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The Japan Neurosurgical Database: Overview and Results of the First-year Survey

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Abstract

The Japan Neurosurgical Database (JND) is a prospective observational study registry established in 2017 by the Japan Neurosurgical Society (JNS) to visualize real-world clinical practice, promote science, and improve the quality of care and neurosurgery board certification in Japan. We summarize JND's aims and methods, and describes the 2018 survey results. The JND registered in-hospital patients' clinical data mainly from JNS training institutions in 2018. Caseload, patient demographics, and in-hospital outcomes of the overall cohort and a neurosurgical subgroup were examined according to major classifications of main diagnosis. Neurosurgical caseload per neurosurgeon in training in core hospitals in 2018 was calculated as an indicator of neurosurgical training. Of 523,283 cases (male 55.3%) registered from 1360 participating institutions, the neurosurgical subgroup comprised of 33.9%. Among the major classifications, cerebrovascular diseases comprised the largest proportion overall and in the neurosurgical subgroup (53.1%, 41.0%, respectively), followed by neurotrauma (19.1%, 25.5%), and brain tumor (10.4%, 12.8%). Functional neurosurgery (6.4%, 3.7%), spinal and peripheral nerve disorders (5.1%, 10.1%), hydrocephalus/developmental anomalies (2.9%, 5.3%), and encephalitis/infection/inflammatory and miscellaneous diseases (2.9%, 1.6%) comprised smaller proportions. Most patients were aged 70–79 years in the overall cohort and neurosurgical subgroup (27.8%, 29.4%). Neurotrauma and cerebrovascular diseases in the neurosurgical subgroup comprised a higher and lower proportion, respectively, than in the overall cohort in elderly patients (e.g. 80 years, 46.9% vs. 33.5%, 26.8% vs. 54.4%). The 2018 median neurosurgical caseload per neurosurgeon in training was 80.7 (25–75th percentile 51.5–117.5). These initial results from 2018 reveal unique aspects of neurosurgical practice in Japan.

Key words: board certification, neurosurgery, real world data, registry, resident training

Introduction

An increasing interest in evidence-based medicine, and improving the quality of patient care and patient safety has created a demand for accurate and accessible information on activity and trends in clinical practice worldwide.[1] In today's rapidly changing healthcare world, physicians and other healthcare providers are under increasing pressure to show improvement in treatment, patient outcomes, and quality of care. Although training the future generation of neurosurgeons is an important task, recent regulations on working hour restrictions in medical practice may affect the quality of neurosurgical training.[2] To address such challenges, several neurosurgical societies have launched nationwide neurosurgical registries. In the United States (US), the American Association of Neurological Surgeons launched the National Neurosurgery Quality and Outcomes Database (N2QOD) in 2012, a nationwide prospective longitudinal registry. In the United Kingdom, the Society of British Neurological Surgeons established the Neurosurgical National Audit Program (NNAP) as a key driver of quality improvement.[3]

The Japan Neurosurgical Society (JNS) was founded in 1965. Its objective is to develop and popularize neurosurgical science and contribute to academic development in Japan, as well as national welfare through neurosurgical practice, by presenting neurosurgical theories and application research, exchanging knowledge, and cooperating and collaborating with other members and related societies in Japan and foreign countries.[4] The JNS is one of the 19 basic clinical departments accredited by the Japanese Medical Specialty Board (JSMB),[5] and is closely associated with relevant subspecialty societies for cerebrovascular; neuroendovascular; brain tumor; functional, pediatric, and spinal surgery; and neurotrauma.

As of September 2018, there were 7794 board certified members engaged in medical practice. The JNS has 9840 members in total, including 148 honorary/special members (including 43 foreign members), 34 guest members, and 60 supporting members.[4] These members include physicians in training. In 2015, the JNS launched the Japan Neurosurgery Registry (JNR) using a web-based system, but this database only enrolled surgical cases and was not linked to the JNS board-certification system.[6] Japanese neurosurgeons are unique in their significant engagement not only in surgical but also in non-surgical patient care, especially in the field of neuroemergency medicine and stroke; but the extent of these contributions in a nationwide, real-world situation remain unknown.

In July 2016, the Database Committee of the JNS was established to create the Japan Neurosurgical Database (JND),[7] a nationwide, hospital-based multicenter registry. The JND is a for-surgeon-by-surgeon program, established in 2017, aimed primarily to visualize real-world clinical practice, promote science, and improve the quality of patient care and the neurosurgery board certification system in Japan.

This paper provides an overview of the aims and methods of the JND and describes the results of the first-year survey.

Overview of the JND and Methods of the First Year Survey

Ethics statement

This study was approved by the Research Ethics Committee of the JNS (2017009) and the Yamagata University Institutional Review Board (2017009R2-1), which waived the requirement for individual informed consent. Patients were provided with an opportunity to indicate whether they wanted to share their clinical information when they registered for care. Our study protocol followed the "opt-out" rule.

Primary aims of the JND

The JND is a prospective observational study project designed to collect, analyze and report nationwide clinical data on both surgical and non-surgical cases mainly in the inpatient hospital setting.[7] The Database Committee of the JNS have convened regular meetings to discuss the aims and design of the JND since 2017.

Target data include:

- Characteristics of the JNS training institutions [e.g. academic vs. nonacademic, hospital classification (core, branch, and related hospitals based on a training program, case volume, geographical location].
- Basic information regarding benchmarks and future reforms of the neurosurgical training systems.
- Assessment of neurosurgical healthcare quality.
- Basic information regarding prediction of risk and outcomes of neurosurgical procedures and management.
- Evaluation of progress and completion of neurosurgical training for individual residents wishing to apply for the JNS Board Examination.
- Evaluation of clinical activities for renewal of the JNS Board Certification.
- Infrastructure for national and international research and clinical trials.

Data sources

The inclusion criteria of the JND were as follows: in-hospital cases admitted to the neurosurgical departments of JNS training institutions; neurosurgeons who work for other related departments (e.g., endovascular or rehabilitation department) may register data in the JND as proof of their personal experience. The registration items of the JND are shown in Table 1.

The database consists of multiple hierarchical levels. The first level contains basic clinical information such as data identification number, age, sex, postal code of home address, level of consciousness on admission as measured by the Japan Coma Scale (JCS), and route (e.g. emergency transportation) or mode (emergency or scheduled) of admission. The individual patient data is linked with attending physicians or residents as proof of their clinical experience (being used to apply for the JNS board examination from 2019 onward). The second level consists of the major classifications of the JND diseases, the main diagnosis, and purposes of admission. The following are the seven major classifications: (1) cerebrovascular diseases, (2) brain tumor, (3) neurotrauma, (4) hydrocephalus/developmental anomalies, (5) functional neurosurgery, (6) spinal and peripheral nerve disorders, and (7) encephalitis/infection/inflammatory and miscellaneous diseases. The main diagnosis is selected from a list linked to the major classification, and up to three subsidiary diagnoses can be registered for each admission (Table 1). The purpose of the admission is selected from a list of nine options: (1) operation, (2) medical management, (3) chemotherapy, (4) radiotherapy, (5) rehabilitation, (6) diagnosis/investigation, (7) terminal care, (8) education admission, and (9) other adjunctive therapy for brain tumor.

The mode of operation is selected from a list of operations based on the relevant main or subsidiary diagnoses. Up to five operations can be registered for each diagnosis (Table 1). Mode of operation is linked with types of anesthesia and classified into types of interventions (e.g. direct surgery versus endovascular; burr hole surgery, craniotomy versus endoscopic). Clinical outcomes at discharge are measured by the modified Rankin Scale and/or Glasgow Outcome Scale (specifically for neurotrauma), in-hospital mortality, short-term functional outcome, length of hospital stay, and destination after discharge are registered.

Data collection and management

Online registration of the JND data started in January 2018. Data were registered using data collection forms after patient data had been de-identified at the participating hospitals. Neurosurgeons are responsible for registering data in the JND, and chief neurosurgeons are responsible for approving the data and confirming data integrity. Data registration at each hospital was approved by either the Institutional Review Board or the hospital director. Data are fixed and summarized on a yearly basis (January 1–December 31), and the chief neurosurgeons are responsible for submission of patient clinical data within 3 months of discharge.

Access to the JND data

The basic statistics and information regarding the registration of the JND are accessible at the JNS homepage by JNS members.[7] The neurosurgeons can download the list of registered cases and individual patient data of their own institutions for administrative and research purposes. The applicants of the JNS Board Examination can access their personal experiences from the JND database.[7]

Analysis of the first year survey

Characterization of the JNS postgraduate training hospitals The overall and surgical caseloads registered in 2018 were examined in the core hospitals for the JNS postgraduate training program. The numbers of JNS neurosurgeons in training in the core hospitals were obtained from the Institutional Report of the JNS.[4]

Annual case volume based on the major classification The number of registered cases in the overall cohort was calculated based on the major classification of the main diagnosis. An individual patient in the overall cohort has one main diagnosis with/without subsidiary diagnoses [e.g. main diagnosis: subarachnoid hemorrhage, subsidiary diagnosis: acquired (secondary) hydrocephalus]. In this study, the neurosurgical subgroup consisted of patients who received at least one neurosurgical procedure related to the main diagnosis listed in Table 1.

Since a patient may undergo multiple neurosurgical procedures related to the main or subsidiary diagnosis, the number of registered neurosurgical procedures were calculated based on the major classification of corresponding main and/or subsidiary diagnoses.

Patient demographics (age and sex), length of hospital stay, and in-hospital mortality were examined based on the main diagnosis of the overall cohort and neurosurgical subgroup, respectively.

Indicator of neurosurgical training in the core hospitals As of 2018, there were 94 postgraduate training programs in the JNS. The institutions participating in each JNS training program consist of single core and branch hospitals, and may also be related hospitals as stipulated in the Internal

Table 1 Japan Neurosurgery Database (JND)

Category	Item name	
Institutional information	Institutional code	
Patient information	Data identification no.	
	Date of birth (Y/M/D)	
	Sex	
	Offer of refusal of registration	
	Date of accepted refusal (Y/M/D)	
	Postal address of patient's home	
	Date of onset (Y, Y/M, Y/M/D, or unknown)	
	Premorbid mRS	
Attending surgeon information	Attending surgeon 1	
	Attending surgeon 2	
	Attending surgeon 3	
	Attending surgeon 4	
	Attending surgeon 5	
	Attending surgeon 6	
Admission information	Japan Coma Scale on admission	○ 0: Normal
		○ 1: Almost fully conscious
		○ 2: Unable to recognize time, place, and person
		○ 3: Unable to recall name or date of birth
		○ 10: Can be aroused by easily by being spoken to
		○ 20: Can be aroused with a loud voice or shaking of shoulders
		○ 30: Can be aroused only by repeated mechanical stimuli
		○ 100: Responds with movements to avoid the stimulus
		○ 200: Responds with slight movements, including decerebrate and decorticate posture
		○ 300: Does not respond at all except for changes in respiratory rhythm

(*Continued*)

Table 1 Japan Neurosurgery Database (JND)—Continued

Category	Item name	
	Glasgow Coma Scale (GCS) (neurotrauma cases >3 years old)	Eye opening (E) ○ 4: Open spontaneousy ○ 3: Open to verbal command ○ 2: Open to pain ○ 1: No eye opening Verbal response (V) ○ 5: Oriented ○ 4: Confused ○ 3: Inappropriate words ○ 2: Incomprehensive sounds ○ 1: No verbal response ○ 1: Intubated (T) Motor response (M) ○ 6: Obeys commands ○ 5: Localising pain ○ 4: Withdrawal from pain ○ 3: Flexion to pain ○ 2: Extension to pain ○ 1: No motor response
	Glasgow Coma Scale (GCS) (neurotrauma cases <2 years old)	Eye opening (E) →same as above Verbal response (V) ○ 5: Coos, babbles ○ 4: Irritable, cries ○ 3: Cries to pain ○ 2: Moans to pain ○ 1: None Motor response (M) →same as above
	Date of admission (Y/M/D)	
	Route of admission	○ In-hospital referral from other department ○ Direct admission from patient home ○ Transfer from other hospital or clinic ○ Transfer from nursing home, welfare facility ○ In-hospital birth ○ Others

Table 1 Japan Neurosurgery Database (JND)—Continued

Category	Item name	
	Scheduled Emergency admission	
	EMS transportation	Y/N
	Information of postal address of EMS call	
Discharge information	Date of discharge (Y/M/D)	
	Length of hospital stay	
	Destination at discharge	○ In-hospital other deparment ○ Home ○ Transfer to other hospital ○ Geriatric health services facility ○ Nursing home other than hospitals ○ In-hospital death ○ Others
	mRS at discharge	○ 0: No symptoms ○ 1: No significant disability. Able to carry out all usual activities, despite some symptoms. ○ 2: Slight disability. Able to look after own affairs without assistance, but unable to carry out all previous activities. ○ 3: Moderate disability. Requires some help, but able to walk unassisted. ○ 4: Moderately severe disability. Unable to attend to own bodily needs without assistance, and unable to walk unassisted. ○ 5: Severe disability. Requires constant nursing care and attention, bedridden, incontinent. ○ 6: Dead
	Glasgow Outcome Sacle (GOS) at discharge	○ 1: Dead ○ 2: Vegetative state ○ 3: Severely disabled ○ 4: Moderately disabled ○ 5: Good recovery

(*Continued*)

Table 1 Japan Neurosurgery Database (JND)—Continued

Category	Item name	
Purpose of admission	☐ Diagnosis investigation	Y/N (if Y, additional data required)
	☐ Education admission	Y/N
	☐ Medical management	Y/N (if Y, additional data required in the medical management section)
	☐ Operation	Y/N (if Y, additional data required in the operation section)
	☐ Chemotherapy	Y/N (if Y, additional data required in the Chemotherapy section)
	☐ Radiotherapy	Y/N (if Y, additional data required in the Radiotherapy section)
	☐ Rehabilitation	Y/N
	☐ Terminal care	Y/N
	☐ Other adjunctive therapy for brain tumor	
Diagnostic procedure	☐ CT ☐ MRI ☐ Electroencephalogram (EEG) ☐ Nuclear medicine (SPECT, PET) ☐ Higher cognitive function test ☐ Myelography ☐ Catheter angiography and interpretation ☐ Others	Attending surgeons are automatically registered for experience of examination (up to six attending surgeons)
Catheter angiography	Operator 1 Operator 2 Operator 3 Operator 4 Operator 5 Operator 6	Attending surgeons are NOT automatically registered for experience of examination. Up to six attending surgeons can be allowed to register for investigation.
Medical management	☐ Antiplatelet therapy ☐ Anticoagulation therapy ☐ Brain protective therapy (Edaravone)	Attending surgeons are automatically registered for experience of examination (up to six attending surgeons)

Table 1 Japan Neurosurgery Database (JND)—Continued

Category	Item name			
	☐ Anti-edema therapy (Glycerol, Mannitol) ☐ Medical management of seizure and epilepsy ☐ Medical management of headache ☐ Medical management of infection ☐ Others			
Chemotherapy	☐ Oral ☐ Intravenous ☐ Intrathecal ☐ Intracerebral ☐ Intraarterial ☐ Others			
Stereotactic radiosurgery	Stereotactic radiosurgery	Y/N	–	Operator 1 Operator 2 Operator 3 + Other operator (except neurosurgeon)
	Radiotherapy (excluding stereotactic radiotherapy)	○ Local ○ Whole brain ○ Whole spinal ○ Others (Proton, heavy particle radiotherapy)		
Other adjunctive therapy	Other adjunctive therapy for brain tumors	☐ Immunotherapy ☐ Optune®		
Operative procedures	Major classification	Main diagnosis	Mode of presentation	Mode of operations (○: single choice ☐: multiple choice)
	Cerebrovascular diseases	○ Cerebral aneurysm	○ Unruptured (Asymptomatic) ○ Unruptured (Symptomatic) ○ Ruptured ○ Others	Direct surgery ☐ Neck clipping ☐ Coating ☐ Parent artery proximal occlusion (parent artery clipping) ☐ Trapping ☐ Bypass (combined) ☐ Others

(*Continued*)

Table 1 Japan Neurosurgery Database (JND)—Continued

Operative procedures	Major classification	Main diagnosis	Mode of presentation	Mode of operations (○: single choice □: multiple choice)
	Cerebrovascular diseases			Endovascular treatment □ Coil embolizaiton (w/o stent) □ Coil embolizaiton (with stent) □ Flow diverter □ Others ○ Endovascular therary for cerebral vasosplasm (ruptured cases only)
		○ Cerebral arteriovenous malformation	○ Unruptured (Asymptomatic) ○ Unruptured (Symptomatic) ○ Ruptured ○ Others	□ Removal □ Endovascular embolizaiton □ Removal of hematoma □ Others
		○ Dural arteriovenous fistula	○ Nonhemorrhagic (Asymptomatic) ○ Nonhemorrhagic (Symptomatic) ○ Hemorrhagic ○ Others	□ Shunt obliteration □ Endovascular embolization □ Removal of hematoma □ Others
		○ Cavernous malformation	○ Asymptomatic ○ Symptomatic ○ Others	□ Removal □ Others
		○ Carotid stenosis (cervical)	○ Asymptomatic ○ Symptomatic ○ Others	□ Endarterecotmy □ STA-MCA bypass □ Other bypass surgery Endovascular surgery □ Carotid stenting □ Percutaneous angioplasty □ Others
		○ Extracranial arterial occlusive disease (excluding carotid stenosis (cervical))	○ Asymptomatic ○ Symptomatic ○ Others	□ Endarterecotmy □ STA-MCA bypass □ OA-PICA bypass □ Other revascularization

Table 1 Japan Neurosurgery Database (JND)—Continued

Operative procedures	Major classification	Main diagnosis	Mode of presentation	Mode of operations (○: single choice □: multiple choice)
	Cerebrovascular diseases			Endovascular surgery □ Percutaneous angioplasty (with stent) □ Percutaneous angioplasty (w/o stent) □ Others
		○ Intracranial arterial occlusive disease (excluding moyamoya disease)	○ Asymptomatic ○ Symptomatic ○ Others	□ STA-MCA bypass □ OA-PICA bypass □ Other revascularization Endovascular surgery □ Percutaneous angioplasty (with stent) □ Percutaneous angioplasty (w/o stent) □ Others
		○ Moyamoya disease	○ Asymptomatic ○ Ischemic ○ Hemorrhagic ○ Others	□ Direct bypass □ Indirect bypass □ Removal of hematoma □ Ventricular drainage □ Others
		○ Hypertensive intracerebal hemorrhage		□ Removal of hematoma □ Ventricular drainage □ Others
		○ Nonhypertensive intracerebal hemorrhage (excluding moyamoya disease and vascular malformation)	□ Cerebral amyloid angiopathy □ Brain tumor □ Anticoagulant-associated □ Others	□ Removal of hematoma □ Ventricular drainage □ Others
		○ Cerebral arterial dissection	○ Asymptomatic ○ Ischemic ○ Hemorrhagic ○ Others	Direct surgery □ Coating □ Proximal artery clipping □ Trapping □ Bypass (combined) □ Others Endovascular surgery □ Coil embolization (with stent) □ Coil embolization (w/o stent) □ Others

(*Continued*)

Table 1 Japan Neurosurgery Database (JND)—Continued

Operative procedures	Major classification	Main diagnosis	Mode of presentation	Mode of operations (○: single choice □: multiple choice)
	Cerebrovascular diseases	○ Ischemic stroke transient ischemic attack	○ Cardioembolic ○ Atherothrombotic ○ Lacunar ○ ESUS ○ Transient ischemic attack ○ Others	□ Intavenous *t*-PA infusion □ Acute reperfusion therapy (endovascular) □ Decompression craniectomy □ Others
		○ Crerebral venous thrombosis		□ Endovascular surgery □ Decompression craniectomy □ Others
		○ Skull defect (after external decompression)		○ Cranioplasty
		○ Other cerebrovascular diseases		
	Major classification	Main diagnosis		Mode of operations (○: single choice □: multiple choice)
	Brain tumor	○ Meningioma ○ Astrocytoma ○ Oligodendroglima ○ Glioblastoma ○ Other neuroepithelial tumor ○ Pituitary adenoma ○ Schwannoma ○ Craniopharyngioma ○ Malignant lymphoma ○ Hemangioblastoma ○ Germ cell tumor, pineal tumor ○ Dermoid, Epidermoid ○ Cystic lesion (other than: Dermoid, Epidermoid, Arachnoid cyst) ○ Chordoma, Chondrosarcoma ○ Primary skull base tumor (other than: Chordoma, Chondrosarcoma including direct invasion to nasopharyngeal locations) ○ Metastatic brain tumor ○ Embryonal brain tumor ○ Other brain tumor		□ Removal □ Biopsy □ Transnasal surgery □ Extensive skill base tumor resection·reconstruction □ Tumor embolization (endovascular surgery) □ Decompressive craniectomy □ Others (e.g. Ommaya reservoir)
		○ Malignant skull tumor ○ Benign skull tumor ○ Other skull tumor		○ Removal ○ Biopsy □ Embolization (endovascular)

Table 1 Japan Neurosurgery Database (JND)—Continued

Operative procedures	Major classification	Main diagnosis	Mode of presentation	Mode of operations (○: single choice □: multiple choice)
	Brain tumor	○ Intraorbital tumor		○ Removal ○ Biopsy □ Embolization (endovascular)
		○ Scalp tumor		○ Removal ○ Biopsy □ Embolization (endovascular)
		○ Skull defect after decompression		○ Cranioplasty
	Major classification	Main diagnosis	Mechanism of injury	Mode of operations (○: single choice □: multiple choice)
	Neurotrauma	○ Traumatic intracranial hemorrhage group □ Acute epidural hematoma □ Acute subdural hematoma □ Traumatic intracerebal hemorrhage/ cerebral contusion □ Traumatic subarachnoid hemorrhage	○ Traffic accident ○ Fall ○ Sport ○ Violence Abuse ○ Others	□ Removal of hematoma □ Decompressive craniectomy □ Burr hole surgery □ Others
		○ Chronic subdural hematoma		□ Burr hole and irrigation □ Removal of hematoma (craniotomy) □ Others
		○ Head bruises		
		○ Skull fracture		○ Cranioplasty
		○ Cerebral concussion		
		○ Diffuse axonal injury		□ Placement of ICP monitor
		○ Intraventricular hemorrhage		□ Ventricular drainage
		○ Cranial nerve injury (optic canal fracture)		○ Ventricular drainage ○ Optic nerve decompression ○ Others
		○ Cranial nerve injury (other than optic canal fracture)		
		○ Traumatic cerebrovascular diseases		□ Bypass surgery □ Endovascular surgery □ Others

(*Continued*)

Table 1 Japan Neurosurgery Database (JND)—Continued

Operative procedures	Major classification	Main diagnosis	Mode of presentation	Mode of operations (○: single choice □: multiple choice)
	Neurotrauma	○ Traumatic epilepsy		
		○ Primary brainstem injury		
		○ Facial injury (orbital fracture)		○ Open reduction of orbital fracture
		○ Facial injury (facial bone fracture)		○ Facial fracture reduction
		○ Facial injury (others)		
		○ Skull defect after external decompression		○ Cranioplasty
		○ Cerebrospinal fluid leakage		○ Repair of CSF leakage
		○ Penetrating brain injury		○ Removal of foreign material
		○ Other head trauma		○ Others
	Major classification	**Main diagnosis**	**Etiology**	**Mode of operations (○: single choice □: multiple choice)**
	Hydrocephalus/ Developmental anomalies	○ Congenital hydrocephalus	○ Aqueductal stenosis ○ Hydrocephalus associated with myelomeningocele ○ Other congenital hydrocephalus	□ VP shunt □ LP shunt □ VA shunt
		○ Acquired (secondary) hydrocephalus	○ Intracerebral hemorrhage, intraventricular hemorrhage ○ Subarachnoid hemorrhage ○ Ischemic stroke ○ Traumatic ○ Brain tumor ○ Meningitis ○ Other	□ Shunt revision □ Third ventriculostomy □ Ventricular drainage
		○ Idiopathic normal pressure hydrocephalus		□ Shunt removal □ Others

Table 1 Japan Neurosurgery Database (JND)—Continued

Operative procedures	Major classification	Main diagnosis	Mode of presentation	Mode of operations (○: single choice □: multiple choice)
	Hydrocephalus/ Developmental anomalies	○ Craniosynostosis		○ Cranioplasty (without distraction) ○ Cranioplasty (with distraction) ○ Suturectomy ○ Others (e.g. removal of devices)
		○ Encephalocele		□ Repair □ Others
		○ Arachnoid cyst		□ Fenestration (craniotomy) □ Fenestration (endoscopic) □ Cyst-peritoneal shunt □ Others
		○ Other cranial cerebral anomaly		□ Surgery □ Others
		○ Chiari malformation (Type I) ○ Chiari malformation (Type II) ○ Other anomaly of craniocervical junction		□ Foramen magnum decompression □ Syringo-subarachnoid shunt □ Fixation □ Others
		○ Myelomeningocele myeloschisis		□ Repair □ Others
		○ Spinal lipoma		□ Untethering □ Others
		○ Other spinal cord spinal anomaly		□ Untethering □ Others
	Major classification	**Main diagnosis**	**Lesion location**	**Mode of operations (○: single choice □: multiple choice)**
	Spinal and peripheral nerve disorders	○ Spinal degenerative disorders □ Spondylosis □ Ossification of posterior longitudinal ligament □ Developmental stenosis □ Disc herniation	○ Craniocervical junction ○ Middle, lower cervical ○ Thoracic ○ Lumbosacral	□ Anterior decompression □ Anterior fixation □ Posterior decompression □ Posterior fixation

(*Continued*)

Table 1 Japan Neurosurgery Database (JND)—Continued

Operative procedures	Major classification	Main diagnosis	Mode of presentation	Mode of operations (○: single choice □: multiple choice)
	Spinal and peripheral nerve disorders	□ Spinal canal stenosis □ Ossification of yellow ligament □ Spondylolysis □ Spondylolisthesis □ Other spinal degenerative disorders		□ Desectomy □ Simultaneous anterior and posterior decompression □ Others
		○ Spinal tumor ○ Intramedullary tumor ○ Extramedullary tumor (intradural confined) ○ Extramedullary tumor (exradural and paraspinal extension) ○ Primary vertebral tumor ○ Metastatic vertebral tumor ○ Other spinal tumor	○ Craniocervical junction ○ Middle, lower cervical ○ Thoracic ○ Lumbosacral	○ Total subtotal removal ○ Partial removal ○ Biopsy ○ Others
		○ Syringomyelia ○ Tonsillar Descent (Chiari Type I) ○ Adhesive arachnoiditis ○ Traumatic ○ Others		□ Syringo shunt □ Foramen magnum decompression □ Lysis of adhesion □ Others
		○ Spinal vascular diseases ○ Dural arteriovenous fistula ○ Perimedullary arteriovenous malformation ○ Extradural arteriovenous fistula ○ Intramedullary arteriovenous malformation ○ Cavernous malformation ○ Extradural hematoma ○ Other spinal vascular disorders	○ Craniocervical junction ○ Middle, lower cervical ○ Thoracic ○ Lumbosacral	○ Arteriovenous fistura obliteration ○ Removal ○ Others □ Endovascular obliteration
		○ Spinal trauma ○ Without bone injury ○ Dislocation fracture ○ Vertebral compression fracture ○ Other spinal trauma	○ Craniocervical junction ○ Middle, lower cervical ○ Thoracic ○ Lumbosacral	□ Anterior decompression □ Posterior decompression □ Fixation □ Percutaneous vertebroplasty □ Others

Table 1 Japan Neurosurgery Database (JND)—Continued

Operative procedures	Major classification	Main diagnosis	Mode of presentation	Mode of operations (○: single choice □: multiple choice)

	Spinal and peripheral nerve disorders	○ Spinal infection
		  ○ With abcess formation
		  ○ Without abcess formation
				□ Anterior decompression
				□ Posterior decompression
				□ Fixation □ Others

		○ Peripheral nerve disorders
		  ○ Carpal tunnel syndrome
		  ○ Cubital tunnel syndrome
		  ○ Tarsal tunnel syndrome
		  ○ Brachial plexus injury
		  ○ Other peripheral nerve disorders
				□ Release surgery
				□ Others

		○ Spinal deformity ○ Other spinal and peripheral nerve disorders	○ Craniocervical junction ○ middle, lower cervical ○ Thoracic ○ Lumbosacral	○ Posterior fixation ○ Simultaneous anterior and posterior decompression ○ Others
	Major classification	Main diagnosis		Mode of operations (○: single choice □: multiple choice)
	Functional neurosurgery	○ Epilepsy		□ Implantation of intracranial electrodes □ Temporal lobectomy (for TLE) □ Selective amygdalohippocampectomy □ Multiple hippocampal transection □ Lobectomy (excluding for TLE, functional or anatomical) □ Multilober resection (functional or anatomical) □ Lesionectomy (structural lesion) □ Focus resection (for neocortical epilepsy) □ Hemispherectomy (functional or anatomical) □ Callosotomy

(*Continued*)

Table 1 Japan Neurosurgery Database (JND)—Continued

Operative procedures	Major classification	Main diagnosis	Mode of presentation	Mode of operations (○: single choice □: multiple choice)
	Functional neurosurgery			□ Multiple subpial transection (MST) □ Stereotactic ablation (including laser or MRI guided) □ Implantation of vagus nerve stimulation system □ Others
		○ Trigeminal neuralgia ○ Hemifacial spasm ○ Other		○ Microvascular decompression ○ Others
		○ Parkinson's disease ○ Essential tremor ○ Dystonia ○ Other involuntary movement disorders ○ Spasicity ○ Pain ○ Other functional disorders		Stereotactic neurosurgery ○ Deep brain stimulation ○ Ablation ○ Focused ultrasound (FUS) ○ Others ○ Implantation of spinal cord stimulation system ○ Implantation of other stimulation system ○ Implantation of drug delivery infusion pump ○ Neurotomy (selective) ○ Dorsal rhizotomy (selective) ○ Other functional neurosurgery
	Major classification	**Main diagnosis**		**Mode of operations (○: single choice □: multiple choice)**
	Encephalopathy / Infection / Inflammatory / Miscellaneous diseases	○ Metabolic encephalopathy, hypertensive encephalopathy		
		○ Viral infection ○ Meningitis ○ Encephalitis ○ Slow virus infection ○ Other virus infection		○ Biopsy ○ Others

Table 1 Japan Neurosurgery Database (JND)—Continued

Operative procedures	Major classification	Main diagnosis	Mode of presentation	Mode of operations (○: single choice □: multiple choice)

	Encephalopathy / Infection / Inflammatory / Miscellaneous diseases	○ Bacterial infection
		  ○ Meningitis
		  ○ Cerebral abscess
		  ○ Subdural empyema
		  ○ Other bacterial infection
				○ Removal
				○ Drainage
				○ Others

		○ Tuberculosis		○ Biopsy ○ Others
		○ Neurosyphilis		○ Biopsy ○ Others
		○ Other infectious diseases		○ Biopsy ○ Others

		○ Inflammatory diseases
		  ○ Degenerative diseases
		  ○ Collagen diseases
		  ○ Angiitis
		  ○ Sarcoidosis
		  ○ Other inflammatory diseases
				○ Biopsy
				○ Others

		○ Vascular dementia		
				○ Others (e.g. tracheostomy)
Operative procedures (main diagnosis)	Date of operation (Y/M/D)			
	Age at the operation			
	Operation 1 classification of mode			
	Operatior			
	Supervisor			
	Operator (craniotomy)			
	Assistant			
	Observer			
	Mode of anesthesia			
	No. of operation			

(*Continued*)

Table 1 Japan Neurosurgery Database (JND)—Continued

Operative procedures	Major classification	Main diagnosis	Mode of presentation	Mode of operations (○: single choice □: multiple choice)
Operative procedures (subsidiary diagnosis 1)	Subsidiary diagnosis 1			
	Operation 2 classification of mode			
	Operatior			
	Supervisor			
	Operator (craniotomy)			
	Assistant			
	Observer			
	Mode of anesthesia			
	No. of operation			
Operative procedures (subsidiary diagnosis 2)	Subsidiary diagnosis 2			
	Operation 2 classification of mode			
	Operatior			
	Supervisor			
	Operator (craniotomy)			
	Assistant			
	Observer			
	Mode of anesthesia			
	No. of operation			
Operative procedures (subsidiary diagnosis 3)	Subsidiary diagnosis 3			
	Operation 2 classification of mode			
	Operatior			
	Supervisor			
	Operator (craniotomy)			
	Assistant			
	Observer			
	Mode of anesthesia			
	No. of operation			
Operative information	Operation 4 or more	Y/N		

Regulations of the JNS on the Board Certification Program.[4] Core hospitals are those designated as advanced treatment hospitals by the Health, Labor and Welfare Minister, or that meet the criteria defined by the JNS (e.g. annual neurosurgical caseload ≥300 cases/year, one program director, and additionally more than four advising doctors). Among the 95 core hospitals, 84 (88.4%) are university hospitals. The branch hospitals must belong to a single training program, but related hospitals may participate in multiple training programs to meet the need for training of specific expertise (e.g. pediatric, functional, or spinal neurosurgery) or local healthcare.

All hospitals belonging to the JNS training programs were asked to participate in the JND project. In addition, other hospitals where JNS board-certified neurosurgeons are enrolled were permitted to participate in this project for renewal of their board certification. Since all the core hospitals participated in the JNS training system in the 2018 first-year survey, the association between the number of neurosurgeons in training and annual surgical caseload in individual core hospitals was examined. Further, the association between the number of neurosurgeons in training and that of the board-certified neurosurgeons in these hospitals was also examined. The median [interquartile range (25–75th percentile)] of surgical caseload per neurosurgeon in training per year was also calculated.

Statistical analysis We described the number and proportion of registered patients in the overall cohort and neurosurgical subgroup based on the major classification of the main diagnosis. Age and length of hospital stay were described using mean ± standard deviation, and median and 25–75th quartile. The association between the number of neurosurgeons, admissions, and neurosurgical cases were examined using linear regression analysis. *P*-values <0.05 were judged to indicate statistical significance. All statistical analyses were performed with JMP software (version pro 13, SAS Institute, Cary, NC, USA).

Results

Characterization of the JNS postgraduate training hospitals

As of August 7, 2019, of the 523,283 cases (male 53.7%, female 46.3%) admitted between January 1, 2018 and December 31, 2018, which were registered from 1360 participating JND institutions, the neurosurgical subgroup (177,184 cases) comprised 33.9%.

The rates of participation in the JND project based on the institutional category were 100%, 95.8%, and 71.8% for the core, branch, and related hospitals, respectively. In addition, 230 other hospitals participated in this study. In the core hospitals, the median (25–75th percentile) overall and neurosurgical caseloads in 2018 were 677.5 (515–885.25) and 353.5 (273.75–435.25) per year, respectively.

Patient demographics based on the major classification of the main diagnosis in the overall cohort

The patient demographics, length of hospital stay, and in-hospital mortality for the overall cohort according to the major classification of the main diagnosis are shown in Table 2. Cerebrovascular diseases comprised 53.1%, followed by neurotrauma, brain tumor, functional neurosurgery, spinal and peripheral nerve disorders,

Table 2 Demographic data of the whole cohort in the first-year survey in the JND

Main classification	No.		Age	Men (%)	In-hospital mortality (%)	Length of hospital stay
	Case no.	%	Mean ± SD			Median ± IQR
Cerebrovascular diseases	277,885	53.1	70.5 (14.9)	53.7	6.5	16 (8–31)
Brain tumor	54,332	10.4	60.9 (18.0)	50.5	3.0	12 (3–25)
Neurotrauma	99,747	19.1	70.3 (21.2)	63.8	4.3	9 (4–18)
Hydrocephalus/Developmental anomalies	14,931	2.9	56.2 (31.0)	53.0	1.2	12 (5–23)
Spinal and peripheral nerve disorders	26,715	5.1	66.4 (16.6)	57.9	0.5	15 (9–25)
Functional neurosurgery	33,521	6.4	60.5 (21.2)	52.8	1.1	8 (4–16)
Encephalitis/Infection/Inflammatory/Miscellaneous diseases	15,363	2.9	64.9 (20.0)	49.6	3.8	8 (3–20)
Unclassified	789	0.2	68.7 (19.1)	-	5.3	10 (4–23)

JND: Japan Neurosurgical Database, SD: standard deviation, IQR: interquartile range, Unclassified: the registered cases with main diagnosis unavailable.

hydrocephalus/developmental anomalies, and encephalitis/infection/inflammatory and miscellaneous diseases. Men comprised the largest proportion in neurotrauma (63.8%), followed by spinal and peripheral nerve disorders (57.9%). For the remaining classifications, the proportion of men ranged between 50 and 55%. In-hospital mortality was highest in cerebrovascular diseases (6.5%), followed by neurotrauma (4.3%). The median length of hospital stay was longest for those with cerebrovascular diseases (range 8–16 days, for all major classifications).

Patient demographics based on the major classification of the main diagnosis in the neurosurgical subgroup

The patient demographics, length of hospital stay, and in-hospital mortality of the neurosurgical subgroup according to the major classification of the main diagnosis are shown in Table 3. Cerebrovascular diseases comprised 41.0%, followed by neurotrauma, brain tumor, spinal and peripheral nerve disorders, hydrocephalus/developmental anomalies, functional neurosurgery, and encephalitis/infection/inflammatory and miscellaneous diseases. The proportion of men ranged from 45.1% in functional neurosurgery to 68.2% in neurotrauma. In-hospital mortality was highest in cerebrovascular diseases (6.0%), followed by neurotrauma (3.4%), and lowest in functional neurosurgery (0.1%). The median length of hospital stay was the longest for those with encephalitis/infection/inflammatory and miscellaneous diseases (range 10–23 days for all major classifications).

Total neurosurgical procedures registered in the first year survey of the JND

The total number of neurosurgical procedures registered in the first year JND survey was 207,783; the neurosurgical procedures, related to the main and subsidiary diagnoses comprised 91.9% and 7.1%, respectively. Cerebrovascular diseases comprised 39.9%, followed by neurotrauma (24.3%), brain tumor (12.2%), spinal and peripheral nerves (9.2%), hydrocephalus/developmental anomalies (8.8%), functional neurosurgery (3.5%), and encephalitis/infection/inflammatory and miscellaneous diseases (2.2%).

The proportion of major classification of the overall cohort by age group

The majority of patients in the overall cohort were aged 70–79 years (27.8%) (Fig. 1), followed by octogenarians (23.0%). In the overall cohort, more than 50% of patients who were aged ≥40 years were classified with cerebrovascular diseases. Neurotrauma classification showed bimodal peaks greater than 25% in patients aged 0–29 years and ≥80–100 years. Brain tumor comprised more than 10% in those aged between 0 and 69 years with a peak (20.5%) at 30–39 years. Hydrocephalus/developmental anomalies were classified in 35.0% of patients aged 0–9 years, and this markedly decreased in patients aged >10 years. Functional neurosurgery peaked in patients who were aged 20–29 years (23.2%), followed by those aged 10–19 and 30–39 years; spinal and peripheral nerve disorders remained almost constant (4–6%) in those aged between 10 and 89 years.

The proportion of major classification of the neurosurgical subgroup by age group

The proportion of the neurosurgical subgroup in the overall cohort remained relatively constant between 28 and 38% in patients aged 0–89 years, and decreased to 23.0% and 16.7% in patients aged 90–99 years and ≥100 years, respectively.

Table 3 Demographic data of the neurosurgical cohort in the first-year survey in the JND

Main classification	No.		Age	Men (%)	In-hospital mortality (%)	Length of hospital stay
	Case No.	%	Mean ± SD			Median ± IQR
Cerebrovascular diseases	72,607	41.0	67.1 (14.9)	50.5	6.0	20 (11–37)
Brain tumor	22,641	12.8	58.6 (18.2)	48.3	1.8	20 (14–36)
Neurotrauma	45,216	25.5	76.0 (14.3)	68.2	3.4	10 (8–19)
Hydrocephalus/Developmental Anomalies	9,309	5.3	54.9 (30.7)	51.2	1.6	17 (12–30)
Spinal and peripheral nerve disorders	17,969	10.1	66.0 (15.4)	59.6	0.3	16 (11–26)
Functional neurosurgery	6,643	3.7	55.0 (19.7)	45.1	0.1	13 (10–19)
Encephalitis/Inflammatory/ Miscellaneous diseases	2,799	1.6	60.8 (19.8)	54.2	2.5	23 (12–44)

JND: Japan Neurosurgical Database, SD: standard deviation, IQR: interquartile range.

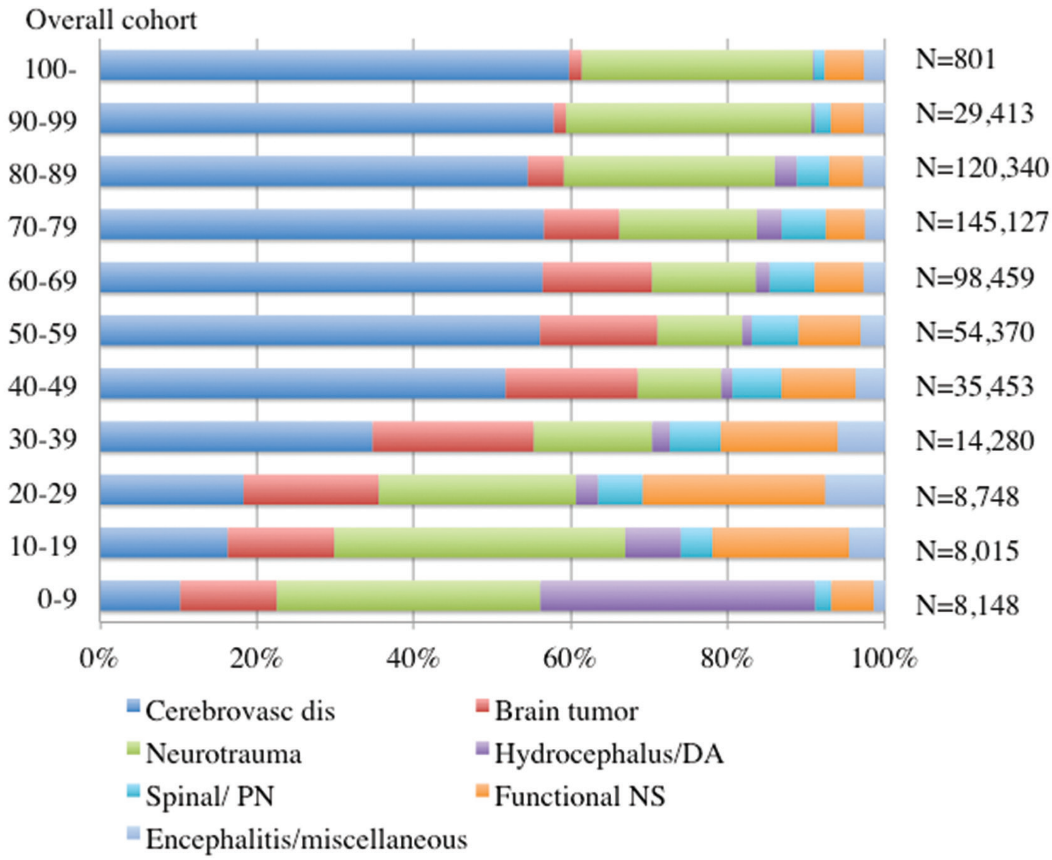

Fig. 1 The proportion of the overall caseload based on the major classification and age. DA: developmental anomalies, PN: peripheral nerve disorders, NS: neurosurgery.

The majority of patients in the neurosurgical subgroup were aged 70–79 years (Fig. 2) (29.4%), followed by octogenarians (20.6%). Compared with the overall cohort, there were notable differences in the proportion of the major classification of the main diagnosis related to neurosurgical procedures based on age. One major difference was a higher proportion of neurotrauma and lower proportion of cerebrovascular diseases in elderly patients aged >80 years in the neurosurgical subgroup. Further, spinal and peripheral nerve disorders were more common (*ca.* 11%) among a broad range (20–79 years) of age groups in the neurosurgical subgroup. In contrast, functional neurosurgery was less common among a broad range of age groups in the neurosurgical subgroup (e.g. 60–69 years, overall cohort 6.2% versus neurosurgical subgroup 4.5%). In addition, hydrocephalus/developmental anomalies accounted for the majority (35.0%) of patients aged between 0 and 9 years.

Indicator of neurosurgical training

In the core hospitals, the median (minimum–maximum, 25–75th percentile) number of board-certified neurosurgeons was 12 (5–41, 9–16), and that of neurosurgeon in training was 4.5 (1–26, 3–7). In those hospitals, the number of neurosurgeons in training was significantly associated with the annual surgical caseload in 2018 (P = 0.0053; Fig. 3). The median number (minimum–maximum, 25–75th percentile) of surgical caseload per neurosurgeon in training was 80.7 (18.1–411, 51.5–117.5) per year.

Discussion

To address the challenges of modern healthcare, the JNS successfully established the largest-ever neurosurgical database in 2018. Here we presented an overview and the results of the first-year survey of the JND. In this first year, the participation rate of the JNS training institutions in the JND was very high, suggesting that the result of our initial experience reflects the real-world neurosurgical practice in Japan. We found that neurosurgeons in Japan cover a wide range of neurosurgical practice, including surgical and non-surgical cases. Of note, patients aged 70–79 years comprised the largest proportion of both the overall cohort and neurosurgical subgroup of the JND, and the proportion of the major

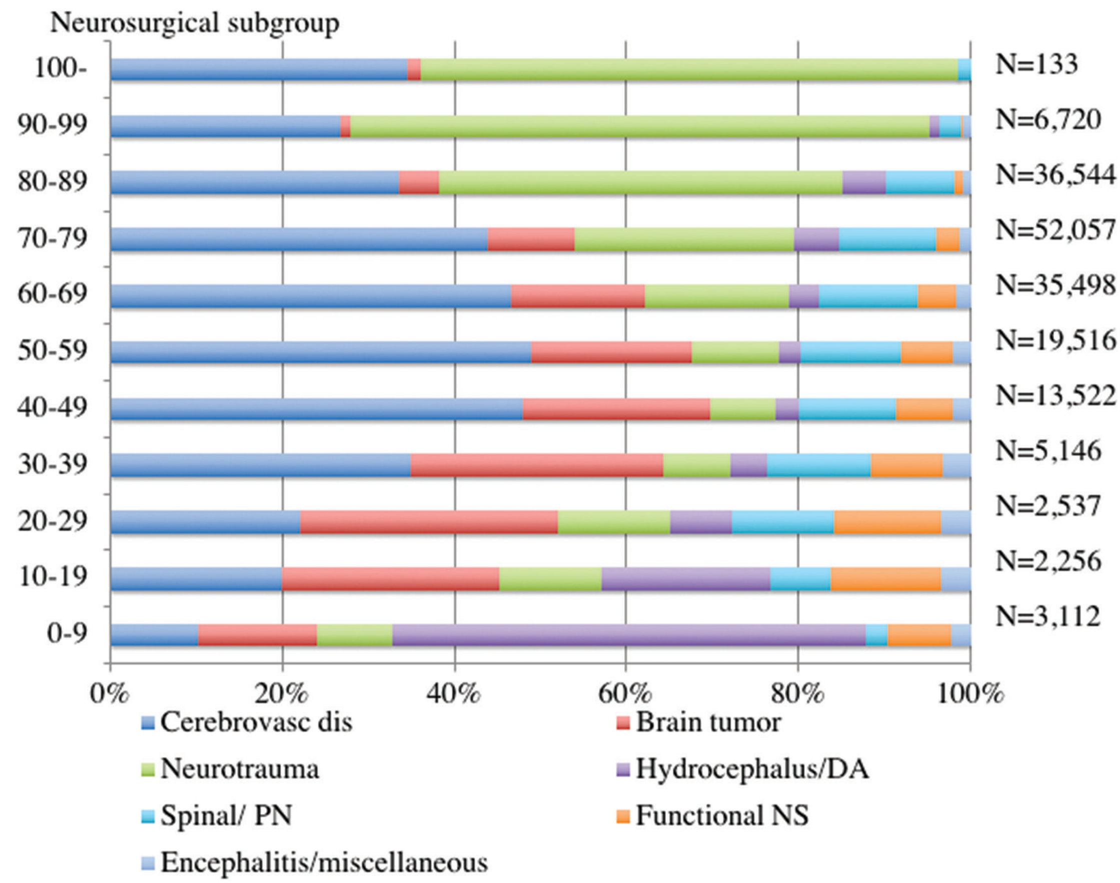

Fig. 2 **The proportion of the neurosurgical caseload based on the major classification and age. DA: developmental anomalies, PN: peripheral nerve disorders, NS: neurosurgery.**

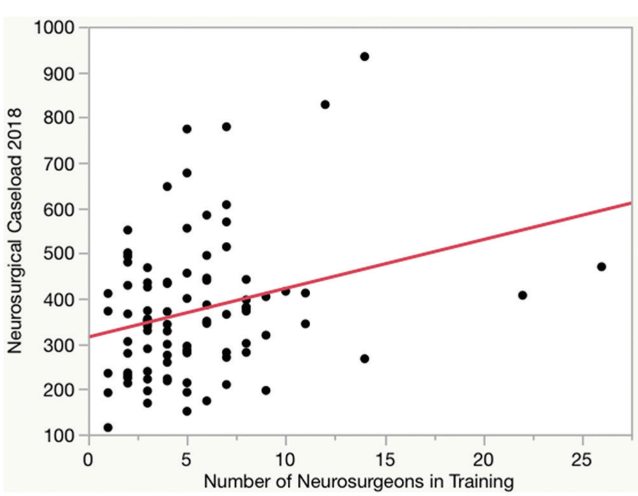

Fig. 3 **Association between the numbers of neurosurgeons in training and neurosurgical caseload in the JNS core hospitals. Annual neurosurgical caseload 2018 = 314.84804 + 10.760009 × Number of neurosurgeons in training in the core hospitals. JNS: Japan Neurosurgical Society.**

classifications of the main diagnosis varied by age both the overall cohort and neurosurgical subgroup. There was a significant association between the number of neurosurgeons in training and neurosurgical cases in core hospitals. Further, the JND provided data on quality indicators of neurosurgical practice (e.g., in-hospital outcomes, length of hospital stays, and readmission rates). These initial findings have provided us with important insights into how to achieve better treatment outcomes, quality of care, patient safety, education of younger generations, and the research and development activities for Japanese neurosurgeons.

Overview of the JND

Characteristics of the training institutions of the JNS The JNS training institutions are certified based on the results of the Institutional Report (IR) of the JNS.[4] The IR examines the number of board-certified neurosurgeons and neurosurgeons in training in comparison with annual case volumes of relevant neurosurgical procedures (e.g. clipping and coiling for aneurysmal subarachnoid hemorrhage), but does not collect patient-level neurosurgical practice data. According to the JNS IR, the patient-level-data collected in the JND, based on the number of board-certified neurosurgeons and neurosurgeons-in-training in 2018, was 530,000, from 1360 hospitals participating in the JNS training program. The JND reveals the characteristics of the JNS training institutions in more detail, including the overall and neurosurgical caseloads, patient demographics, and in-hospital outcomes, based on the geographical location and types of training institutions. In Europe, the median numbers of residents and board-certified faculty neurosurgeons are seven and eight, respectively. Further study is necessary to examine the characteristics of the JNS training institutions regarding personnel, diagnostic apparatus, infrastructure, specific expertise, and educational components related to neurosurgical education.

Assessment of neurosurgical healthcare quality and prediction of risk and outcomes of neurosurgical procedures and management Recently, increasing attention has been given to defining the quality and value of health care through the reporting of process and outcome measures. As quality indicators of neurosurgical care, in-hospital outcomes, length of hospital stay, and reoperation,[8] readmission rates of specific diagnoses/operations could be calculated after adjustment for patient- and hospital level factors using the JND database. Such risk-adjusted outcomes and quality measures may be used as a national benchmark to improve neurosurgical care and for international comparison with other national neurosurgical registries such as N2QOD and NNAP. A recent study, however, showed that the implemented benchmarking programs in both the US and UK failed to identify a considerable number of complications in high-volume centers.[9]

Evaluation of neurosurgical training for residents and clinical practice related to the JNS board certification system The board examination system of the JNS was established in 1965. Neurosurgeons in training in Japan must belong to a JNS training program; they are required to accumulate specific numbers of surgical and non-surgical neurosurgical patient management experiences during a four-year training period. Until 2018, however, applicants for the JNS board examination have only been required to submit defined numbers of case management experiences, thus the individual caseload of each neurosurgeon in training remained uncertain. The first-year survey of the JND demonstrated an association between the neurosurgical caseload and neurosurgeons in training in the core hospitals of the JNS training program, although some outliers existed.

Differences in the postgraduate neurosurgical training program may exist worldwide, suggesting the potential necessity to exchange trainees between programs and even between countries.[10] The median neurosurgical caseload per neurosurgeon in training in the core hospitals in the JND corresponds to the middle range of surgical caseload among different countries in Europe.[10] Since individual neurosurgeons in training in Japan are required to rotate through several branches and related hospitals in addition to core hospitals, further study is necessary to examine the neurosurgical caseload per neurosurgeon in training during the whole training period.

In Europe, there has been a strong decline in surgical cases over time, and trainees graduating after introduction of the European Working Time Directive 2003/88/EC have had less surgical exposure. In Japan, there is increasing pressure to restrict working hours for both attending physicians and neurosurgeons-in-training. To further complicate this situation, the number of new neurosurgeons-in-training per prefecture is now under the control of the JSMB in Japan. The JND, a for-surgeon-by-surgeon program, may provide optimum solutions to this difficult situation.

National and international research and clinical trials infrastructure The JND database provides a basic infrastructure for more specific studies on a wide range of neurosurgical sciences, and its multi-level system of registry will make national and international research and clinical trials possible for Japanese neurosurgeons. In future, risk calculators for specific neurosurgical procedures could be developed by adding detailed information to the JND database and used as a decision-support tool to inform patients and their families about the risks of relevant procedures.[11]

Limitations

The JND in its current form has several limitations. First, regarding the feasibility of registering all in-patient data in the JND, the JND currently does not include detailed and critical information such as comorbidity, locations of lesions, indicators of disease severity, or long-term patient outcomes. Second, the participation rates of the hospitals differed according to the types (e.g. core, branch, and related hospitals) of the JNS training program groups and the training system of the JNS. Further effort is required to improve the participation rates among the training institutions. Third, validation of the registered cases remains unexplored. Audit and internal quality control are necessary to improve the accuracy of the database.

Conclusion

The JNS successfully established the JND, the largest-ever, real-world neurosurgical database (*ca*. 520,000 cases) in 2018, and this paper summarizes the design, primary aims, and main results of the first-year survey. Our initial experience revealed unique aspects of clinical practice of Japanese neurosurgeons, and the relationship between the number of neurosurgeons in training and neurosurgical caseload in the core hospitals. The findings of the JND may provide important insight into achieving better treatment outcomes, quality of care, patient safety, education of younger generations, and research and development activities for Japanese neurosurgeons in future.

Supplementary Material

The participating institutions are listed in Supplementary Table 1 (available online).

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Conflicts of Interest Disclosure

The funder had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; or decision to submit the manuscript for publication. All authors have no conflict of interest.

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