Expenditures in the elderly with peripheral neuropathy

Where should we focus cost-control efforts?

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Summary

To optimize care in the evaluation of peripheral neuropathy, we sought to define which tests drive expenditures and the role of the provider type. We investigated test utilization and expenditures by provider type in those with incident neuropathy in a nationally representative elderly, Medicare population. Multivariable logistic regression was used to determine predictors of MRI and electrodiagnostic utilization. MRIs of the neuroaxis and electrodiagnostic tests accounted for 88% of total expenditures. Mean and aggregate diagnostic expenditures were higher in those who saw a neurologist. Patients who saw a neurologist were more likely to receive an MRI and an electrodiagnostic test. MRIs and electrodiagnostic tests are the main contributors to expenditures in the evaluation of peripheral neuropathy, and should be the focus of future efficiency efforts.

Medical societies, including the American Academy of Neurology (AAN), are working proactively to address health care inefficiencies through efforts to identify specific tests that are unnecessary or unwarranted in common clinical scenarios.^{1,2} Such efforts need to be informed regarding aggregate expenditures associated with individual tests so that the focus can be on high-impact tests.³ Identifying these high-impact tests in the evaluation of peripheral neuropathy is particularly important because it is a highly prevalent disease encountered by many provider types.⁴⁻⁷ However, the optimal

University of Michigan (BC, JB, AR, RM, KML, EF, KK); VA Center for Clinical Management Research (JB, KML); and Institute for Social Research (KML), Ann Arbor.

Funding information and disclosures are provided at the end of the article. Full disclosure form information provided by the authors is available with the **full text of this article at Neurology.org/cp.**

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diagnostic testing algorithm for this condition is unknown. While peripheral neuropathy comprises many different subtypes that may affect what constitutes appropriate testing, the vast majority of patients have a distal symmetric polyneuropathy.⁸ Recently, the AAN published a systematic review of diagnostic testing in distal symmetric polyneuropathy, and found evidence to support routine testing with serum protein electrophoresis (SPEP), B₁₂, fasting glucose test, and glucose tolerance test (GTT).⁸ However, the strength of the evidence is modest (Class C), and the review does not address other commonly ordered tests for this condition, including MRIs of the neuroaxis and electrodiagnostic tests. More work is needed to establish what should constitute a clinically effective evaluation of peripheral neuropathy, and efficiency efforts should focus on the high-impact tests that drive expenditures.³

Given the limited available evidence, it is not surprising that a survey found that physicians order many costly tests at the time of peripheral neuropathy diagnosis and also have substantial variation in evaluation patterns.⁵ Interestingly, high-cost, low-yield tests such as MRIs of the neuroaxis are frequently ordered (23.2%), whereas low-cost, high-yield tests like glucose tolerance tests are rarely ordered (1%).⁹ Furthermore, neurologists report that they would order more tests than internists when presented with the same clinical vignettes of distal symmetric polyneuropathy.⁵ Specifically, neurologists reported the increased utilization of laboratory and electrodiagnostic testing, but not MRIs of the brain or spinal cord, which internists indicated that they would order more often. However, the actual utilization of diagnostic testing and expenditures in patients with peripheral neuropathy who see a neurologist compared to those who see other provider types is unknown.

The purpose of this study was to determine the tests that have the largest effect on expenditures in patients with a new diagnosis of peripheral neuropathy within a nationally representative sample of patients aged 65 or over. In addition, we wanted to explore the differences in test utilization and expenditures by medical specialty to inform future physician intervention efforts aimed at improving this evaluation.

METHODS

Population

We used data from biennial interviews between 1998 and 2006 of the Health and Retirement Study (HRS) linked with Medicare Standard Analytic File data from 1997 to 2007, and the Dartmouth Hospital Referral Region (HRR) data (<http://www.dartmouthatlas.org>). These linked data provide rich demographic detail from the HRS, detailed health care utilization data from Medicare claims, and regional practice patterns from the Dartmouth HRRs. We identified individuals with incident peripheral neuropathy diagnosed between 1998 and 2007, as previously described.⁹ We defined an incident diagnosis in persons who had an International Classification of Diseases (ICD)–9 code of peripheral neuropathy in a Medicare claim and no previous neuropathy diagnosis during the preceding 30 months. We included all ICD–9 codes for peripheral neuropathy (354.5, 356.0–9, and 357.0–9). We included individuals who were at least 65 years old (30 months before diagnosis), were continuously enrolled in Medicare parts A and B fee-for-service from 30 months preceding the index

diagnosis through 6 months following the index diagnosis, and completed an HRS interview within 3 years prior to the diagnosis date.

Standard protocol approvals, registrations, and patient consents

The University of Michigan institutional review board approved this study.

Demographics/health measures

HRS data were used to obtain information on age, sex, race/ethnicity, education, and limitations in activities of daily living (ADLs), and to determine HRR region based on zip code. To identify patients with pain, we recorded the answer to the HRS question “Are you often troubled with pain?” during the HRS interview just prior to incident neuropathy diagnosis. The Medicare claims database provided the diabetes status of patients based on the following Chronic Condition Warehouse definition: 2 outpatient or Carrier claims with diabetes diagnostic codes (249.X, 250.X, 357.2, 362.01, 362.02, or 366.31) during the 24 months prior to the diagnostic period (time period from 6 months prior to 6 months after the neuropathy diagnosis), or at least one inpatient, skilled nursing, or home health claim with a diabetes diagnostic code.¹⁰ If and when a patient was evaluated by a neurologist was determined using Medicare claims to search for physician office visits with a neurology provider indicated as the specialty type within the diagnostic period. Using the Dartmouth HRR data, we calculated inpatient expenditures during the last 6 months of life, by HRR and year. A geographic expenditure indicator was calculated by separating patients into quartiles of HRR expenditures during the last 6 months of life in the year in which they were diagnosed with neuropathy. We also calculated a personal baseline expenditure indicator by summing all expenditures during the 12 months prior to the diagnostic period and categorizing patients by quartiles. Limitations in ADLs (bathing, eating, dressing, walking across a room, and getting in or out of bed) were used to determine the degree of disability. Moderate disability was defined as one limitation in an ADL, and severe disability was defined as 2 or more limitations in ADLs.

Diagnostic tests

We used Current Procedural Terminology codes to identify diagnostic tests in the Medicare claims. We selected tests based on their relevance to the diagnostic evaluation of peripheral neuropathy and included fasting glucose level, hemoglobin A1C (HA1C), GTT, SPEP, B₁₂, antinuclear antibodies (ANA), erythrocyte sedimentation rate (ESR), thyroid-stimulating hormone (TSH), complete blood count (CBC), comprehensive metabolic panel, electrodiagnostic tests, and MRI studies (brain, cervical, thoracic, or lumbosacral spine).

Medicare expenditures

We estimated Medicare payments (technical and professional components) by using the publicly available Centers for Medicare and Medicaid Services (CMS) 2012 national payment amounts for MRIs and electrodiagnostic tests (<http://www.cms.gov/apps/physician-fee-schedule>). For laboratory tests, we used the 2012 national limit payment amounts from the publicly available CMS clinical laboratory fee schedule (<http://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/ClinicalLabFeeSched>). Test-specific expenditures were calculated by adding all payments from the diagnostic tests listed above. Total aggregate expenditures were calculated by adding all payments from the diagnostic tests for all patients.

Statistical analysis

We used *t* tests to compare normally distributed continuous variables for those who saw a neurologist vs those who did not (unpaired) and for comparing continuous variables for patients before and after their first neurology provider visit (paired). The χ^2 tests (unpaired) and McNemar tests (paired) were used to analyze categorical variables. Multivariable logistic regression models were developed to determine the association of neurology providers on the dependent variables electrodiagnostic and MRI utilization after adjusting for

Table 1 Demographic and clinical variables in patients with neuropathy

Measure	No. (%), unless otherwise specified (n = 1,031)
Age at index date, y, mean (SD)	77.6 (6.8)
Male	474 (46.0)
Race/ethnicity	
Hispanic	82 (8.0)
Non-Hispanic Caucasian/other	822 (79.7)
Non-Hispanic African American	127 (12.3)
Education	
Less than high school graduation	338 (32.8)
High school	342 (33.2)
At least some college	351 (34.0)
Diabetes (30–6 months pre index date)	428 (41.5)
Diabetic complications (non-neurologic)	168 (16.3)
ADL limitations	
0	719 (69.8)
1	164 (15.9)
2–5	147 (14.3)

Abbreviation: ADL = activities of daily living.

demographics, health status including disability, a geographic expenditure indicator, and a personal baseline expenditure indicator. We calculated an overall concordance statistic (*c* statistic) in order to assess the predictive ability of the adjusted models. All analyses were performed with SAS 9.1 (Cary, NC).

RESULTS

Population

During the 10-year study period, an incident ICD-9 diagnosis of peripheral neuropathy was observed in 1,031 of the 8,783 (11.7%) patients. Demographic and other characteristics of the population are summarized in table 1. Mean age of the population was 77.6 years and 54.0% were female. Twelve percent were non-Hispanic black, 8.0% were Hispanic, 41.5% had diabetes, and 16.3% had diabetic complications. Thirty-six percent (n = 374) saw a neurology provider during the diagnostic period.

Test utilization

Patients who saw a neurologist received a mean (SD) of 11.1 (8.1) of the relevant tests compared to 7.2 (6.7) tests in those who did not see a neurologist ($p < 0.0001$). Laboratory tests endorsed by the AAN guideline (fasting glucose, B₁₂, SPEP, GTT) were more commonly ordered in patients seen by a neurologist with the exception of fasting glucose, which had similar utilization between provider types (table 2). The 3 tests with the largest absolute difference in utilization between patients seen by neurologists and non-neurologists were nerve conduction studies (50% vs 17%, $p < 0.0001$), MRIs of at least one component of the neuroaxis (45% vs 13%, $p < 0.0001$), and EMG (37% vs 10%, $p < 0.0001$). Laboratory tests, including ANA, ESR, TSH, CBC, and comprehensive metabolic panels, were utilized more often among those who saw a neurologist with the exception of HA1C.

Table 2 Test utilization by provider type

Test	Neuropathy subjects without a neurology provider, n (%) (total = 657)	Neuropathy subjects with a neurology provider, n (%) (total = 374)	p Value
EMG	65 (10)	139 (37)	<0.0001
Nerve conduction study	111 (17)	186 (50)	<0.0001
Any MRI	87 (13)	168 (45)	<0.0001
Brain MRI	23 (4)	118 (32)	<0.0001
Cervical spine MRI	16 (2)	41 (11)	<0.0001
Thoracic spine MRI	10 (2)	12 (3)	0.07
Lumbosacral spine MRI	52 (8)	65 (17)	<0.0001
ANA	41 (6)	73 (20)	<0.0001
ESR	134 (20)	159 (43)	<0.0001
SPEP	44 (7)	90 (24)	<0.0001
TSH	336 (51)	225 (60)	<0.01
GTT	2 (0)	7 (2)	<0.01
B ₁₂	154 (23)	179 (48)	<0.0001
Fasting glucose	146 (22)	89 (24)	0.56
CBC	457 (70)	289 (77)	<0.01
CMP	333 (51)	212 (57)	0.06
HA1C	289 (44)	148 (40)	0.17

Abbreviations: ANA = antinuclear antibody; CBC = complete blood count; CMP = comprehensive metabolic panel; ESR = erythrocyte sedimentation rate; GTT = glucose tolerance test; HA1C = hemoglobin A1C; SPEP = serum protein electrophoresis; TSH = thyroid-stimulating hormone.

Expenditures associated with tests

Total aggregate diagnostic expenditures in the neuropathy population were \$497,544, with a mean of \$483 per patient. MRIs of the neuroaxis accounted for 46% (\$228, 026) of total testing expenditures. Electrodiagnostic tests accounted for an additional 42% (\$209, 639). Laboratory tests, considered in aggregate, accounted only for 12% (\$59,879). MRIs and electrodiagnostic tests were the dominant contributors to expenditures both in patients seen by neurologists (92%) and in patients not seen by neurologists (81%). Both mean test-specific expenditures and total aggregate expenditures were higher in those seen by a neurology provider compared with those not seen by a neurology provider (\$849 vs \$274, $p < 0.0001$; \$317,526 vs \$180,018, $p < 0.0001$) (table 3). Of note, in the 374 patients with a neurology provider, a mean (SD) of 7.3 (5.8) tests were completed after the neurology visit, compared to 3.9 (4.9) before this visit, and most test-specific expenditures occurred after the neurology visit (\$652 per patient vs \$197).

Predicting test utilization

In an adjusted model, neurology provider (odds ratio [OR] = 5.30, 95% confidence interval [CI] 3.87–7.26), diabetes (OR = 0.63, 95% CI 0.46–0.87), age (OR = 0.96, 95% CI 0.93–0.98), and Hispanic ethnicity (OR = 3.62, 95% CI 2.01–6.51) were significantly associated with electrodiagnostic utilization (overall model c statistic = 0.764) (table 4). Similarly, neurology provider (OR = 5.00, 95% CI 3.63–6.89), higher education status (OR = 1.80, 95% CI 1.16–2.79), and age (OR = 0.96, 95% CI 0.93–0.98) were associated with MRI utilization (c statistic 0.759).

Table 3 Medicare expenditures by provider type

Test	Neuropathy subjects without a neurology provider, \$, mean (SD) (total = 657)	Neuropathy subjects with a neurology provider, \$, mean (SD) (total = 374)	p Value
EMG	14 (47)	57 (84)	<0.0001
Nerve conduction study	103 (313)	298 (445)	<0.0001
Brain MRI	22 (125)	233 (389)	<0.0001
Cervical spine MRI	15 (101)	62 (186)	<0.0001
Thoracic spine MRI	10 (87)	22 (154)	0.17
Lumbosacral spine MRI	57 (226)	110 (263)	<0.01
ANA	1 (4)	2 (7)	<0.01
ESR	1 (5)	2 (4)	0.08
SPEP	1 (7)	4 (13)	<0.01
TSH	12 (20)	17 (27)	<0.01
GTT	0 (0)	0.1 (0.9)	0.32
B ₁₂	4 (11)	7 (13)	<0.01
Fasting glucose	2 (6)	2 (5)	0.96
CBC	14 (33)	16 (37)	0.41
CMP	7 (13)	10 (21)	0.04
HA1C	10 (18)	8 (17)	0.06
EDS total	117 (339)	355 (504)	<0.0001
MRI total	104 (325)	427 (624)	<0.0001
Laboratory total	53 (67)	67 (87)	<0.01
Total	274 (517)	849 (875)	<0.0001

Abbreviations: ANA = antinuclear antibody; CBC = complete blood count; CMP = comprehensive metabolic panel; EDS = electrodiagnostic studies (EMG and nerve conduction study); ESR = erythrocyte sedimentation rate; GTT = glucose tolerance test; HA1C = hemoglobin A1C; SPEP = serum protein electrophoresis; TSH = thyroid-stimulating hormone.

DISCUSSION

In this nationally representative sample of neuropathy patients aged ≥ 65 years, MRI studies were the single largest contributor to diagnostic testing expenditures. MRIs were performed in 25% of patients and accounted for 46% of total expenditures. Electrodiagnostic studies also contributed substantially to expenditures, being performed in 29% and accounting for 42% of expenditures. Laboratory tests, on the other hand, accounted for only a small proportion of total expenditures. Future efforts are needed to define what constitutes an appropriate and efficient evaluation of peripheral neuropathy. Specifically, a focus on the role of MRIs and electrodiagnostic tests should be a priority.

An additional finding of this study was the differences in the evaluation of neuropathy by medical specialty. Even though neurologists saw a minority of the patients, aggregate expenditures were significantly higher in patients seen by neurologists compared to those not seen by neurologists (\$317,526 vs \$180,018). Most of this difference was explained by higher utilization of MRI and electrodiagnostic tests. In addition, the dominant contributor to predicting MRI or electrodiagnostic utilization was being seen by a neurologist, even after adjusting for important confounders. Whether this increased utilization is appropriate cannot be determined with these data. Similarly, some tests may be more appropriate than others. For example, electrodiagnostic tests likely have more utility in the evaluation of peripheral neuropathy than MRIs, but future studies are needed to clearly define the role of both of these tests. Furthermore, patients who

Table 4 Predictive models for electrodiagnostic and MRI utilization

Independent variables	Model 1: Associations with electrodiagnostic testing, odds ratio (95% CI)	Model 2: Associations with MRI, odds ratio (95% CI)
c Statistic	0.764	0.759
Neurology provider	5.30 (3.87–7.26)	5.00 (3.63–6.89)
Diabetes	0.63 (0.46–0.87)	0.71 (0.51–1.00)
Age at diagnosis	0.96 (0.93–0.98)	0.96 (0.93–0.98)
ADL limitations (reference = none)		
Moderate	0.74 (0.47–1.16)	0.66 (0.41–1.07)
Severe	0.67 (0.41–1.11)	0.96 (0.58–1.58)
Female	0.81 (0.60–1.11)	1.04 (0.75–1.43)
Race/ethnicity (reference = Caucasian/other)		
African American	1.05 (0.63–1.74)	0.91 (0.53–1.55)
Hispanic	3.62 (2.01–6.51)	1.15 (0.58–2.29)
Education level (reference = < high school)		
High school	1.19 (0.79–1.79)	1.40 (0.91–2.17)
At least some college	1.06 (0.70–1.61)	1.80 (1.16–2.79)
Pain	1.12 (0.80–1.55)	1.31 (0.93–1.85)
Personal baseline expenditure indicator (reference = quartile 1)		
Quartile 2	1.04 (0.68–1.59)	1.04 (0.65–1.64)
Quartile 3	1.01 (0.65–1.57)	1.36 (0.85–2.16)
Quartile 4	0.82 (0.53–1.28)	1.12 (0.70–1.78)
HRS interview year (reference = 1998)		
2000	1.11 (0.71–1.75)	1.62 (1.00–2.62)
2002	1.32 (0.82–2.11)	1.17 (0.70–1.96)
2004	1.06 (0.67–1.69)	1.56 (0.96–2.54)
2006	0.83 (0.48–1.43)	1.23 (0.70–2.17)
Geographic expenditure indicator (reference = quartile 1)		
Quartile 2	1.11 (0.64–1.92)	0.85 (0.48–1.49)
Quartile 3	0.78 (0.45–1.33)	0.86 (0.50–1.47)
Quartile 4	1.54 (0.92–2.58)	1.23 (0.73–2.08)

Abbreviation: ADL = activities of daily living; CI = confidence interval; HRS = Health and Retirement Study.

are seen by neurologists are different from those who are not seen by neurologists. Neurologists likely are referred patients with more severe neuropathy or rare neuropathy subtypes. Furthermore, we currently do not have evidence for or against the utilization of these tests. However, these data do suggest that neurologists are likely to be important targets for any physician interventions aimed at improving the efficiency of the evaluation of peripheral neuropathy. Neurologists may also be a more feasible target for interventions to optimize neuropathy evaluations because they are a much smaller group and have a more concentrated interest in neuropathy evaluation and management. Targeting neurologists is also important because their practice patterns are likely to diffuse into general medicine practices.

By comparison, non-neurologists had much lower utilization of MRIs and electrodiagnostic tests, but also had lower utilization of AAN-recommended laboratory tests for neuropathy,

Both vitamin B₁₂ and SPEP have been shown to have a substantial yield in neuropathy presentations and abnormal results influence further relevant management including specific treatments.

particularly vitamin B₁₂ levels and SPEP. Both vitamin B₁₂ and SPEP have been shown to have a substantial yield in neuropathy presentations and abnormal results influence further relevant management including specific treatments.^{8,11,12} This result highlights the fact that more testing does not equate with overutilization. Furthermore, the low utilization of AAN-recommended tests by all provider types emphasizes the opportunity we have to improve the care of many patients with neuropathy. In steps to optimize care, the initial step, especially for non-neurologists, may be a focus on increasing utilization of these tests, which would likely only lead to a minor increase in expenditures.

We identified one major difference when comparing the utilization results with our previous survey. Specifically, in our prior survey, neurologists indicated they would order fewer MRIs of the neuroaxis than internists (12.9% vs 19.8%) given the same distal symmetric polyneuropathy vignette, whereas in this study we found the opposite.⁵ Possible explanations include that peripheral neuropathy patients with a neurologist are more likely to have a separate indication for an MRI, the real-world practice of neurologists does not match their ideal intentions, the evaluation of neuropathy is different in Medicare vs non-Medicare populations, or neurology survey respondents were more likely to be lower MRI test utilizers. On the other hand, both studies demonstrated higher overall test utilization, including electrodiagnostic utilization, by neurologists. Similarly, both studies revealed higher utilization of the 4 AAN-recommended tests by neurologists. While our previous survey and current HRS-Medicare claims data reveal similar results, future work is necessary to address the reasons for the conflicting data on MRI utilization.

Potential limitations of our study include that cases were identified by ICD-9 codes, which may lead to misclassification bias. With this data, we are unable to determine the frequency of misclassification or how it might differ between provider types. The purpose of the current analysis was to describe utilization and expenditures in peripheral neuropathy. The study does not address whether the use or nonuse of a test in an individual patient was appropriate or not. We were also unable to investigate detailed information on why patients received specific tests. For example, patients who received MRIs may have had another indication for this test, such as additional features indicating the possible presence of brain or spinal cord disease. On the other hand, our previous work revealed substantially higher MRI utilization in this neuropathy group compared with propensity-matched controls. Moreover, we did not have information on neuropathy severity or subtype, both of which may influence testing and subsequent expenditures. However, we were able to include many patient characteristics into our predictive models, and the models had high predictive ability. We also were only able to study those 65 and older and enrolled in fee-for-service Medicare; therefore, how these results apply to a population that is younger and covered by other types of insurance is unknown.

MRIs and electrodiagnostic tests have the greatest effect on expenditures in the evaluation of peripheral neuropathy. These tests are performed more frequently in patients who are evaluated by a neurology provider. Therefore, MRIs and electrodiagnostic tests in patients seen by neurologists should be the main targets of cost-control and efficiency efforts in the evaluation of peripheral neuropathy.

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STUDY FUNDING

No targeted funding reported.

DISCLOSURES

B.C. Callaghan received a junior faculty award from the American Diabetes Association. J.F. Burke is funded through an advanced fellowship from the US Department of Veterans Affairs and the Robert Wood Johnson Foundation. A. Rodgers and R. McCammon report no disclosures. K.M. Langa receives research support from the NIH/NIA. E.L. Feldman serves on a Data Safety Monitoring Board for Novartis. KA. Kerber has received speaker or author honoraria from the American Academy of Neurology, Munson Medical Center, The University of Utah, Janssen India (a division of Johnson & Johnson, Ltd.), and Michigan Academy of Family Physicians; has received publishing royalties from Oxford University Press; has served as a consultant for the American Academy of Neurology and the University of California San Francisco; has received an NIH loan repayment award; has received research support from NIH/NCRR and AHRQ; and has acted as a consultant in legal proceedings. Full disclosure form information provided by the authors is available with the **full text of this article at Neurology.org/cp**.

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