

# Trends in characteristics of neurologists who provide stroke consultations in the USA, 2008–2021

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## ABSTRACT

**Introduction** Patients with acute ischaemic strokes (AIS), on average, fare better with timely neurologist consultation, and a growing proportion of them receive one. However, little is known about trends in the characteristics of neurologists who treat AIS.

**Methods** We identified AIS and transient ischaemic attack (TIA) episodes with neurologist consults in fee-for-service Medicare from January 2008 to September 2021. For each episode, we determined whether the neurologist was a vascular neurologist, was a high-volume provider, whether the patient was transferred between hospitals and the distance between the patient's home and physician's practice.

**Results** From 2008 to 2021, the share of AIS/TIA episodes (n=5 073 294) with neurologist consults increased (52.9% to 61.7%). Among episodes with consults, the fraction conducted by a vascular neurologist (5.2% to 13.7%) or by a high-volume neurologist (13.2% to 14.9%) also increased. The fraction with the patient's home and neurologist greater than 100 miles apart (4.8% to 9.6%) or in different states (5.1% to 8.1%) increased, as did the fraction with transfers (4.2% to 8.5%).

**Discussion** Over the study period, the proportion of AIS/TIA episodes with consultations from neurologists with either vascular neurology certifications or high volumes increased substantially.

Patients with acute ischaemic strokes (AIS) on average fare better with timely neurologist consultation.<sup>1,2</sup> To facilitate this, the USA has invested in 'stroke systems of care' by certifying stroke centres, improving referral patterns and adopting telestroke.<sup>3,4</sup> A growing proportion of patients with AIS is receiving a neurology consult.<sup>5</sup>

However, little is known about AIS-consulting neurologists. Vascular neurology was introduced as a neurology subspecialty in 2003, and those certified in vascular neurology have received specialised training in treatment of AIS.<sup>6</sup> There is also an association between greater physician stroke case volume and improved outcomes.<sup>7</sup> It is unknown whether board certified vascular neurologists and/or high-volume stroke physicians are managing more AIS cases, either in-person or through telemedicine.

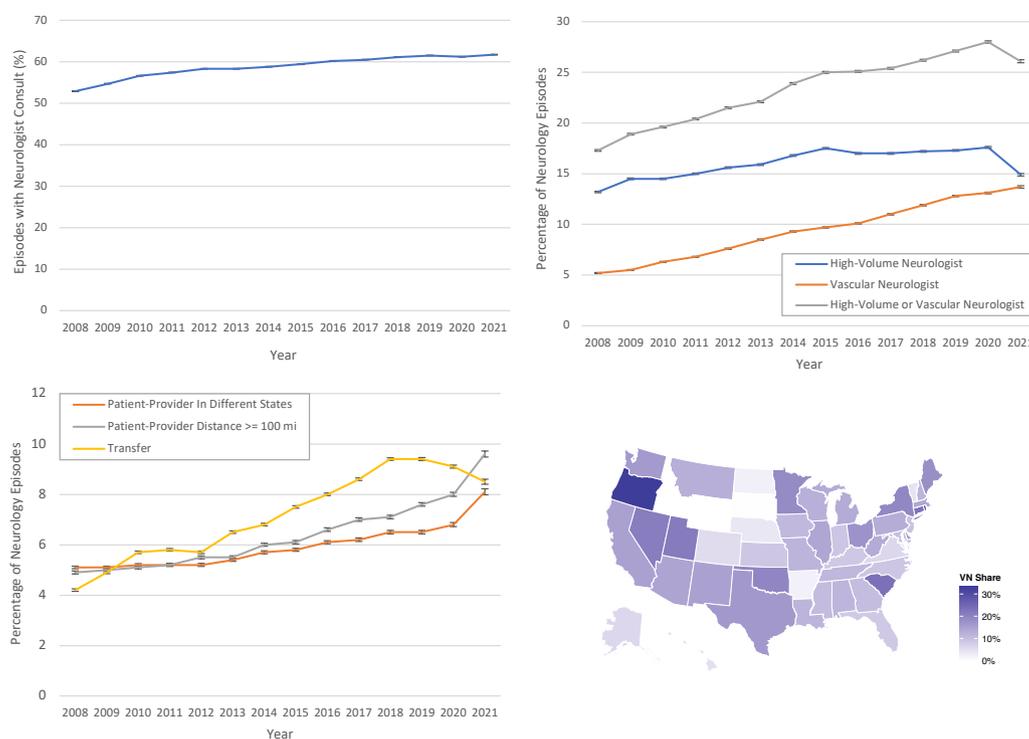
We describe trends in the subspecialty, case volume, patient transfer rate and distance between the patient's home and the physician's practice among stroke-consulting neurologists.

## METHODS

Using fee-for-service Medicare claims from January 2008 to September 2021, we identified all AIS and transient ischaemic attack (TIA) episodes using diagnosis codes (listed in online supplemental appendix 1). An episode was defined as all hospital care (emergency department, inpatient, observation stays) for AIS/TIA patient with no intervening days at home or in rehabilitation: all care for a patient transferred between acute care hospitals would be one episode.

After identifying AIS/TIA episodes, we identified billed neurology visits on the day of presentation or following day using the physician specialty code of 13. We restricted to the first 2 days to capture all acute care, including for late night stroke presentations treated early the next morning. We recognise that we capture some non-acute care as an unintended consequence. We determined whether the neurologist was certified in vascular neurology using the American Board of Psychiatry and Neurology certification status and verification system website (<https://application.abpn.com/verifycert/verifycert.asp>) to generate a list of vascular neurologists in 2021 which we merged into the NPPES NPI file by matching on first name, last name, city and state. We calculated the distances between the centroids of the zip codes for neurologist practices and patient residences and noted whether they were in different states, hypothesising that more consults would come from neurologists from farther away, including other states because of telestroke or better transfer protocols.

We classified neurologists as high volume based on stroke consultation counts. Initially,



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**Figure 1** Stroke episode neurologist characteristics, January 2008–July 2021. (A) Stroke episode share with neurologist consult. (B) Vascular neurology training and high-volume shares among neurology stroke consults. (C) Provider more than 100 miles away from patient's home or in a different state, patient transferred during episode. (D) Share of stroke neurology consults provided by vascular neurologists in 2020 by state.

our plan was to define high-volume using a 100 episode per year threshold, but we chose a variable cut-off because the number of stroke episodes varied over the years due to a pandemic-related drop in stroke episodes in 2020 and also because data were only available for part of 2021. Over the first decade of data, we found that 100 consults translated into a cut-off of roughly 2.5 SD above the mean, so we applied this 2.5 SD cut-off across all years. We did not capture telestroke usage as a distinct category from other stroke consultations based on procedure codes because we have found it is vastly underreported in claims.<sup>8</sup> We identified means and SEs for these measures each year.

The study was approved by the institution's Committee on Human Studies.

## RESULTS

From 2008 to 2021, the share of AIS/TIA episodes ( $n=5\,073\,294$ ) with early neurologist consultation increased (52.9%–61.7%) (figure 1A). Among those episodes, there was an increase over time in both consults by a vascular neurologist (5.2%–13.7%) and high-volume neurologist consults (13.2%–14.9%) (figure 1B). There was also an increase over time in the proportion of consults where the patient's home and neurologist were greater than 100 miles apart (4.8% to 9.6%), in different states (5.1%

**Table 1** Characteristics of stroke episodes with vascular neurologist and non-vascular neurologist consultations, 2019–2021

	Non-vascular neurologist	Vascular neurologist
Patient region (%)		
West	15.3 (0.05)	17.5 (0.14)
Midwest	23.3 (0.06)	22.4 (0.15)
Northeast	18.5 (0.05)	21.5 (0.15)
South	42.8 (0.07)	38.6 (0.18)
NIH Stroke Scale <sup>1</sup>	4.93 (0.03)	5.96 (0.09)
Months of dual enrolment	2.2 (0.01)	2.3 (0.02)
Share of consults conducted via telemedicine (%)	6.8 (0.04)	13.3 (0.12)
Patient rurality (%)		
Metropolitan	81.6 (0.05)	81.4 (0.14)
Micropolitan	9.7 (0.04)	9.8 (0.11)
Small Town	5.2 (0.03)	5.6 (0.08)
Rural	3.5 (0.03)	3.3 (0.06)

1. National Institutes of Health (NIH) Stroke Scale Quantifies Stroke Impairment. More information at [www.stroke.nih.gov/resources/scale.htm](http://www.stroke.nih.gov/resources/scale.htm)  
Standard errors included in parentheses.

to 8.1%), and in episodes involving a transfer (4.2% to 8.5%) (figure 1C). In 2020, 8.3% of vascular neurology consults were from an out-of-state physician versus 6.6% of consults by neurologists without vascular specialisation ( $p < 0.01$ ).

There is substantial state-level variation in the share of neurology consults performed by vascular neurologists (figure 1D) with the highest rates in Rhode Island (33.3%), Washington, D.C. (33.1%) and Oregon (32.7%) and lowest rates in South Dakota and Idaho (0.0%). There is slight variation in the region and rurality of consults performed by vascular neurologists as opposed to non-vascular neurologists (table 1).

## DISCUSSION

Over the study period, there was a 50% increase in the proportion of patients with AIS/TIA who received an early consultation from a neurologist with either vascular certification or high stroke volume. These neurologists might provide better care, in which case this shift may result in better outcomes. However, a third of the patients have no neurology consultation in 2021, and among those seen by a neurologist, most are treated by neurologists without stroke certification. Future work should explore methods of improving access to certified stroke neurologists and quantifying the benefits and harms from this shift in which providers treat patients with stroke.

These trends are concurrent with more patients being transferred during their episode and receiving care from a physician in another state or more than 100 miles away. These changes likely reflect the development of stroke systems of care to facilitate specialist evaluations.

There are important limitations to our analyses. Our data were limited to the Medicare fee-for-service population and, therefore, cannot generalise to those with commercial or Medicaid insurance. Furthermore, as noted above, while many telestroke consultations result in a submitted bill and are included in our analysis, some telestroke consultations are not billed. Therefore, we cannot capture those neurology consultations and underestimate what fraction of patients receive a neurology consultation.<sup>8</sup> However, our findings are consistent with prior research in which a large fraction of patients with ischaemic stroke never receive any neurology consultation.<sup>5</sup> Though we focused on consultations within a day of presentation, we recognise that some of these evaluations may not have been for an acute stroke. We also likely underestimate the fraction of neurologists who have vascular neurology training. We could only access vascular neurology certification data from 2021 and therefore miss vascular neurologists who previously retired or who led their certification lapse. Furthermore, we matched vascular neurology certification based on name and

location and, therefore, may not have matched neurologists who moved and did not update their location.

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**Patient consent for publication** Not applicable.

**Ethics approval** This study involves human participants and was approved by Harvard Medical School Committee on Human Studies, IRB19-1571 Patient informed consent was not required, given that the data were deidentified.

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**States, 2008 to 2021**

### **Supplemental Material**

#### **Supplemental Methods**

##### **Codes used to identify TIA/AIS episodes**

*Diagnosis codes: ICD-9 codes (433.X (except for 433.10), 434.X, 435.X, 436.25), and ICD-10 codes (I63-I66 (except I65.2), I67.89, G45.X).*

##### **Defining an episode**

An episode included inpatient or outpatient ED/observation stays in any short-term acute care or critical access hospital with a primary diagnosis for acute ischemic stroke (see “Codes used to identify TIA/AIS episodes and neurology consultations”). For patients with multiple, contiguous claims for stroke at the same hospital or across different hospitals, we consolidated their claim records into a single episode. For example, if a patient with stroke was cared for in the ED of one hospital, then transferred and admitted to another hospital, those different claims were combined into a single admission episode that was classified based on the first hospital where they received care.

##### **Statistics**

Error bars are given by standard errors calculating using SAS.