosis	1,900 (5.2)	764 (4.5)	649 (2.9)	3,313	0.87 (0.76–1.01)	0.71 (0.59–0.86) ^b
Depression	75 (0.20)	40 (0.24)	41 (0.18)	156	0.75 (0.41–1.39)	0.87 (0.41–1.89)
Urinary tract infection	1,267 (3.5)	486 (2.9)	477 (2.2)	2,230	0.87 (0.76–0.98) ^c	0.74 (0.63–0.87) ^b
Traumatic injury	246 (2.2)	96 (1.8)	99 (1.2)	441	0.86 (0.67–1.11)	0.56 (0.40–0.78) ^b
General medical						
Angina	121 (0.33)	77 (0.46)	72 (0.32)	270	1.34 (0.98–1.85)	1.10 (0.75–1.62)
Diabetes	265 (0.72)	130 (0.77)	118 (0.53)	513	0.90 (0.69–1.17)	0.76 (0.53–1.08)
Hypertension	169 (0.46)	80 (0.47)	97 (0.44)	346	1.15 (0.85–1.58)	1.02 (0.70–1.50)
Gastrointestinal obstruction	402 (1.10)	149 (0.88)	229 (1.03)	780	0.90 (0.71–1.11)	1.01 (0.76–1.30)
Congestive heart failure	990 (2.7)	445 (2.6)	529 (2.4)	1,964	0.92 (0.78–1.10)	1.05 (0.86–1.28)

CI = confidence interval; DRG = diagnosis-related group; HR = hazard ratio; PD = Parkinson disease.

^a Calculated using a Cox proportional hazard model with infrequent neurologist care as the reference category, adjusting for patient race, age, sex, socioeconomic deprivation, score, and modified Charlson comorbidity index.

^b $p < 0.001$.

^c $p < 0.01$.

justed OR 0.50, 95% CI 0.35–0.71) was similar (table 3). There was no difference in the risk of repeat hospitalization for traumatic injury. Similar to our primary data, no difference in repeat hospitalization risk was found across neurologist treatment groups for hospitalization due to neurode-

generative disease, depression, or for the general medical illnesses we examined.

Utilization and cost patterns. Total cost for PD patient care in our cohort was \$1.48 billion during the 4-year observation period (\$59,530 per person).

Table 3 Disparity in repeat hospitalization for PD-related illness by neurologist involvement in PD care

DRG-based illness category	No. (%) of repeat hospitalizations (2002–2005) according to neurologist frequency				Adjusted odds of repeat hospitalization with increasing outpatient neurologist care, HR (95% CI) ^a	
	Infrequent	Intermediate	Frequent	Total	Intermediate	Frequent
PD-related						
Neurodegenerative disease	174 (17.7)	86 (16.6)	145 (16.6)	405	1.02 (0.77–1.36)	1.2 (0.95–1.54)
Psychosis	408 (45.7)	161 (40.8)	131 (35.5)	700	0.72 (0.58–0.88) ^b	0.41 (0.33–0.51) ^b
Depression	7 (10.3)	3 (8.1)	4 (10.8)	14	1.47 (0.35–6.23)	1.43 (0.37–5.56)
Urinary tract infection	172 (17.1)	69 (17.6)	48 (11.5)	289	0.96 (0.70–1.30)	0.50 (0.35–0.71) ^b
Traumatic injury	15 (6.1)	5 (5.2)	5 (5.1)	25	0.61 (0.20–1.89)	0.53 (0.18–1.51)
General medical						
Angina	121 (0.33)	77 (0.46)	72 (0.32)	270	1.34 (0.98–1.85)	1.10 (0.75–1.62)
Diabetes	265 (0.72)	130 (0.77)	118 (0.53)	513	0.90 (0.69–1.17)	0.76 (0.53–1.08)
Hypertension	169 (0.46)	80 (0.47)	97 (0.44)	346	1.15 (0.85–1.58)	1.02 (0.70–1.50)
Gastrointestinal obstruction	402 (1.10)	149 (0.88)	229 (1.03)	780	0.90 (0.71–1.11)	1.01 (0.76–1.30)
Congestive heart failure	990 (2.7)	445 (2.6)	529 (2.4)	1,964	0.92 (0.78–1.10)	1.05 (0.86–1.28)

Abbreviations: DRG = diagnosis-related group; HR = hazard ratio; PD = Parkinson disease.

^a Calculated using a Cox proportion hazard model with infrequent neurologist care as the reference category, adjusting for patient race, age, sex, socioeconomic deprivation, score, and modified Charlson comorbidity index.

^b $p < 0.001$.

Table 4 Variation in health care utilization and aggregate cost by frequency of neurologist care (2002–2005)

Service utilization	Neurologist care frequency category			
	Infrequent (n = 11,440)	Intermediate (n = 5,404)	Frequent (n = 8,085)	Overall (n = 24,929)
Hospitalizations, mean (SD)	3.21 (2.89)	3.13 (2.73)	2.73 (2.30)	3.04 (2.69)
Outpatient physician office visits, mean (SD)	20.64 (21.32)	23.37 (23.35)	22.05 (20.45)	21.69 (21.53)
Skilled nursing facility days, ^a mean (SD)	27.51 (49.44)	21.28 (42.20)	15.21 (33.60)	21.17 (43.63)
Cost by service type (2002–2005) (per person in US dollars), mean (SD)				
Physician fees	14,420 (11,590)	16,366 (14,178)	16,738 (11,550)	15,594 (12,233)
Inpatient	25,160 (29,062)	25,160 (27,174)	22,179 (24,278)	24,193 (27,216)
Outpatient fees	5,320 (7,991)	6,241 (9,622)	6,158 (9,462)	5,819 (9,329)
Medical equipment	2,070 (5,136)	1,871 (5,066)	1,455 (3,250)	1,828 (4,600)
Skilled nursing facility	9,227 (16,852)	7,222 (14,261)	5,420 (12,058)	7,558 (14,978)
Home health	4,150 (9,270)	4,241 (8,491)	3,618 (6,756)	3,997 (8,362)
Hospice	693 (6,869)	598 (5,916)	292 (3,726)	540 (5,811)
Total	60,348 (52,835)	60,715 (48,154)	54,863 (42,682)	58,989 (49,627)

^a Medicare-covered skilled nursing facility days.

Medicare-covered SNF days and hospitalizations were inversely related to neurologist involvement in PD care: there were an average of 27.5 (± 49.4) SNF days and 3.2 (± 2.9) hospitalizations among those in the infrequent neurologist treatment category and 15.2 (± 33.6) SNF days and 2.73 (± 2.3) hospitalizations among those in the frequent neurologist treatment category (each, $p < 0.01$, t test). Similarly, per person expenditures for inpatient, durable medical equipment, SNF, home health, and hospice care services were lowest for those with the most frequent neurologist care (table 4).

DISCUSSION In this study, we investigated specific health outcomes and cost associated with neurologist care in incident PD. Our data suggest that consistent neurologist care is associated with a reduced risk of hospitalization, specific to PD-related complications. In our recent study of specialist treatment in PD, we found increased survival in those who had neurologist care.²⁴ These study findings are consistent with our previous study and further suggest that prevention of PD-related complications requiring hospitalization may help explain a portion of the improved survival among PD cases treated by neurologists.

The potential reasons that regular neurologist care is associated with reduced risk of PD-related hospitalization are numerous and require careful consideration. As a result of their training, neurologists have greater knowledge of the autonomic dysfunction that is highly prevalent in PD, particularly that involving the bladder, which greatly predisposes patients with PD to urinary tract infection.^{25–29} In PD, clues to a

subacute urinary tract infection may be unfamiliar to a primary care physician, and may include an increase in PD motor symptoms or worsening of motor fluctuations (which may be mistaken for disease progression), psychosis, and confusion.²⁶ Early detection of these infections prior to the need for hospitalization due to knowledge of disease pathophysiology, increased screening for atypical infection symptoms, and patient education about the unique presentation of infection in PD may account for the differences in hospitalization rates for urinary tract infections found in this study. Neurologists may also be more comfortable managing such infections as an outpatient, using confidence also gained by training and experience. In contradistinction, generalists may correctly identify infection at an early stage but feel more comfortable treating a patient with PD in the hospital, especially if outpatient neurologic care is less available. Future studies that use accepted clinical and laboratory diagnostic standards to survey infection rates and screening practices and examine the distribution of infection severity and outcomes across patient and physician strata may clarify these observations.

Psychosis in incident PD can represent disease manifestation or an iatrogenic complication of treatment. Neurologist-treated patients may have a lower risk of iatrogenic psychosis due to physician understanding of the interaction between CNS-acting or CNS-penetrating medications in the elderly and heightened screening and outpatient treatment of psychosis and confusion. The finding that regular

neurologist care is also associated with reduced repeat hospitalization for psychosis suggests that differences in prevention, recognition, and treatment of psychosis likely account for the differences in hospitalization risks. Our finding of no relative increase in hospitalization for depression is expected, as primary care physicians are very familiar with screening for and outpatient treatment of depression in the elderly.

Although our primary analysis of frequent vs infrequent neurologist care demonstrates an association of neurologist care with the outcome variables, we also found a stepwise reduction in risk of hospitalization for psychosis, urinary tract infection, and traumatic injury with neurologist care, even after adjusting for multiple potential confounders, including the number of PD outpatient visits performed by a primary care physician. While potentially evidence of a “dose response” or causal relationship between neurologist care and improved outcomes in PD, these preliminary data may better be interpreted as evidence that frequent neurologist care is important even in the first years after diagnosis. This study also provides some evidence supporting the American Academy of Neurology PD quality measures recommending yearly neurologist visits.³⁰

There are several important limitations to our study, which utilized administrative data. In comparison to a randomized controlled trial, which has minimal differences between study groups (high internal validity), but has significant overall selection bias and limited generalizability (low external validity), this retrospective observational study is representative of actual health care practices, but also may be prone to nuisance effects of between-group differences. We attempted to control for demographic, clinical, and socioeconomic factors that may influence the utilization of neurologist care. However, there are several variables for which we could not control but which likely influence whether a person with PD seeks or receives regular neurologist care: PD motor phenotype, treating physician experience, personal health behaviors, or beliefs. It is also possible that some patients were too ill, due to either advancing PD or comorbid disease, to obtain consistent care from a neurologist. Our cost data may provide evidence of this potential bias. The lower selected health care expenditures for neurologist-treated patients with PD we observed could be interpreted as evidence of optimal care in neurologist-treated patients with PD. Alternatively, the lower cost could just as easily be interpreted as evidence of confounding by health state, with higher costs and services required by those with more severe PD symptoms. Future research will be needed to understand how PD severity influences

referral patterns and how differences in treatment paradigms between primary care physicians and neurologists influence these outcomes.

We adjusted for comorbid illnesses using the CCI, the standard index applied in research. The 0.2-point difference in comorbidity score we observed between the most and least frequently treated groups is well below the reported threshold (1–2 points) for an increase in mortality.³¹ However, the CCI contains diseases such as AIDS, which is not common in an elderly population, and malignancy, which is less common among those with PD. It is therefore possible that a PD-specific comorbidity index would improve the precision of this and future PD outcomes studies. Furthermore, a comorbidity score based on mortality data may not adequately adjust for comorbid impact on intermediate outcomes such as those we have studied. Again, considering how confounding by health state may influence our observations, it is also possible that comorbid severity may impact the use of specialty care in PD and also influence cost and outcomes. Future studies will examine the impact of comorbid disease burden on specialty utilization patterns, cost, and overall health care quality in PD.

Although we excluded those with concomitant diagnoses for the much rarer and faster progressing Parkinson plus syndromes, studies consistently show at least a 10% diagnostic error rate.³² Nonrandom distribution of these cases could alter our findings. Finally, between-group differences in unknown variables may explain some of the results we obtained. In spite of these limitations, this study identifies important PD-associated comorbidities that could be targeted to improve outcomes in the Medicare population. Regular neurologist care may prove to be an important disease-modifying intervention for patients with PD should these data be confirmed with long-term studies including more detailed assessment of comorbid disease severity, adjustment for disease progression, quality of life, and functional assessment.

AUTHOR CONTRIBUTIONS

Dr. Allison Wright Willis performed primary data analysis and primary authorship of the manuscript. Dr. Willis had full access to and takes full responsibility for the accuracy of the data. Dr. Mario Schootman provided study design input and manuscript review. Ms. Rebecca Tran provided data processing and manuscript revision. Dr. Nathan Kung provided data processing and manuscript revision. Dr. Bradley Evanoff provided input for study design and manuscript revision. Dr. Joel Perlmutter provided study design input and manuscript review. Dr. Brad Racette provided study design input and manuscript review.

DISCLOSURE

A. Willis receives research support from the NIH, the American Parkinson Disease Association, St. Louis Chapter, Walter and Connie Donius, and The Robert Renschen Fund. M. Schootman receives research support from the NIH. R. Tran and N. Kung report no disclosures. B. Evanoff

receives support from the NIH and has served as a paid consultant for Monsanto and Concentra Health Care. J. Perlmutter serves on the scientific advisory boards of the American Parkinson Disease Association, Dystonia Medical Research Foundation, Missouri Chapter of the Dystonia Medical Research Fund, and Greater St. Louis Chapter of the APDA; serves as an editorial board member of *Neurology*[®]; received honoraria from Ceregene for travel to lecture; received honoraria from Parkinson Disease Study Group for grant reviews; received partial fellowship support for fellows from Medtronic Inc; and receives research support from the NIH, the Huntington Disease Society of American Center of Excellence, Michael J. Fox Foundation, HiQ Foundation, McDonnell Center for Higher Brain Function, Greater St. Louis Chapter of the American Parkinson Disease Association, American Parkinson Disease Association, Bander Foundation for Medical Ethics and Advanced PD Research Center at Washington University, and the Barnes Jewish Hospital Foundation. B. Racette received research support from Teva, Eisai, and Solvay; receives research support from Schwarz, Solstice, Eisai, Allergan, and Neurogen; and received research support from the NIH, BJHF/ICTS [Neuropathology of Chronic Manganese Exposure" (PI)], and the Michael J. Fox Foundation. **Go to Neurology.org for full disclosures.**

Received November 30, 2011. Accepted in final form June 12, 2012.

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