Accessibility to Tertiary Stroke Centers in Hokkaido, Japan: Use of Novel Metrics to Assess Acute Stroke Care Quality

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Background: Both the accessibility and availability of stroke specialists are major determinants of patient outcomes following acute ischemic stroke (AIS). The purpose of this study was to implement novel metrics to assess the accessibility of tertiary stroke centers as well as to evaluate regional disparities in stroke specialists.

Methods: Using network analysis in a geographic information system, we calculated areas within 30- and 60-minute travel times to facilities providing intravenous recombinant tissue-type plasminogen activator and mechanical thrombectomy. We further evaluated the accessibility for the proportion of the population aged 65 years or older that resided outside of these areas. Uniformity in the geographical distribution of stroke specialists was then evaluated using optimal statistical analysis.

Results: Accessibility varied widely from region to region, with low accessibility being concentrated in rural areas with low population density. Accessibility to facilities providing mechanical thrombectomy was especially low, and 17.8% of elderly individuals lived ≥60 minutes from treatment facilities. In addition, the distribution of stroke specialists was uneven compared with the distribution of hospital beds and full-time medical doctors.

Conclusion: The results of this study revealed regional disparities in the spatial accessibility to treatment facilities, as well as in the distribution of stroke specialists in Hokkaido. These findings provide useful information that could be employed to appropriately allocate resources toward the formation of a medical supply system for patients with AIS.

Key Words: Acute ischemic stroke—regional disparity—spatial accessibility—intravenous rt-PA—mechanical thrombectomy.

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Introduction

Intravenous (IV) recombinant tissue-type plasminogen activator (rt-PA) is used for the treatment of acute ischemic stroke (AIS) due to its excellent therapeutic effect.1 Mechanical thrombectomy is additionally performed in patients who demonstrate major artery occlusion, and it is associated with excellent outcomes.2 However, the quality of acute stroke care is not satisfactory, especially in rural areas of Japan. Thus, the collection of clinical evidence to establish an optimal medical system will help ensure the best medical practice is provided to patients with acute stroke nationwide. Both the accessibility and availability of stroke specialists are major determinants of patient outcomes following AIS. It has been reported that the good
outcomes decrease by at least 10% for every 30-minute delay in recanalization. In Japan, only 5%-6% of patients with AIS receive IV rt-PA; this figure is associated with diverse interregional differences and is probably due to the scarcity of stroke specialists in rural areas.

As mentioned, the efficacy of AIS treatment increases with earlier intervention. Hence, measuring spatial accessibility, which represents the ease of access to treatment facilities, can help evaluate regional disparities in patients receiving IV rt-PA. Hokkaido, which accounts for 22% of the total land area of Japan, has a population density of 68.6 people per square kilometer—the lowest of the 47 prefectures. The island is divided into 21 secondary medical areas, according to a regional unit for systematizing the appropriate placement of medical resources and health-care provision systems (Fig 1). Thus, the geographical characteristics of Hokkaido are optimal to assessing regional disparities in spatial accessibility to treatment facilities for the care of AIS.

A geographic information system is a computer-based tool that analyzes, stores, manipulates, and visualizes geographic information on a map. The ArcGIS Network Analyst—a stand-alone commercial software provided by Esri Japan Corporation—can estimate transportation times. The Gini coefficient is an economic index that measures the inequality of income distribution in society and can be applied to indicate uniformity in medical resource distribution. We speculated that analyses using the above-mentioned software and statistical approach could provide novel insights into medical systems providing AIS care in Japan.

The ultimate goal of the present study was to improve the quality of AIS care. To this end, we used descriptive statistics so that we could provide useful information to the legislature in order to aid in the development of optimal medical system infrastructure. More specifically, we implemented novel metrics via a geographic information system to assess the accessibility of tertiary stroke centers, and we mapped regional disparities in the availability of stroke specialists. Additionally, we evaluated uniformity in the geographical distribution of secondary medical areas with respect to stroke specialists.

### Materials and Methods

**Measurement of Spatial Accessibility to Treatment Facilities**

We calculated the population of individuals (aged 65 or older) living outside the service areas of facilities providing IV rt-PA and mechanical thrombectomy, and we used the calculated percentage for each secondary medical area as an evaluation index for spatial accessibility. Based on previous research, “service area” was defined as the driving time, which allowed for transportation to a medical facility that fell within 30 and 60 minutes. Although used in Hokkaido, helicopters were excluded from this study because the main means of emergency transportation is an ambulance. We determined the reach of facilities...
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