Primary Care Providers perform more neurologic visits than neurologists among Medicare beneficiaries

Short running title: PCPs perform more neurologic visits than neurologists

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Abstract

Objective: To describe the current distribution of outpatient neurologic care by provider type.

Data Source: A 20% national sample claims database that contains information on medical care utilizations from adult Fee-for-Service Medicare beneficiaries in 2015.

Data Collection: We identified all patient visits for evaluation and management services for common neurologic conditions in 2015.

Study Design: We conducted a retrospective, cross-sectional analysis to determine the proportion of visits for neurologic conditions by medical provider type.

Principal Findings 40% of neurologic visits were performed by primary care providers (PCPs) and 17.5% by neurologists. The most common neurologic conditions were back pain (49.3%), sleep disorders (8.0%), chronic pain/abnormality of gait (6.4%), peripheral neuropathy (5.9%), and stroke (5.5%). Neurologists cared for a large proportion of visits for Parkinson's disease (75.6% vs. 20.8%), epilepsy (70.9% vs. 26.6%), multiple sclerosis (63.9% vs. 26.2%), other central NS disorders (54.2% vs. 24.9%), and tremor/RLS/ALS (54.0% vs. 31.2%) compared to PCPs. PCPs provided a greater proportion of visits for dizziness/vertigo (57.8% vs. 9.3%) and headache/migraine (50.4% vs. 35.0%) compared to neurologists.

Conclusions: PCPs perform more neurologic visits than neurologists. With the anticipated increased demand for neurologic care, strategies to optimize neurologic care delivery could consider expanding access to neurologists as well as supporting PCP care for neurologic conditions.

Introduction

The prevalence of neurologic conditions has increased and is likely to continue to increase over time because of an expanding and aging population.[1] While neurologists may play a critical role in accurate diagnosis, treatment and outcomes of some neurologic conditions [2,3], many patients with neurologic conditions are not cared for by neurologists.[2,4,5] Some studies suggested that in conditions, such as dizziness [5] or Parkinson's disease [2], primary care providers (PCPs) may be the ones providing the care. However, outside of these conditions, little is known about which providers, other than neurologists, are involved in the care of neurologic conditions. In order to plan for the anticipated increase in patients, understanding how neurologic care is currently managed by provider type is important. In this context, we explored the distribution of outpatient neurologic care across medical provider types. Our findings would provide insight for health policy makers to identify the gaps in neurologic care and inform initiatives to optimize the delivery of neurologic care in the United States.

Methods

We used a 20% sample of 2015 Fee-for-Service Medicare Carrier Files. Visits for neurologic care were defined as office-based new or established patient visits for evaluation and management services (E/M [Current Procedural Terminology codes: 99201-99205, 99241-99245, 99211-99215]) with a neurologic condition as the primary diagnosis. Neurologic conditions were defined by rank ordering neurologic diagnostic categories seen by neurologists (eFigure1). Diagnostic categories were classified using the Clinical Classifications Software (CCS) categories of International Classification of Disease and modified slightly by the authors to reflect disease categories among neurologic sub-specialties (eTable1).[6] Visits from patients aged <18 or resided outside US or with missing residence were excluded. The unit of analysis for this study was visits. This study used the limited data set and was determined as not regulated by the Institutional Review Board of University of Michigan.

Providers were identified by provider specialty code in the Medicare Carrier Files or healthcare taxonomy codes in the National Provider Identifier files. PCPs were defined as general practice, family practice, and internal medicine specialties. We did not include internal medicine subspecialties (e.g. geriatric medicine, endocrinology, pulmonary disease) as PCPs. Since the practice patterns of nurse practitioner and physician assistant in neurologic care were similar to primary care physicians (eFigure2), we included them as PCPs.

Statistical Analysis

Descriptive statistics were used to summarize visits with a primary neurologic diagnosis cared for by neurologists and other specialties, both in aggregate and across conditions. The proportion of visits cared by neurologists compared to other specialties were assessed by neurologic condition. Given that some conditions, such as back pain, sleep disorders, dizziness/vertigo, or syncope, might be considered as less specific neurological diagnoses, a sensitivity analysis excluding these conditions were conducted. All statistical analyses were performed using SAS 9.4 (SAS Institute, Cary, NC).

Results

In 2015, there were 33.5 million Fee-for-Service Medicare beneficiaries who had 265 million visits provided by 13,627 neurologists, 263,772 PCPs and 349,021 other clinicians. The average age of beneficiaries was 71 and 17% were under age 65. Visits for the most common neurologic conditions (Figure 1A, eTable 2) accounted for 11.5% (30.6 million) of all E/M visits.

Most of neurologic visits were performed by PCPs (40.0% [12.2 million] of neurologic visits) and neurologists (17.5% [5.4 million]) (Figure 1B). Other clinicians, such as physicians with specialties in physical medicine/rehabilitation and orthopedic surgery, also provided neurologic visits (6.8% and 5.8% of neurologic visits, respectively). Neurologic visits accounted for the majority (85%) of all neurologist visits (6.3 million visits) while accounting for about 10.5% of all PCP visits (116.7 million visits) and 9.1% of all other clinicians visits (142.4 million visits). Top five most common neurologic

conditions were: back pain (49.3%), sleep disorders (8.0%), chronic pain/abnormality of gait (6.4%), peripheral neuropathy (5.9%) and stroke (5.5%). More than one fourth (27.4%) of neurologic visits were for beneficiaries aged <65. The proportion of visits from beneficiaries aged <65 varied by neurologic condition (eFigure3). More than half of visits for multiple sclerosis (66.8%) and epilepsy (57.4%) were for beneficiaries aged <65.

The distribution of neurologic conditions cared for by medical provider type varied greatly (Figure 2). The three most common neurologic conditions cared for by neurologists were dementia (11.8%), epilepsy (11%), and peripheral neuropathy (10.9%) while the top three conditions encountered by PCPs were back pain (49.7%), sleep disorders (8.6%) and chronic pain/abnormality of gait (7.4%).

For some conditions compared to PCPs, neurologists were the dominant providers: Parkinson's disease (75.6% vs. 20.8%), epilepsy (70.9% vs. 26.6%), multiple sclerosis (63.9% vs. 26.2%), other central NS disorders (such as mild cognitive impairment, reflex sympathetic dystrophy) (54.2% vs. 24.9%), and tremor/restless legs syndrome/ALS (54.0% vs. 31.2%) (Figure 3). PCPs, on the other hand, cared for a greater proportion of visits for dizziness/vertigo (57.8% vs. 9.3%) and headache/migraine (50.4% vs. 35.0%) compared to neurologists.

In the sensitivity analysis excluding less specific neurological diagnoses, the proportion of neurologic visits provided by neurologists increased from 17.5% to 39.2%

while the proportion of neurologic visits provided by PCPs changed little (from 40.0% to 36.6%)(eFigure4).

Discussion

In a nationally representative Medicare sample of adults receiving care for the most common neurologic conditions, PCPs performed 40% of neurologic visits, about 10% of their total visits, while neurologists performed 17.5% of neurologic visits. This is not a surprising finding since PCPs outnumber neurologists 20-fold in the United States. However, neurologic visits by provider type varied by condition. Parkinson's disease, epilepsy, and multiple sclerosis were predominantly (>50% visits) cared for by neurologists while for others, neurologists provided cared for <10% of visits.

The provider-based distribution of current neurological care provides some insight into how best to prepare for the anticipated increase in patients with neurologic conditions. In the near term, strategies to optimize neurologic care delivery likely depend on whether the neurologic condition is predominately neurologist-managed, whereby strategies to expand access to neurologists may be reasonable, or predominately PCP-managed, whereby supporting PCP care could be considered. For conditions that are predominately neurologist-managed, strategies to accommodate growth in these conditions may focus on expanding access to neurologists, including increasing neurology residency programs, telehealth and shared care models. Telehealth, best developed for the

assessment of stroke, has recently been used with multiple sclerosis [7] and Parkinson's disease [8]. Shared care models, in which neurologists and PCPs share responsibility for a patient's care, are successful in chronic medical conditions and are expanding to neurologic conditions [9].

For conditions that are predominantly primary care-managed, strategies could focus on supporting PCP care via physician clinical decision support, increasing of neurology exposure during residency [10], or developing patient self-management tools [11], could be considered. Thoughtful attention to physician training focused on development of a basic proficiency in recognition and referral of complex neurologic conditions would increase the current workforce capacity.

How to best utilize the limited pool of neurologists is complex and requires an understanding of the value of neurologic care. Across neurologic conditions and varying patient presentations, some visits with neurologists likely have very high value (e.g., improved functioning [3]), whereas others are low value (e.g., increased costs without established outcome benefit [12]). For optimal patient care and to specifically evaluate the value of neurologic care, future studies should be performed to understand the reasons underlying current practice patterns and test the effect of different models of neurologic care delivery on patient-centered outcomes. One approach would be to examine the

association of neurologist density with geographic variation the neurologic care and outcomes.

Our study has several limitations. First, our results are limited to adults with Fee-for-service Medicare and cannot be generalized to all Americans, particularly the working age population. Second, while accuracy of coding for neurologic conditions is reasonable, coding inaccuracy may still exist; physician specialties may be miscoded. Third, only the primary diagnosis of each E/M visit was used and thus neurologic diagnoses may be underestimated. Fourth, we cannot use claims to know the role providers played in patients' neurologic care (e.g. as a referral, follow-up, or a primary provider). Further study of the relationship between PCPs and neurologists is needed.

Conclusions

PCPs perform more neurologic visits than neurologists overall, but there is substantial variation by condition. With the anticipated increased demand for neurologic care, strategies to optimize neurologic care delivery should consider expanding access to neurologists as well as supporting PCPs care for neurologic conditions. To better inform innovative strategies, future studies should explore neurologist and PCP focused interventions and their effect on patient outcomes.

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Conflict of Interest

Dr. Callaghan consults for a PCORI grant, DynaMed, the Immune Tolerance Network, and performs medical legal consultations including consultations for the Vaccine Injury Compensation Program. Drs. Lin, Burke, Kerber, Skolarus, Hill, Hartley report no disclosures.

Figure legends

Figure 1: The distribution of visits for the most common neurologic conditions

(A) Neurologic conditions

Back pain

Sleep disorders

Chronic pain/abnormality of gait

Stroke

Peripheral Neuropathy

Dementia

Dizziness/Vertigo

Headache/Migraine

Epilepsy

Parkinson's disease

Tremor/RLS/ALS

Syncope

Multiple Sclerosis

Other central NS disorders

(B) Medical provider type

Primary Care

Neurology

Physician medicine and rehabilitation

Orthopedic surgery

Anesthesiology

Interventional pain management

Pain management

Pulmonary disease

Neurosurgery

Cardiology

Otolaryngology

Others

Figure 2. The distribution of neurologic conditions cared for by medical provider type

Dementia

Epilepsy

Peripheral Neuropathy

Parkinson's disease

Back pain

Headache/Migraine

Stroke

Chronic pain/abnormality of gait

Tremor/RLS/ALS

Sleep disorders

Multiple sclerosis

Other central NS disorders

Dizziness/Vertigo

Syncope

Figure 3. The proportion of neurologic visits cared for by medical provider type

Parkinson's disease

Epilepsy

Multiple sclerosis

Tremor/RLS/ALS

Other central NS disorders

Dementia

Headache/Migraine

Peripheral Neuropathy

Stroke

Chronic pain/abnormality of gait

Sleep disorders

Syncope

Dizziness/Vertigo

Back pain

eFigure 1. The distribution of diagnoses in all visits to Neurologists

Dementia

Epilepsy

Peripheral Neuropathy

Parkinson's disease

Back pain

Headache/Migraine

Stroke

Chronic pain/abnormality of gait

Tremor/RLS/ALS

Sleep disorders

Multiple sclerosis

Other central NS disorders

Dizziness/Vertigo

Syncope

Others

eFigure2. Practice patterns of nurse practitioner and physician assistant in neurologic care

PCP

APP

Neurologist

eFigure3. Proportion of visits from Medicare beneficiaries aged <65

Multiple sclerosis

Epilepsy

Headache/Migraine

Chronic pain/abnormality of gait

Back pain

Other central NS disorders

Sleep disorders

Peripheral Neuropathy

Tremor/RLS/ALS

Syncope

Stroke

Dizziness/Vertigo

Parkinson's disease

Dementia

eFigure4: Distribution of visits for the most common neurologic conditions excluding back pain, sleep disorders, syncope, and dizziness/vertigo

(A) Neurologic conditions

Chronic pain/abnormality of gait

Peripheral Neuropathy

Stroke

Dementia

Headache/Migraine

Epilepsy

Parkinson's disease

Tremor/RLS/ALS

Other central NS disorders

Multiple Sclerosis

(B) Medical provider types

Primary Care Providers

Neurologists

Non-PCP clinicians

eTable 1. Single-level Clinical Classifications Software (CCS) categories

CCS	CCS category description
1	Tuberculosis
2	Septicemia (except in labor)
3	Bacterial infection; unspecified site
4	Mycoses
5	HIV infection
6	Hepatitis
7	Viral infection
8	Other infections; including parasitic
9	Sexually transmitted infections (not HIV or hepatitis)
10	Immunizations and screening for infectious disease
11	Cancer of head and neck
12	Cancer of esophagus
13	Cancer of stomach
14	Cancer of colon
15	Cancer of rectum and anus
16	Cancer of liver and intrahepatic bile duct
17	Cancer of pancreas
18	Cancer of other GI organs; peritoneum
19	Cancer of bronchus; lung
20	Cancer; other respiratory and intrathoracic
21	Cancer of bone and connective tissue
22	Melanomas of skin
23	Other non-epithelial cancer of skin
24	Cancer of breast
25	Cancer of uterus
26	Cancer of cervix
27	Cancer of ovary
28	Cancer of other female genital organs
29	Cancer of prostate
30	Cancer of testis
31	Cancer of other male genital organs
32	Cancer of bladder
33	Cancer of kidney and renal pelvis
34	Cancer of other urinary organs
35	Cancer of brain and nervous system
36	Cancer of thyroid
37	Hodgkin`s disease
38	Non-Hodgkin`s lymphoma
39	Leukemias
40	Multiple myeloma
41	Cancer; other and unspecified primary

CCS	CCS category description
42	Secondary malignancies
43	Malignant neoplasm without specification of site
44	Neoplasms of unspecified nature or uncertain behavior
45	Maintenance chemotherapy; radiotherapy
46	Benign neoplasm of uterus
47	Other and unspecified benign neoplasm
48	Thyroid disorders
49	Diabetes mellitus without complication
50	Diabetes mellitus with complications
51	Other endocrine disorders
52	Nutritional deficiencies
53	Disorders of lipid metabolism
54	Gout and other crystal arthropathies
55	Fluid and electrolyte disorders
56	Cystic fibrosis
57	Immunity disorders
58	Other nutritional; endocrine; and metabolic disorders
59	Deficiency and other anemia
60	Acute posthemorrhagic anemia
61	Sickle cell anemia
62	Coagulation and hemorrhagic disorders
63	Diseases of white blood cells
64	Other hematologic conditions
76	Meningitis (except that caused by tuberculosis or sexually transmitted disease)
77	Encephalitis (except that caused by tuberculosis or sexually transmitted disease)
78	Other CNS infection and poliomyelitis
79	Parkinson`s disease
80	Multiple sclerosis
81	Other hereditary and degenerative nervous system conditions
82	Paralysis
83	Epilepsy; convulsions
84	Headache; including migraine
85	Coma; stupor; and brain damage
86	Cataract
87	Retinal detachments; defects; vascular occlusion; and retinopathy
88	Glaucoma
89	Blindness and vision defects
90	Inflammation; infection of eye (except that caused by tuberculosis or sexually transmitted disease)
91	Other eye disorders
92	Otitis media and related conditions
93	Conditions associated with dizziness or vertigo
94	Other ear and sense organ disorders

CCS	CCS category description
96	Heart valve disorders
97	Peri-; endo-; and myocarditis; cardiomyopathy (except that caused by tuberculosis or sexually transmitted disease)
98	Essential hypertension
99	Hypertension with complications and secondary hypertension
100	Acute myocardial infarction
101	Coronary atherosclerosis and other heart disease
102	Nonspecific chest pain
103	Pulmonary heart disease
104	Other and ill-defined heart disease
105	Conduction disorders
106	Cardiac dysrhythmias
107	Cardiac arrest and ventricular fibrillation
108	Congestive heart failure; nonhypertensive
109*	Stroke (including CCS single-level categories: 109 (Acute CVD), 110 (Occulsion or stenosis of precerebral artieries), 111 (Other CVD), 112 (TIA), 113 (Late effects of CVD))
114	Peripheral and visceral atherosclerosis
115	Aortic; peripheral; and visceral artery aneurysms
116	Aortic and peripheral arterial embolism or thrombosis
117	Other circulatory disease
118	Phlebitis; thrombophlebitis and thromboembolism
119	Varicose veins of lower extremity
120	Hemorrhoids
121	Other diseases of veins and lymphatics
122	Pneumonia (except that caused by tuberculosis or sexually transmitted disease)
123	Influenza
124	Acute and chronic tonsillitis
125	Acute bronchitis
126	Other upper respiratory infections
127	Chronic obstructive pulmonary disease and bronchiectasis
128	Asthma
129	Aspiration pneumonitis; food/vomitus
130	Pleurisy; pneumothorax; pulmonary collapse
131	Respiratory failure; insufficiency; arrest (adult)
132	Lung disease due to external agents
133	Other lower respiratory disease
134	Other upper respiratory disease
135	Intestinal infection
136	Disorders of teeth and jaw
137	Diseases of mouth; excluding dental
138	Esophageal disorders
139	Gastroduodenal ulcer (except hemorrhage)

CCS	CCS category description
140	Gastritis and duodenitis
141	Other disorders of stomach and duodenum
142	Appendicitis and other appendiceal conditions
143	Abdominal hernia
144	Regional enteritis and ulcerative colitis
145	Intestinal obstruction without hernia
146	Diverticulosis and diverticulitis
147	Anal and rectal conditions
148	Peritonitis and intestinal abscess
149	Biliary tract disease
151	Other liver diseases
152	Pancreatic disorders (not diabetes)
153	Gastrointestinal hemorrhage
154	Noninfectious gastroenteritis
155	Other gastrointestinal disorders
156	Nephritis; nephrosis; renal sclerosis
157	Acute and unspecified renal failure
158	Chronic kidney disease
159	Urinary tract infections
160	Calculus of urinary tract
161	Other diseases of kidney and ureters
162	Other diseases of bladder and urethra
163	Genitourinary symptoms and ill-defined conditions
164	Hyperplasia of prostate
165	Inflammatory conditions of male genital organs
166	Other male genital disorders
167	Nonmalignant breast conditions
168	Inflammatory diseases of female pelvic organs
169	Endometriosis
170	Prolapse of female genital organs
171	Menstrual disorders
172	Ovarian cyst
173	Menopausal disorders
175	Other female genital disorders
176	Contraceptive and procreative management
179	Postabortion complications
180	Ectopic pregnancy
181	Other complications of pregnancy
182	Hemorrhage during pregnancy; abruptio placenta; placenta previa
183	Hypertension complicating pregnancy; childbirth and the puerperium
190	Fetal distress and abnormal forces of labor
193	OB-related trauma to perineum and vulva
195	Other complications of birth; puerperium affecting management of mother

CCS	CCS category description
196	Other pregnancy and delivery including normal
197	Skin and subcutaneous tissue infections
198	Other inflammatory condition of skin
199	Chronic ulcer of skin
200	Other skin disorders
201	Infective arthritis and osteomyelitis (except that caused by tuberculosis or sexually transmitted disease)
202	Rheumatoid arthritis and related disease
203	Osteoarthritis
204	Other non-traumatic joint disorders
205	Spondylosis; intervertebral disc disorders; other back problems
206	Osteoporosis
207	Pathological fracture
208	Acquired foot deformities
209	Other acquired deformities
210	Systemic lupus erythematosus and connective tissue disorders
211	Other connective tissue disease
212	Other bone disease and musculoskeletal deformities
213	Cardiac and circulatory congenital anomalies
214	Digestive congenital anomalies
215	Genitourinary congenital anomalies
216	Nervous system congenital anomalies
217	Other congenital anomalies
218	Liveborn
219	Short gestation; low birth weight; and fetal growth retardation
220	Intrauterine hypoxia and birth asphyxia
223	Birth trauma
224	Other perinatal conditions
225	Joint disorders and dislocations; trauma-related
226	Fracture of neck of femur (hip)
227	Spinal cord injury
228	Skull and face fractures
229	Fracture of upper limb
230	Fracture of lower limb
231	Other fractures
232	Sprains and strains
233	Intracranial injury
234	Crushing injury or internal injury
235	Open wounds of head; neck; and trunk
236	Open wounds of extremities
237	Complication of device; implant or graft
238	Complications of surgical procedures or medical care
239	Superficial injury; contusion

CCS	CCS category description
240	Burns
241	Poisoning by psychotropic agents
242	Poisoning by other medications and drugs
243	Poisoning by nonmedicinal substances
244	Other injuries and conditions due to external causes
245	Syncope
246	Fever of unknown origin
247	Lymphadenitis
248	Gangrene
249	Shock
250	Nausea and vomiting
251	Abdominal pain
252	Malaise and fatigue
253	Allergic reactions
254	Rehabilitation care; fitting of prostheses; and adjustment of devices
255	Administrative/social admission
256	Medical examination/evaluation
257	Other aftercare
258	Other screening for suspected conditions (not mental disorders or infectious disease)
260*	Subcategorized from CCS Single-level category 259 (Unclassified): Sleep disorders
261*	Subcategorized from CCS Single-level category 259 (Unclassified): Altered mental status, unspecified
262*	Subcategorized from CCS Single-level category 259 (Unclassified): Misc
650	Adjustment disorders
651	Anxiety disorders
652	Attention-deficit conduct and disruptive behavior disorders
653	Delirium dementia and amnestic and other cognitive disorders
654	Developmental disorders
655	Disorders usually diagnosed in infancy childhood or adolescence
656	Impulse control disorders NEC
657	Mood disorders
658	Personality disorders
659	Schizophrenia and other psychotic disorders
660	Alcohol-related disorders
661	Substance-related disorders
662	Suicide and intentional self-inflicted injury
663	Screening and history of mental health and substance abuse codes
670	Miscellaneous mental health disorders
2603	External cause codes: Fall
2607	External cause codes: Motor vehicle traffic (MVT)
2617	Adverse effects of medical drugs
6.9.1*	Subcategorized from CCS Single-level category 95 (Other nervous system disorders): Disorders of the peripheral nervous system

CCS	CCS category description
6.9.2*	Subcategorized from CCS Single-level category 95 (Other nervous system disorders): Other central nervous system disorders
6.9.3*	Subcategorized from CCS Single-level category 95 (Other nervous system disorders): Other nervous system symptoms and disorders
6.9.4*	Subcategorized from CCS Single-level category 95 (Other nervous system disorders): Disorders cannot categorized to 6.9.1, 6.9.2, 6.9.3

*CCS categories has been slightly modified after reviewed by the authors to reflect disease categories among neurologic sub-specialties

eTable 2. Most common neurologic CCS diagnostic categories and top 3 diagnoses in the category

Single-level CCS category		Top 3 diagnoses
205	Back pain	Lumbago: ICD-9: 724.2; ICD-10: M54.5 Thoracic or lumbosacral neuritis or radiculitis unspecified: ICD-9: 724.4; ICD-10: M54.14, M54.15, M54.16 Degeneration of lumbar or lumbosacral intervertebral disc: ICD-9: 722.52; ICD-10: M51.36, M51.37
260	Sleep disorder	Obstructive sleep apnea: ICD-9: 327.23; ICD-10: G47.33 Insomnia, unspecified: ICD-9: 780.52; ICD-10: G47.00 Sleep apnea, unspecified: ICD-9: 780.57, 780.53; ICD-10: G47.30
6.9.3	Chronic pain /Abnormality of gait	Chronic pain syndrome: ICD-9: 338.4; ICD-10: G89.4 Chronic pain: ICD-9: 338.2x; ICD-10: G89.2x Abnormality of gait: ICD-9: 78.s; ICD-10: R26.0, R26.1, R26.89, R26.9
653	Dementia	Memory loss: ICD-9: 780.93; ICD-10: R41.2, R41.3 Alzheimer's disease: ICD-9: 331.0; ICD-10: G30.9 Dementia, unspecified: ICD-9: 294.20, 290.0; ICD-10: F03.90
109a	Stroke	Occlusion and stenosis of carotid artery: ICD-9: 433.10, 433.11; ICD-10: I65.21, I65.22, I65.23, I65.29, I63.139, I63.239 Occlusion of cerebral arteries: ICD-9: 434.00, 434.01, 434.10, 434.11, 434.90, 434.91; ICD-10: I63.30, I66.09, I66.19, I66.29, I63.40, I63.9, I66.9, I63.50 Transient cerebral ischemia (13.74%): ICD-9: 435.0-435.9; ICD-10: G45.0, G45.8, G45.1, G45.9, I67.848
6.9.1	Peripheral Neuropathy	Neuropathy: ICD-9: 356.x, 357.x; ICD-10: G60.x, G63, E08.4s, E09.42, E10.42, E11.42, E13.42, G61.81, G62.81, G61.89, G61.9 Carpal tunnel syndrome: ICD-9: 354.0; ICD-10: G56.00, G56.01, G56.02 Mononeuritis of lower limb and unspecified site: ICD-9: 355.x; ICD-10: G57.0x, G57.1x, G57.2x, G57.3x, G57.4x, G57.5x, G57.6x, G57.7x. G57.8x, G57.9x, G58.9
84	Headache/Migraine	Headache: ICD-9: 784.0; ICD-10: R51 Migraine, unspecified: ICD-9: 346.90-346.93; ICD-10: G43.909, G43.919, G43.901, G43.911 Migraine without aura: ICD-9: 346.10-346.13; ICD-10: G43.009, G43.019, G43.001, G43.011
93	Dizziness/Vertigo	Dizziness and giddiness: ICD-9: 780.4; ICD-10: R42 Other and unspecified peripheral vertigo: ICD-9: 386.1x; ICD-10: H81.1x, H81.2x, H81.39x

		Amblyopia ex anopsia: ICD-9: 386.0x; ICD-10: H81.0x
83	Epilepsy	Epilepsy and recurrent seizures: ICD-9: 345.xx; ICD-10: G40.xxx Convulsions: ICD-9: 780.3x; ICD-10: R56.xx
79	Parkinson's disease	Parkinson's disease: ICD-9: 332.0; ICD-10: G20
81	Tremor/RLS/ALS	Essential and other specified forms of tremor: ICD-9: 333.1; ICD-10: G25.1, G25.2, G25.0 Restless legs syndrome: ICD-9: 333.94; ICD10: G25.81 Motor neuron disease: ICD-9: 335.2x; ICD-10: G12.2x
80	Multiple sclerosis	Multiple sclerosis: ICD-9: 340; ICD-10: G35
245	Syncope	Syncope and collapse: ICD-9: 780.2; ICD-10: R55
6.9.2	Other CNS disorders	Mild cognitive impairment: ICD-9: 331.83; ICD-10: G31.84 Reflex sympathetic dystrophy: ICD-9: 337.2x; ICD-10: G90.50, G90.59, G90.511, G90.512, G90.513, G90.521, G90.522, G90.523, G90.529 Encephalopathy, not elsewhere classified: ICD-9: 348.3x; ICD-10: G93.40, G93.41, G93.49

[a]6.9.1, 6.9.2, 6.9.3 were originally single-level CCS 95 (other nerve diagnosis). To better understand the distribution of these other nerve diagnosis, we adopted their corresponding multi-level CCS categories.
[b]260 was originally part of single-level CCS 259 (unclassified). We modified to create a separate category for sleep disorder for this study.
[c]109a were composed of single-level CCS 109, 110, 111, 112, 113 as a stroke category.
[d]Neuro-infectious disease are mostly under “other CNS infection and myelitis” and “encephalitis(except that caused by TB or STD)” categories and are not included in the most common neurologic categories due to the proportion of their visits to all neurologist visits were small

Figure 1.

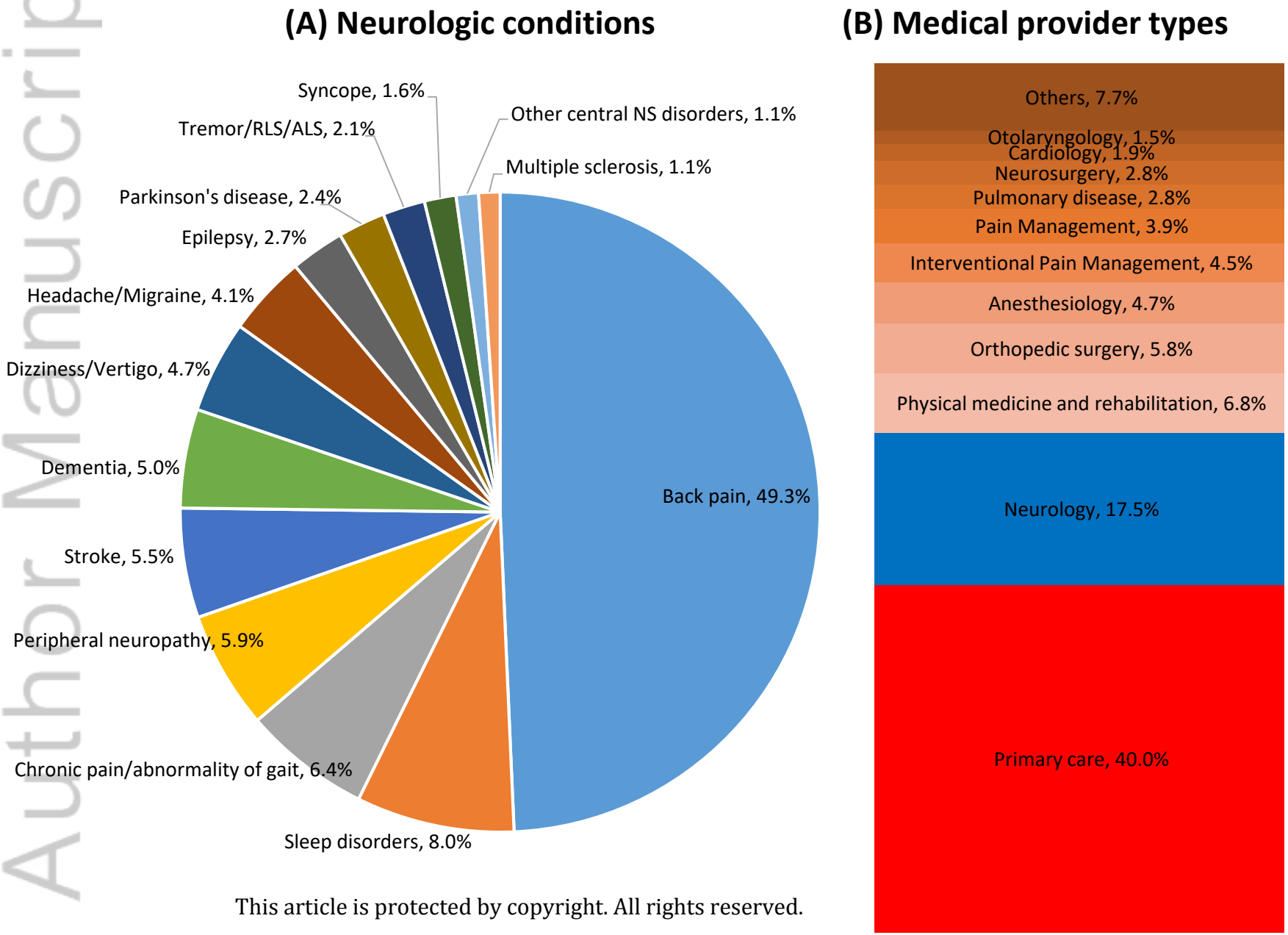
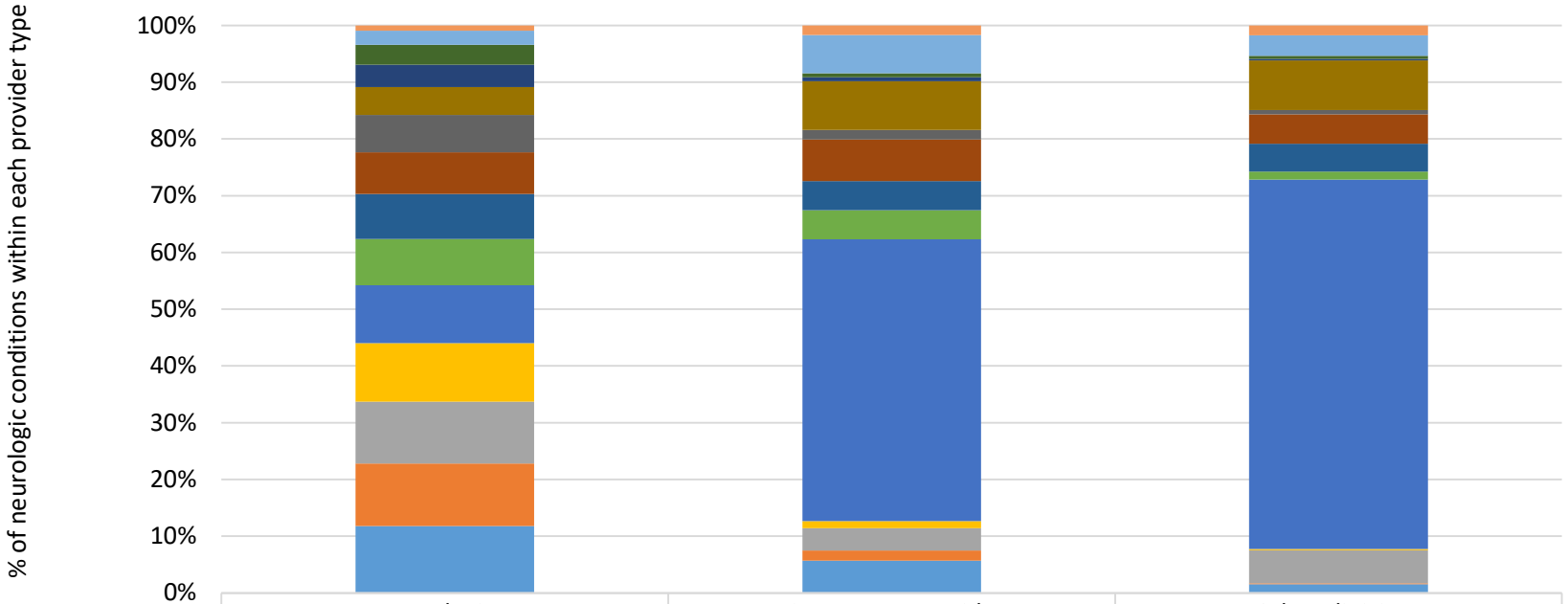


Figure 2.



	Neurologists	Primary care providers	Other clinicians
Syncope	1.0	1.7	1.8
Dizziness/Vertigo	2.5	6.7	3.6
Other central NS disorders	3.5	0.7	0.6
Multiple sclerosis	3.9	0.7	0.3
Sleep disorders	4.9	8.6	8.7
Tremor/RLS/ALS	6.6	1.7	0.8
Chronic pain/abnormality of gait	7.3	7.4	5.2
Stroke	8.0	5.1	4.9
Headache/Migraine	8.1	5.1	1.4
Back pain	10.2	49.7	65.1
Parkinson's disease	10.3	1.2	0.2
Peripheral neuropathy	10.9	3.9	5.8
Epilepsy	11.0	1.8	0.2
Dementia	11.8	5.7	1.6

Figure 3.