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Structure of Neurosurgical Care in Germany in Comparison to Countries Organized in the European Association of Neurosurgical Societies: A Need to Reorganize Neurosurgical Training and Care in Germany

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Abstract

Background Although the world is experiencing a deficit in the neurosurgical workforce, the number of neurosurgeons in Germany has increased within the last two decades. The aim of the present study was to assess the neurosurgical workforce in Germany, compare it to European countries, and assess structures in neurosurgical departments in Germany.

Methods Data regarding the number of neurosurgeons in Germany as well as the number of departments, beds, cases, and neurosurgical procedures were gathered. A survey among German neurosurgical departments was performed to assess the structure of neurosurgical care. Furthermore, another survey among European countries was performed to acquire information regarding the number of surgeons and the regulation of training.

Results From 2000 to 2019, the number of board-certified neurosurgeons in Germany increased by 151% from 973 to 2,446. During the same period, the German population increased by only 1% from 82.26 million to 83.17 million. Thus, the number of neurosurgeons per 100,000 inhabitants increased from 1.18 to 2.94. The increase of neurosurgeons is not paralleled by an increase in departments or an increase in neurosurgical

Keywords
- structure of neurosurgical care
- number of neurosurgeons
- resident training
- neurosurgical residents
- workforce

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procedures within the active neurosurgical departments. In comparison to the participating European countries, where the number of neurosurgeons per 100,000 inhabitants ranged from 0.45 to 2.94, with Germany shows the highest number.

Conclusions German institutions of medical administration urgently need to consider regulation of neurosurgical specialist training to prevent a further uncontrolled increase in neurosurgeons in a manner that is not adapted to the needs of neurosurgical care for the German population. Actions might include a regulation of entry to the training and of the number of training sites. Furthermore, an integration of non-physician assistant health care professionals and delegation of non-surgical workload from neurosurgeons is necessary. A further increase in neurosurgeons would be associated with a decrease in the surgical caseload per surgeons during training and after board certification, which might compromise the quality of neurosurgical care.

Introduction

For several years, German institutions of medical self-administration and medical organizations representing physicians have deplored an increasing lack of physicians in Germany. Although this might be true for several disciplines, the number of neurosurgeons has steadily increased during the past two decades. Moreover, during that time, an increasing number of small to very small neurosurgical units, not even fulfilling the criteria for a department, were established and the number of neurosurgical private practices increased. The extent to which this increase is (1) an adaptation to medical demands of an aging population or to newly established surgical treatment options, (2) an alignment to an increasing workload per single case, (3) an adaption to the European working time directive that took effect in August 2004, (4) driven by economic interests due to the good reimbursement in neurosurgery, or (5) due to any other cause remains unclear. In Germany, the number of neurosurgical training positions and entry into residency are nonregulated and might be the basis for an unrestricted increase of board-certified neurosurgeons. The resulting increase of neurosurgeons might guarantee excellent neurosurgical availability, but on the other hand, it is potentially associated with a reduced number of surgeries during and after training, a risk of decline of surgical quality due to the reduced caseload, and a potential shift or undue expansion of neurosurgical interventions. For the neurosurgical community, an increasing number of surgeons may reduce career perspectives for younger surgeons and affect the selection of the best medical students entering the specialty.

The present study aimed at assessing the numbers of trainees and practicing neurosurgeons in Germany over the last 20 years as well as assessing the present structure of neurosurgical care in Germany. The results are compared to data from other European countries.

Material and Methods

Number of Neurosurgeons in Germany

To assess the number of board-certified neurosurgeons in Germany, the database of the German Medical Association (Bundesärztekammer) was used. Bundesärztekammer is the central organization in the German system of medical self-administration that collects information from the 17 State Chambers of Physicians, which are registered corporations under public law. Every physician is a compulsory member of the respective state chamber and is registered with his or her specialty following board certification. The occupations of all members are assessed yearly and specialists leaving specialty care as well as newly board-certified members for a specialty are documented. The numbers of neurosurgeons in Germany from 2000 to 2019 were extracted from the database.

German Survey among Neurosurgical Departments

A web survey hosted on SurveyMonkey.com was used. The survey contained 29 questions regarding the structure of national neurosurgical care and residency as shown in ►**Appendix 1**. The questions covered aspects of neurosurgical organization of the respective hospital, regarding hospital type and representation of disciplines. The size of the department was evaluated by the number of beds, the number of neurosurgeons, the number of neurosurgeons in training, and the number of cases. The surgical spectrum and volume and technical equipment in the operating room were queried. Specially certified subdisciplines within the department as well as certified interdisciplinary centers and personal certifications of neurosurgeons were assessed. The organizational structures of intensive care beds and intermediate care beds, including governance, number of beds, and responsibilities for routine daily care, were also evaluated.

The survey was sent to chairs of all neurosurgical departments in Germany listed by the German Society of Neurosurgery. Reminders to participate in the survey were sent out twice. The survey was started on March 24, 2020, and closed on June 1, 2020.

Procedures Performed in Neurosurgical Departments in Germany

OPS codes (procedure codes) from all German neurosurgical departments were obtained from the Federal Statistical Office (Statistisches Bundesamt). The Federal Statistical

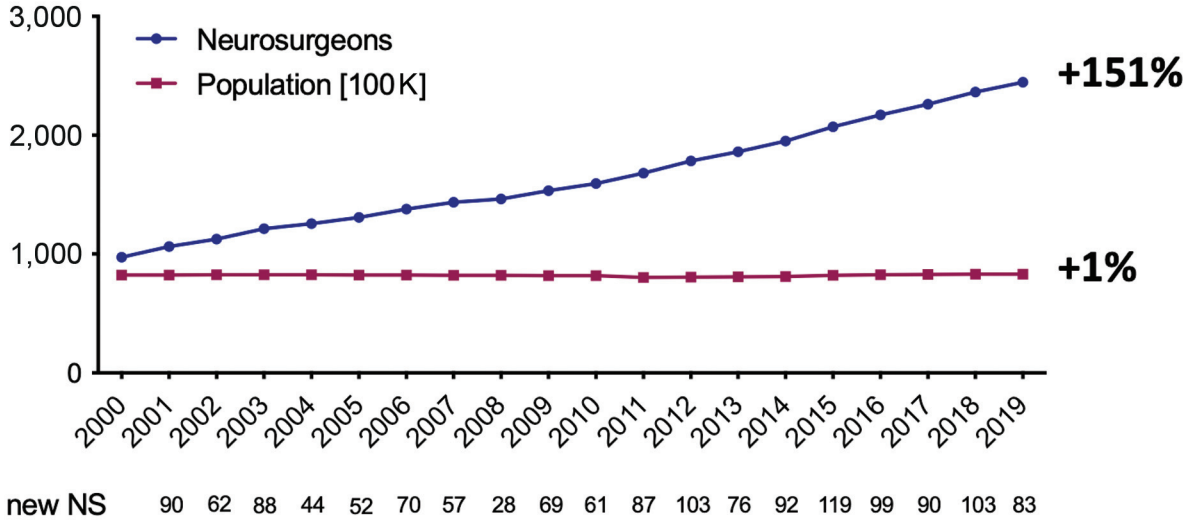

Fig. 1 Growth of the number of neurosurgeons (NS) in Germany between 2000 and 2019. Simultaneous increase of the German population.

Office independently collects all international classification of diseases (ICD) codes, procedure codes, and disease-related groups (DRG) codes from health care institutions in Germany. Data from neurosurgical departments were collected for 2011 to 2019. Procedure codes were analyzed to obtain information on the number of neurosurgical procedures performed. Procedures were considered at an aggregate level and clustered as (1) biopsies; (2) trauma, infection, and intracerebral hemorrhages; (3) intracranial tumors; (4) vascular neurosurgery; (5) functional neurosurgery; (6) peripheral nerve surgery; and (7) spine surgery.

European Survey

Another web survey hosted on SurveyMonkey.com was used to assess the structure and neurosurgical care in European countries. The survey contained 17 questions regarding national neurosurgical care structure and resident training, outlined in Appendix 2. The survey was sent to representatives of the 36 member countries of the European Association of Neurosurgical Societies (EANS). Either the national society presidents or the EANS representatives of the national societies were contacted. Reminders were sent out, and in cases of no data entry, personal contacts in the member countries were used to achieve data entry. The survey was started on March 24, 2020, and closed on June 1, 2020.

Further information regarding the countries where data were entered, such as national population, gross domestic product (GDP), country surface in square kilometers, and population density, were acquired from Wikipedia.com. The number of neurosurgeons per 100,000 inhabitants was correlated with GDP, average population age, and population density.

Data Analysis

Data analysis and plotting was performed with Microsoft Excel v16.16.27 and GraphPad Prism v9.01. Statistical analysis was performed with Prism v9.01.

Funding Source

The study was not supported by any external funder; it was solely financed by internal sources.

Ethical Considerations

Survey participation was voluntary. No patient data were collected. Formal consent was not required for this type of study.

Results

Neurosurgeons in Germany

In 2000, 973 board-certified neurosurgeons were active in their profession in Germany, serving a population of 82.26 million. A mean net of 77 (range 28–119) additional neurosurgeons was added each year, totaling 2,446 active neurosurgeons in 2019 serving a population of 83.17 million (►**Fig. 1**). The number of neurosurgeons increased by 151%, whereas the population rose by 1% between 2000 and 2019. Thus, the number of neurosurgeons per 100,000 persons in Germany grew from 1.18 in 2000 to 2.94 in 2019. In 2019, the majority of active neurosurgeons (1,662 of 2,446 [68%]) were employed at a hospital and 686 of 2,446 (28%) were employed in private practice. In 2007, 165 official neurosurgical departments were registered in Germany and the number grew to 184 in 2017. The total number of neurosurgical beds increased from 6,202 to 6,988 between 2000 and 2017 (i.e., from 7.54 to 8.44 beds per 100,000 persons). Between 2007 and 2017, the yearly caseload treated in these departments rose from 220,029 to 253,252 and thus from 267.6 to 305.9 cases per 100,000 persons per year. Based on these numbers, the average calculated caseload per board-certified neurosurgeon in Germany in 2017 was 112.06 per year (►**Fig. 2**).

Taking into consideration the 6-year duration of neurosurgical training in Germany, the residents already in training plus those entering training in 2020, which was not included in the official numbers, will cause a further net

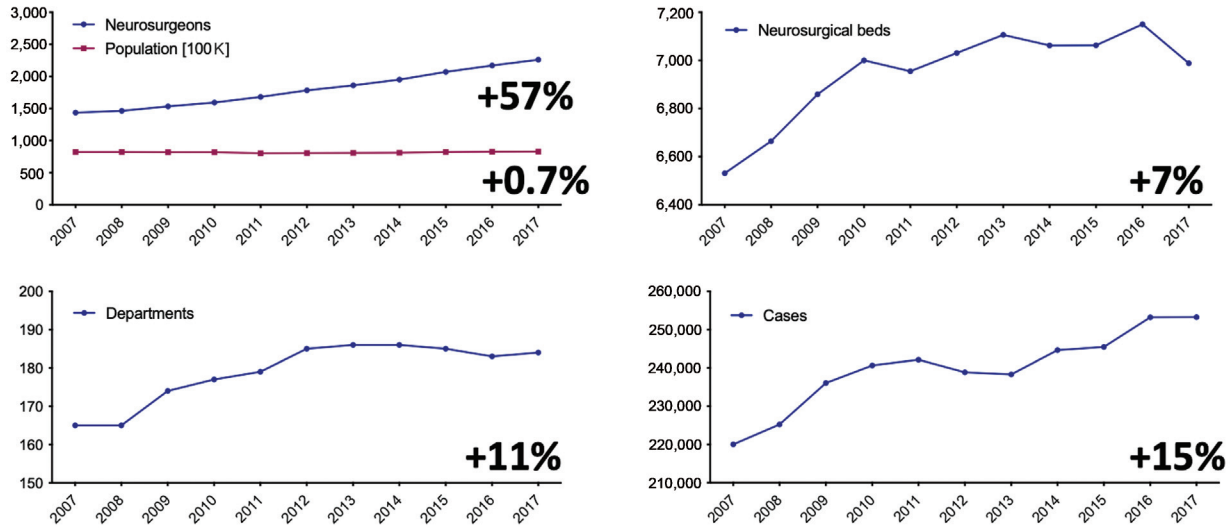

Fig. 2 Number of neurosurgeons, neurosurgical beds, neurosurgical departments, and treated cases in Germany between 2007 and 2017.

increase within the next 6 years (until 2026) of an estimated 539 board-certified neurosurgeons, resulting in 2,985 neurosurgeon specialists. By 2026, the population is estimated to rise to 84.09 million, resulting in 3.55 neurosurgeons per 100,000 persons.

German Survey Results

Out of 131 neurosurgical departments asked to participate in the survey, 65 (50%) responded within the given 2-month period and sent evaluable data. The hospital type in which the neurosurgical department was situated in was academic in 22 cases, nonacademic in 37 cases, and private in 6 cases.

The mean number of beds per department was 43 (range: 14–108), run by a mean of 18.9 full-time equivalents (range: 4–42), including board-certified neurosurgeons and residents in training. Ten departments had limited accreditation for resident training (not permitted for a full training duration of 6 years), but 54 departments had accreditation for full resident training of 6 years.

The mean yearly number of outpatient treatments was 5,017 (range: 80–16,000) and that of inpatient treatments was 1,973 (range: 660–6,000). The mean number of surgical procedures was 1,803 per department (range: 600–5,600). The types of procedures performed at the departments are given in ►**Table 1**.

Thirty-three departments were certified as neuro-oncological centers of the German Cancer Society (Deutsche Krebsgesellschaft [DKG]), 34 were part of a neurovascular network, 17 were certified skull base centers, and 21 were certified as spine centers by the German Spine Society (Deutsche Wirbelsäulengesellschaft [DWG]) or Eurospine. A neurosurgeon was certified especially for neurovascular surgery in 29 departments, for neuro-oncology in 29 departments, for peripheral nerve surgery in 16 departments, and for pediatric neurosurgery in 14 departments. One hundred and forty-seven neurosurgeons were certified as spinal surgeons by the DWG.

Procedures Performed in Neurosurgical Departments in Germany

The data from the Federal Statistical Office of Germany revealed that for officially registered neurosurgical departments, 249,421 neurosurgical procedures were performed in 2011 and 239,311 were performed in 2019, a 4% decrease. The clustered data are presented in ►**Fig. 3**. The numbers of procedures changed between 2011 and 2019 from 6,081 to 8,519 (+40%) for biopsies, from 19,767 to 22,290 (+13%) for trauma cases, from 24,076 to 27,129 (+13%) for intracranial tumors, from 4,633 to 4,896 (+6%) for vascular cases, from 2,221 to 2,957 (+33%) for functional neurosurgical cases, from 4,977 to 6,969 (+40%) for peripheral nerve surgery, and from 187,666 to 166,551 (−11%) for spine cases (►**Fig. 3**).

Based on these numbers, the caseload per neurosurgeon specialist in Germany would be 97.83 surgeries per year.

European Survey Results

Twentynine of 36 countries (80%) answered the European survey. The absolute and relative number of neurosurgeons per 100,000 persons is summarized in ►**Fig. 4**. The mean and median of neurosurgeons per 100,000 persons are 1.46 and 1.30, respectively, ranging between 0.45 and 2.94. Germany has the highest absolute and relative numbers within all countries organized in the EANS, with 2,446 neurosurgeons overall and 2.94 neurosurgeons per 100,000 inhabitants. In an analysis of potentially influencing factors for the number of neurosurgeons, the GDP, average population age, and population density were assessed. However, none of these factors significantly correlated with the relative number of neurosurgeons in any country.

In the German medical system, the number of residents in training is not limited for any given department or medical discipline. Nor is it limited by the number of cases, spectrum of cases, or quantity of population served. A structured and formalized selection process of residents does not exist and in general all residents are in training; physicians not in

Table 1 Number of the 65 responding departments performing procedures for the given indications

Neuro-oncology	*n*	Neurovascular	*n*	Spine	*n*	TBI	*n*	Functional	*n*	Pediatrics	*n*
Meningiomas	64	Asymptomatic aneurysms	64	Trauma	63	Decompressions	65	DBS	28	Hydrocephalus	50
Gliomas	64	Symptomatic aneurysms	61	Intradural tumors	65			Epilepsy surgery	24	Dysraphic malformations	44
Vestibular schwannomas	62	Asymptomatic AVMs	58	Extradural tumors	65	Peripheral nerves		Microvascular decompressions	63	Tumors	47
Pituitary surgery	59	Symptomatic AVMs	59	Degenerative noninstrumented	65	Entrapment syndromes	62	Modulation for pain	60	Craniosynostosis	32
Awake craniotomies	45	Cavernomas	45	Degenerative instrumented	64	Tumors	64				
Orbital tumors	56	Bypasses	21	Adult deformities	34	Complex reconstructions	31				
				Adolescent deformities	12						
				Infections	65						

Abbreviations: AVM, arteriovenous malformation; DBS, deep brain stimulation; TBI, traumatic brain injury.

training for a specialty are almost nonexistent. A physician assistant is not a common position in Germany and a ranking of health care professionals from nurse assistant to nurse to physician assistant to physician does not exist. The academization of nursing professions is just beginning. A centralization of procedures is not in action.

In comparison, in the EANS-represented countries with available data, 41% had regulated resident training and 45% used a structured selection process. Residents not in training for a specialty and physician assistants were deployed in 24 and 21% of countries, respectively. Centralization of certain subspecialty procedures was already active in 59% of respondents' countries (►**Fig. 5**).

Discussion

Key finding of this study is that the German neurosurgical workforce continuously increased in the investigated period (i.e., 2000–2019), resulting in a 151% increase. During the same period, the German population grew by only 1%. Thus, a distinct increase of neurosurgeons per 100,000 persons added up, leading to the highest absolute and relative count within European countries organized in the EANS. The number of neurosurgeon specialists in Germany in 2019 was 2.94 per 100,000 persons. The number of neurosurgical cases in accessible databases did not increase and fluctuated at a rather stable level. In comparison to other European countries, where regulation of neurosurgical training and centralization of neurosurgical procedures is already active, German resident training is completely unregulated and a centralization of procedures is not active. Therefore, the integration of active regulation seems essential to control the increase in neurosurgical specialists and maintain surgical caseloads per surgeon and thereby treatment quality.

As an estimated 5.2 million cases per year worldwide requiring neurosurgical care remain undone, an additional workforce of 22,626 neurosurgeons is needed globally.[1] In 2001, the global density of neurosurgeons was estimated as 0.43/100,000 persons, and in 2019, the worldwide number of neurosurgeons was assessed as 49,940.[2,3] Only three WHO regions (United States/Canada, Europe, and the Western Pacific) do not demonstrate a neurosurgical workforce deficit and the average number of neurosurgeons per 100,000 is 0.051 in Africa, 0.973 in the Americas, 0.327 in the Eastern Mediterranean, 1.176 in Europe, 0.259 in Southeast Asia, and 1.208 in the Western Pacific area.[3] The number of neurosurgeons per 100,000 is globally highest in Japan with 5.5, whereas 33 countries do not have any neurosurgeons.[3,4] These statistics demonstrate the large heterogeneity of the neurosurgical workforce worldwide. For most areas, Europe does not have a workforce deficit, but has a wide range of neurosurgical workforce per population. As assessed in the present study, the number of neurosurgeons within European countries ranges from 0.45 to 2.94, with the highest number in Germany. In further comparison, in the United States, 1.52 neurosurgeons served 100,000 inhabitants in 2013, and in Canada the rate was 0.90 per 100,000 in 2019.[5] However, the adequate number of neurosurgeons remains

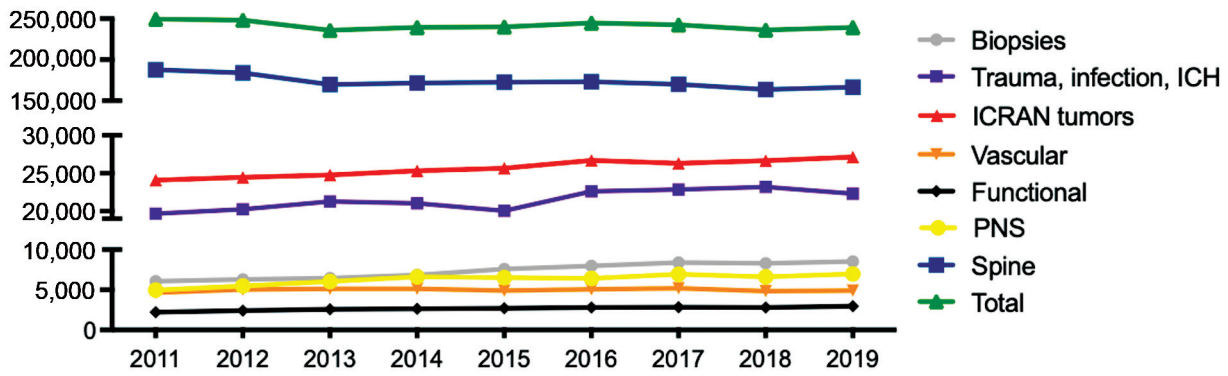

Fig. 3 Number of yearly surgical cases performed by neurosurgical departments in Germany (ICH, intracerebral hemorrhage; ICRAN; PNS, peripheral nervous system).

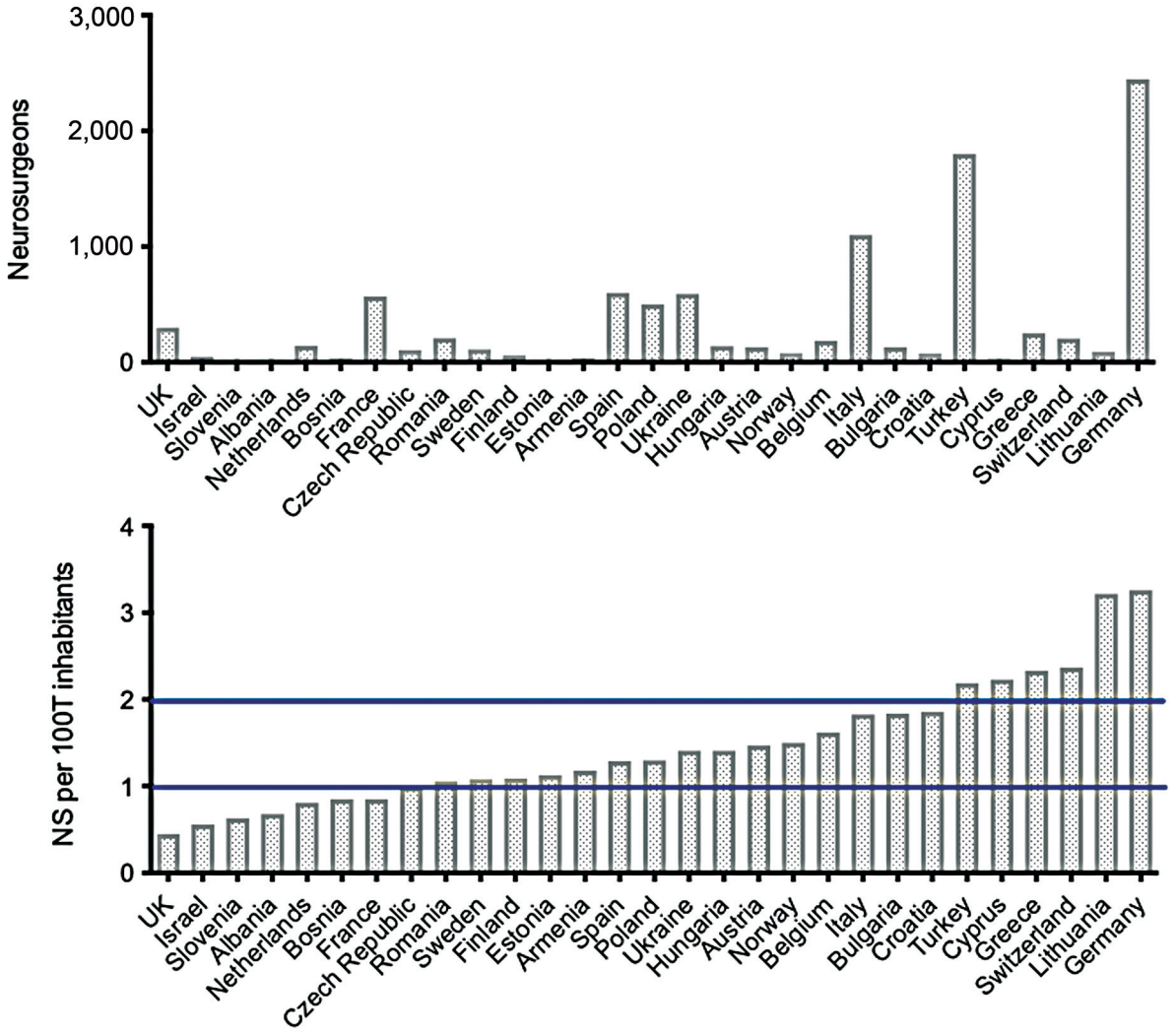

Fig. 4 Absolute (upper panel) and relative (lower panel) number of neurosurgeons (NS) in European countries.

unclear. In 1977, one neurosurgeon per 100,000 persons was estimated as adequate to serve the population.[6] Whether this number remains valid in an aging population or as surgical therapeutic options improve and technology advances in comparison to 1977 is unclear, but a tripling of the treatment demand as suggested by the German numbers is certainly not expected and therefore Germany appears oversupplied. Yet, the number of necessary neurosurgeons depends on the medical practice and involvement of neurosurgeons in nonsurgical areas. Although, for a country such as Japan, the high number of neurosurgeons is explained by a participation in prevention, diagnostics, neurointerventions,

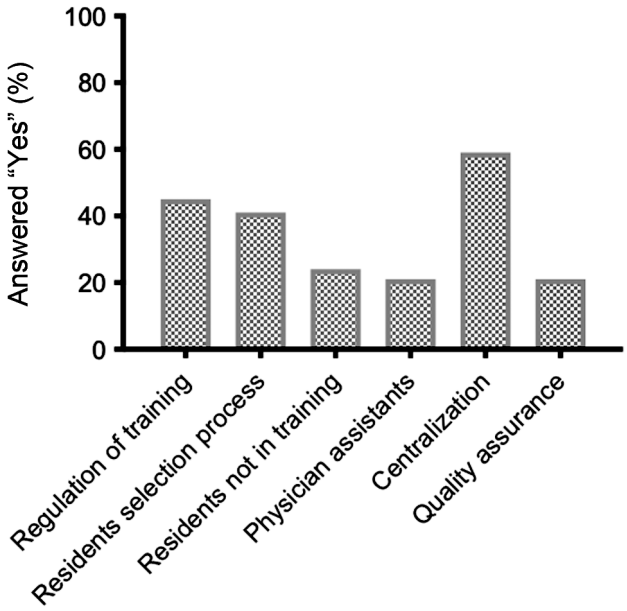

Fig. 5 Proportion of countries that answered "yes" to the questions of whether training is regulated and resident entry into training is formalized, whether physicians not in training for a specialty or physician assistants are employed in neurosurgical departments, and whether neurosurgical procedures are centralized and a quality assurance program is in action.

drug therapy, radiation therapy, and rehabilitation, leading to a broad spectrum of nonsurgical engagements in addition to the surgical cases, in Germany, most neurosurgeons are active surgeons without involvement in nonsurgical medical practice.[4]

The number of cases performed in neurosurgical departments in Germany does not explain the increase in the number of surgeons. The increase in cases is far behind the increase in number of surgeons and the resulting caseload of approximately 100 cases per year is certainly far from an upper load limit. Neurosurgeons worldwide perform a median of 190 cases and a mean of 245 cases, and the optimal workload was assessed to be around 223 cases per year and surgeon.[7] Therefore, calculated cases based on the available numbers in Germany are below the international caseload. However, an unknown proportion of cases performed by neurosurgeons in Germany do not show up in the official statistics. These cases are performed outside a neurosurgical department in departments of general surgery, trauma, or orthopaedic surgery and can be spine, peripheral nerve, trauma, or stroke cases.

Although the overall rate of surgeries per 100,000 persons in Germany increased to 306 cases in the present study, showing an increase over recent years,[8] the medically necessary number of cases per 100,000 inhabitants remains ambiguous. Therefore, judging this frequency of procedures is not possible.

Several reasons could contribute to the increase in the neurosurgical workforce in Germany. The European Working Time Directive limiting the working time to a maximum of 48 hours per week became active in Europe in 2004, increasing the demand for additional residents and attendings and leading to a significant reduction in duty hours.[9,10] However, since 2004, there has been a continuous rise in neurosurgeons without any plateau in the following years, which would be expected after compensation of the missing workforce to compensate for the working time regulations. Therefore, the working time directive alone is not a sufficient reason. Another aspect could be the changed organization of neurosurgery in Germany during the recent three decades. Although in former times, neurosurgical procedures were only performed in larger tertiary care units, the number of neurosurgeons in private practice outside a registered neurosurgical department and the neurosurgeons employed in trauma surgery or orthopaedic departments as well as in dedicated spine centers not registered as neurosurgical institutions drastically increased. However, as mentioned earlier, the number of neurosurgical procedures available for analyses in this study is similar to that performed only within dedicated neurosurgical departments, whereas the number of neurosurgeons is similar to the number of neurosurgeons overall, irrespective of their working circumstances (i.e., those working in a neurosurgical department and those in private practice or employed in a non-neurosurgical department). This is certainly a limitation of the study, but the overall cases performed by neurosurgeons are not available. Therefore, the number of cases performed by neurosurgeons in Germany is potentially higher than the number of cases performed in neurosurgical departments available for analysis.

As a consequence of the increasing number of neurosurgeons in Germany, a reduction in workload and underemployment can be expected, with the consequence of reduced quality of care because perioperative morbidity and mortality are closely related to the individual caseload.[11] Although the European Working Time Directive has already resulted in a reduction in caseloads during training, the continued increase in neurosurgeons will contribute to further reduction in training cases[12] and cases after training. Furthermore, the decrease in individual caseloads and increased supply of neurosurgeons could potentially generate less stringent surgical indications to increase the individual caseload. A further negative effect of the increasing numbers of specialists is the reduced career prospects for young neurosurgeons leaving training programs. Positions as staff neurosurgeons are occupied at many institutions and an increasing number of neurosurgeons are urged to seek employment at non-neurosurgical departments or in private practice.

As long as regulation of neurosurgical training and centralization of procedures is not in place in Germany, the increase in the number of neurosurgical specialists could continue in an uncontrolled manner. Therefore, measures to reduce a further uncontrolled increase in the number of neurosurgeons are required. These measures potentially include (1) a reduction in training programs, (2) a reduction of residents in training and adjustment to future needs, (3) an alignment of the number of training positions to the departmental resources, (4) a centralization of highly specialized neurosurgical procedures to high-volume tertiary care centers out of non-neurosurgical departments, (5) an integration of non-physician or physician assistant health care professionals to reduce neurosurgeons' nonsurgical

workload, and (6) alliances with other disciplines such as anesthesia for intensive care or neurology to reduce the nonsurgical workload.

The European Union of Medical Specialists and the Joint Residency Advisory and Accreditation Committee of the EANS already provide recommendation for the necessary cases of a department per resident in training and for further structural requirements necessary to obtain accreditation as a training center. These recommendations could be implemented in German departments. Because neurosurgical service has increasingly diversified away from neurosurgical departments, high-care neurosurgical cases should be centralized and confined to high-volume departments to allow adequate quality of care.

Conflict of Interest
None declared.

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Appendix 1

Questionnaire: Structure of Neurosurgical Departments in Germany

Hospital type

- public
- private
- academic
- church

Additional departments/institutes at hospital

- Neurology with stroke unit
- Neurology without stroke unit
- Internal medicine
- Oncology
- Cardiology
- General surgery
- Visceral surgery
- Thoracic surgery
- Vascular surgery
- Cardiac surgery
- Trauma surgery
- Orthopedics
- Independent spine surgery
- Gynecology and obstetrics
- Radiology
- Neuroradiology without interventions
- Neuroradiology with interventions
- Nuclear medicine
- Radiation oncology
- Pathology
- Neuropathology
- Intensive care medicine
- Ophthalmology
- ENT
- Pediatrics
- Pediatric surgery
- Urology
- Geriatrics
- Human genetics

Number of regular care neurosurgical beds

- Fixed number of beds n =
- Variable number of beds n =

Number of physicians in neurosurgical department

- Chairpersons n =
- Neurosurgical Oberärzte n =
- Additional board-certified neurosurgeons n =
- Neurosurgical trainees n =
- Non-neurosurgical board-certified physicians n =, specialty? n =
- Physicians in part-time employment n =
- Physicians with certified subspecialty of intensive care n =
- Physicians with certified subspecialty of pain therapy n =

Training authorization

- Full training
- Training authorization for … years

Neurosurgeon on call in house 24/7

- Yes
- Neurosurgical background only
- Call sharing with other specialties

DRG performance

- casemix per year
- casemix index

Surgical procedures per year

- n=

Proportion of spinal procedures

- 0%
- 1–20%
- 21–40%
- 41–60%
- 61–80%
- 81-99%
- 100%

Theaters per day

- Monday n=
- Tuesday n=
- Wednesday n=
- Thursday n=
- Friday n=
- Saturday n=

Equipment

- Microscope
- Navigation cranial
- Navigation spinal
- Ultrasound in OR
- Ultrasonic aspirator
- 3D C-arm cone beam CT
- iCT
- iMRI
- iRT
- iDSA
- IONM
- Robotics
- Endoscopy spinal
- Endoscopy cranial

Performed procedures

Neuro-oncology cranial
- Meningiomas
- Gliomas
- Vestibular schwannomas

- Pituitary adenomas
- Awake craniotomies
- Orbital tumors

Vascular cranial
- Aneurysms nonhemorrhaged
- Aneurysms hemorrhaged
- AVMs nonhemorrhaged
- AVMs hemorrhaged
- Cavernomas
- Bypasses
- Endovascular treatment of vascular pathologies

Trauma
- Treatment of traumatic brain injury

Peripheral nerve surgery
- Entrapment syndromes
- Tumors
- Complex reconstructions

Pediatric neurosurgery
- Hydrocephalus
- Dysraphic malformations
- Tumors
- Craniosynostosis

Functional
- DBS
- Epilepsy surgery
- Microvascular decompressions
- Neuromodulation as pain treatment

Spinal
- Trauma
- Intradural pathologies
- Intramedullary tumors
- Spinal tumors
- Degenerative non-instrumented
- Degenerative instrumented
- Adult deformities
- Juvenile/adolescent scoliosis
- Infections

Interdisciplinary centers
- Interdisciplinary center for neuro-oncology
- Interdisciplinary neurovascular center
- Interdisciplinary spine center
- Interdisciplinary skull base center
- Interdisciplinary pain center

Institutional certifications
- Neuro-oncology of DKG
- Certified Neurovaskuläres Netzwerk
- Certified skull base center
- Certified DWG center level 1
- Certified DWG center level 2
- Certified DWG center level 3
- Certified Eurospine center
- ISO 9001 or 2

Personal certifications of chairperson
- Vascular certificate DGNC
- Neurooncological certificate DGNC
- Certificate for peripheral nerve surgery
- Certificate for spine surgery DGNC
- Pediatric certificate DGNC
- Basiszertifikat DWG
- Masterzertifikat DWG
- Exzellenzzertifikat DWG

Personal certifications of coworkers
- Vascular certificate DGNC
- Neurooncological certificate DGNC
- Certificate for peripheral nerve surgery
- Certificate for spine surgery DGNC
- Pediatric certificate DGNC
- Basiszertifikat DWG
- Masterzertifikat DWG

Catchment population
- <200,000
- 200,001–500,000
- 500,001–1,000,000
- 1,000,001–2,000,000
- >2,000,000

Outpatient treatment
- Hochschulambulanz
- §116b
- Kassenermächtigung
- MVZ

Intensive care beds
- Fixed number of intensive care beds n=
- Variable number of ICU beds n=

Control of ICU
- Anesthesiology (AN)
- Neurosurgery (NS)
- Neurology (NL)
- Shared
- Other

Main personnel ICU
- AN
- NS
- Shared
- Other

ICU rotational physicians
- AN
- NS
- Shared
- Other

Neurologists on ICU
Coworkers with subspecialty in intensive care treatment

- Neurosurgeons n=
- Other discipline n=

Training authorization in intensive care medicine

- No
- 1 year
- 2 years

Neurosurgical ICU treatment/procedures

- ICP measurement
- External ventricular drainage
- Extended neuromonitoring (ptiO$_2$, microdialysis)
- TCD, EEG
- Treatment of raised ICP
- Differential ventilation for raised ICP
- Blood pressure management (CPP & cerebral autoregulation)
- Neuroradiological procedures
- Wound management
- Prognostication and end of therapy decisions

Routine postoperative monitoring of craniotomies

- ICU
- IMC
- Postsurgical recovery room
- Regular ward

IMC beds

- Fixed number of IMC beds n=
- Variable number of IMC beds n=

Control of IMC

- AN
- NS
- NL
- Shared
- Other

Appendix 2

Structure of neurosurgical care in countries represented in the European Association of Neurosurgical Societies (EANS)

1. Country
2. Number of board-certified neurosurgeons within your country
3. Number of dedicated neurosurgical departments
4. Number of additional departments where neurosurgical procedures are performed
5. Number of university departments
6. Number of neurosurgical training programs
7. Number of neurosurgeons in training
8. Duration of training in years
9. Nationwide selection process for neurosurgical residents
10. National regulation/limitation of neurosurgical training
11. Number of new residents entering neurosurgical training per year
12. Are there residents not in training?
13. Proportion of residents not in training of all residents
14. Are physician assistants commonly employed in neurosurgery?
15. Number of cases performed per year by the department
16. Are any neurosurgical procedures centralized in the country?
    Type of procedures
    Number of centers allowed to perform this procedure
17. Are there any centralized national obligatory quality assurance programs?
    Yes … please describe which measures are used
    No