



## Full Length Article

## Hospital and demographic characteristics associated with inpatient neurological services in the United States



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## ABSTRACT

**Objective:** To determine nationwide availability and factors associated with inpatient neurological services.

**Patients and methods:** Using the 2011 American Hospital Association survey, we determined the proportion of hospitals that provided inpatient neurological services. Demographic and household data from the 2010 national census and survey results were utilized to determine regional factors associated with the availability of inpatient neurologic services. Using rate ratios, the association was estimated using Poisson regression. Hospitals lacking emergency departments or with a bed size of less than 25 beds were excluded to focus on acute care facilities with the potential to have subspecialty services.

**Results:** Of 3969 hospitals that completed the survey, 2017 (65%) provided inpatient neurological services. Hospitals with Joint Commission (JC) accreditation were 1.35 times more likely (95% CI: 1.16–1.57) to have inpatient neurological services. Compared to small hospitals (bed size 25–36), large hospitals (bed size 246–2264) were 4.53 times more likely (95% CI: 2.79–7.35) to provide inpatient neurological services. Hospitals that were the sole community provider or were non-federal governmental hospitals had a lower probability of providing inpatient neurological services with rate ratio of 0.65 (95% CI: 0.5–0.84) and 0.81 (95% CI: 0.7–0.94), respectively.

**Conclusions:** Approximately two-thirds of hospitals in this nationwide survey provided hospital-based neurological services. Larger hospitals and those with JC accreditation were more likely to provide neurological services, whereas small hospitals, sole community providers, and non-federal governmental hospitals were less likely to provide them.

## 1. Introduction

Improvements of care with specialization have been demonstrated in hospital-based programs such as primary stroke center certification, which has been shown to improve stroke clinical outcomes [1,2]. These centers are also more likely to offer hospital-based neurological services [3]. Over the last decade, the neurohospitalist model of care was created as a response to the increasing role of neurologists in caring for hospitalized patients [4]. Previous studies in the United Kingdom have highlighted the significant extent to which clinical management is changed with inpatient neurological consultation [5–7]. Development of a neurohospitalist service at an academic medical center has also been associated with decreased length of stay and cost [8]. Furthermore, use of neurology referral services has been shown to significantly

contribute to increased access to and efficiency of patient care [9].

Although inpatient neurological consultation is likely to improve care of patients hospitalized with neurological disease, there is little data on the availability of this service nationwide in the United States. We aimed to determine nationwide availability of hospital inpatient neurological services, defined as neurologists available to see hospitalized patients, and identify hospital-based and location-specific demographic factors associated with inpatient neurological services. An improved understanding of the hospital-based factors and demographic factors associated with inpatient neurological services will help to guide efforts to improve access to inpatient neurological services with the ultimate goal of improving clinical patient outcomes.

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## 2. Patients and methods

We determined the availability of inpatient neurological services based on response to the 2011 American Hospital Association (AHA) annual survey of hospitals in the United States. The AHA Annual Survey of Hospitals is administered to more than 6400 hospitals throughout the United States. The response rate for the 2011 survey was 75%. Hospitals that provide survey data are not paid. Inpatient neurological services were defined as neurologists available to see hospitalized patients.

We analyzed survey information on hospital Accreditation Council for Graduate Medical Education (ACGME) residency affiliation, American Medical Association (AMA) medical school affiliation, Council of Teaching Hospitals of the Association of American Medical Colleges (AAMC), The Joint Commission (JC) accreditation, rural referral center status, sole community provider designation, hospital county, control ownership type (government, non-federal; government, federal; non-government, non-for-profit; investor-owned, for profit), process of emergency response (ER) triage, teaching affiliation, number of medical-surgical intensive care beds, intensive care beds, total number of hospital beds, annual hospital admissions, total hospital average daily census, annual emergency room visits, annual total surgical operations, certification and level of trauma center certification/level of certification, and presence of a 24-h emergency department (ED). We obtained demographic information by linking the hospitals participating in the AHA survey to the 2010 national census for population and household using the hospital address. Demographic information obtained from the census was population of area, percent white, percent black, percent Hispanic, median house value and median household income.

To exclude small hospitals that would not be expected to have the potential to offer inpatient neurological services, only hospitals with greater than or equal to 25 beds were included in the analysis. To describe the differences between hospitals with and without inpatient neurological service, independent *t*-test or Wilcoxon rank sum test were used for comparing continuous measurement depending on whether data are normally distributed. Data normality was determined by both visualization through histogram and D'Agostino-Pearson omnibus test. For the descriptive analysis for categorical measurements,  $\chi^2$  tests were used. Poisson regression was used to estimate the association (rate ratio) between hospital or population factors and the likelihood of having inpatient neurological service. Both univariate and multivariate models were built. The beta coefficients were compared between univariate and multivariate models for the interpretation of confounding or mediation effect. SAS 9.4 was used for all data analysis.

## 3. Results

Of the 3969 hospitals that completed the survey, 3124 fulfilled study criteria, and, among them, 2017 (65%) offered inpatient neurological services, while 1107 did not. A graphic depiction of the nationwide distribution of hospitals that did and did not offer inpatient neurological services can be found in Fig. 1. Compared to hospitals that did not offer inpatient neurological services, those that did were typically larger (mean number of beds 288 versus 92; > 500 beds, 13% versus 0.2%), had higher average daily census (mean 193 versus 52), and had more frequent ED visits (47000 visits vs. 15000 visits per year). Hospitals that offered inpatient neurological services were also more often affiliated with ACGME residency programs (37% versus 4%) and AMA medical schools (45% versus 9%), and were more likely to have JC accreditation (89% versus 58%), primary stroke center certification (44% versus 5%), comprehensive stroke center certification (2% versus 0%), and any teaching affiliation (46% versus 9%). In addition, hospitals with inpatient neurological services were more likely to be certified trauma centers (48% versus 33%), be located in the community (21% versus 5%), have emergency medical service routing of stroke

patients to designated hospitals (50% versus 36%), have higher emergency department triage level system (74% versus 43%), and have intensive care units (20% versus 5%) (Table 1).

Hospitals with inpatient neurological services were more likely to be located in areas with a younger population (median age 36 versus 39 years), with higher percentage of black (16% versus 11%) or Hispanic individuals (14% versus 11%), with a higher median household income (\$50000 versus \$45000), a higher average house value (\$220000 versus \$150000), and a higher population in the immediate area. It was less likely to be located in rural area (15% versus 22%).

Table 2 shows rate ratios after univariate and multivariate analyses. Since we have a large enough sample size (over 3000), all 20 candidate factors were entered for the multivariate analysis. After adjusting for each other, independent hospital characteristics associated with hospital-based neurological services were The Joint Commission accreditation (adjusted rate ratio [RR], 1.35; 95% confidence interval [CI], 1.16–1.57) and larger hospital size (per quartile in number of beds; fourth quartile 4.53; 2.79–7.35). Sole community providers and non-federal government hospitals were less likely to have hospital-based neurological services (0.65; 0.5–0.84 and 0.81; 0.7–0.94). The adjusted RR reported above remained similar after removing those non-significant factors ( $p > 0.05$ ) from the full model.

Of those hospitals that participated in the survey that did not offer inpatient neurologic services, only about 27% (686/1849) were in a region that offered emergency medical service routing of stroke patients to designated hospitals.

## 4. Discussion

We found that among 3124 hospitals greater than 25 beds with emergency departments, approximately two-thirds offered inpatient neurological services. Our results also found that larger hospitals and those hospitals with JC accreditation were both independent hospital characteristics associated with hospital-based neurological services, while sole community provider hospitals and non-federal governmental hospitals were less likely to have such services. Although it is intuitive that hospital size and accreditation would be associated with offering a larger breadth of consultation and specialty services, to our knowledge, previous research has not demonstrated that hospitals under non-federal governmental control are less likely to offer inpatient neurological services. There is currently limited literature available on the differences between non-federal and federal governmental hospitals, though one analysis comparing the services offered by for-profit, non-profit and government hospitals suggested that government hospitals are most likely to supply the unprofitable services that are disproportionately needed by poor and underinsured patients [10]. Based on the results of our analyses, we have found that non-federal hospitals are less likely to offer inpatient neurological services, highlighting a difference between federal and non-federal hospitals and the subspecialty services they provide.

Several factors may contribute to the presence of hospital-based neurological services. Larger hospitals with more resources and funding may be able to offer a wider breadth of specialty consultation services and inpatient services, which then allows them to both afford and prioritize inpatient neurological services. Urban environments may also attract more neurologists to practice in the surrounding community, providing increased opportunities for affiliation with hospitals and provision of inpatient neurological services. Based on our analysis of the 2010 census data, we also found that hospitals offering neurological services were in more affluent, populated and ethnically diverse regions. However, because these demographic factors were not independently associated with inpatient neurological services, this result likely reflected the presence of larger hospitals in more urban areas.

Numerous studies have suggested that consultation or management by a neurologist results in shortened length of stay, reduced costs, high patient satisfaction, and improved patient care [4–8,11]. Similarly,

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