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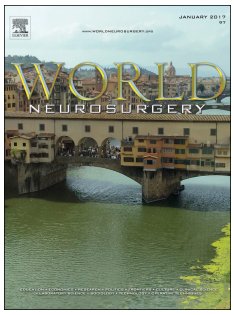

Neurosurgery Education in the Medical School Curriculum: A Scoping Review

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Abstract

Objective

Despite a high burden of neurosurgical disease that is often assessed, investigated and managed by generalists, to our knowledge, there is no specific medical school curriculum in neurosurgery. This scoping review was carried out to map available evidence pertaining to the provision of neurosurgery education in the medical school curriculum across the world.

Method

This review was conducted in accordance to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis extension for Scoping Reviews. Inclusion criteria were full-text articles published from 1999 onwards, that reported on neurosurgery education in the medical curriculum.

Results

Ten studies were included. Six were from the United Kingdom, two from the United States, and one each from Canada and Ireland. Seven studies reported perceptions of medical students and five reported perceptions of clinicians. Three main themes were identified. Neurosurgery was perceived as an important part of the general medical student curriculum by students and neurosurgeons but less so by medical school deans. Exposure to neurosurgery teaching was varied but when received, deemed useful and students were keen to receive more. Interest in a neurosurgical career amongst surveyed medical students was high.

Conclusions

The limited evidence has demonstrated variability of perceptions about the importance of neurosurgery amongst stakeholders and medical students' exposure to neurosurgery teaching. Our findings highlight the need to systematically assess specialty-specific teaching and determine adequacy. Stakeholders should include neurosurgeons, medical educators, general practitioners and the variety of specialists that play a crucial role in the management of patients with neurosurgical conditions.

Introduction

Current medical school curricula across the world emphasize general practice principles. For example, the United Kingdom (UK) undergraduate medical curriculum is undergoing significant changes in an effort to fulfil governmental mandates on producing and recruiting more general practitioners (GPs).[1, 2] As a consequence, there are growing concerns from specialists that smaller specialties such as neurosurgery are receiving significantly less attention in the medical curriculum.[3] In low and middle-income countries (LMICs), this is of even more concern given the lack of access to much of the world's population to surgical, and more specifically, neurosurgical expertise.[4-6]

Disease burden in neurosurgery is high;[7] For instance, stroke (both ischemic and hemorrhagic) is the fifth leading cause of death in the United States (US) and the leading cause of serious long-term disability.[8] Both acute and chronic neurosurgical patients present to primary and secondary care for initial investigation, diagnosis and management; in the acute setting, this can often be with time-critical conditions. Therefore, knowledge of neurosurgical conditions for the generalist is still vital to allow prompt recognition, investigation and initial management of these conditions, and, importantly, when to escalate and refer to neurosurgery, either as an emergency or in a more elective setting.

Unlike other specialties,[9, 10] to our knowledge, there is currently no national or international specialty-specific guideline or curriculum for the teaching of neurosurgical topics at medical school. The Royal College of Surgeons of England (RCSEng) in the UK published a national undergraduate surgical curriculum in 2015

incorporating four neurosurgical topics that medical students are expected to be competent in,[11] namely painful/paralyzed limb, back pain (including cauda equina syndrome), peripheral nerve palsies and raised intracranial pressure. The Association of Surgeons in Training (ASiT) has produced a national consensus of this surgical curriculum to establish what medical students and foundation doctors perceived as core content and, within neurosurgery, only the topic of raised intracranial pressure reached significant consensus.[12] Similarly, the American College of Surgeons (ACS) and the Association for Surgical Education (ASE) in the United States (US) developed a medical student core surgical curriculum consensus to address the foundation of core surgical knowledge needed by all medical students irrespective of their future specialties; no neurosurgical topics were incorporated.[13]

In order to explore neurosurgery education and exposure to neurosurgery in the medical school curricula across the world, we chose to undertake a scoping review to explore the existing literature. A scoping review was chosen over a systematic review as emerging evidence relating to the provision of neurosurgery education in the medical curriculum has not been comprehensively reviewed (only 2% of all medical education research is in neurosurgery) and large variation in reporting exists between studies.[14] A scoping review is therefore more suitable in this instance as it remains relatively unclear what specific questions should be asked and valuably addressed by a more precise systematic review and meta-analysis.[15]

To our knowledge, this is the first scoping review carried out to map available evidence relevant to the provision of neurosurgery education at medical school. The overall aims of the scoping review were to collate, map, assess and describe the

existing evidence base relating to this topic, in a formal, systematic and transparent way.[15] It is intended that the findings of this review will identify potential gaps in knowledge and contribute to further development of neurosurgery teaching in the medical school curriculum to enhance the preparedness of newly qualified doctors in dealing with neurosurgical conditions.

Methods

This scoping review was conducted in accordance to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis extension for Scoping Reviews (PRISMA-ScR).[16] Unlike systematic reviews, scoping reviews do not need to have a protocol registered.[15]

Search strategy

A search string was developed to identify original studies reporting neurosurgery teaching in medical school education. The search terms comprised synonyms of three key concepts, namely: medical student, clinician and neurosurgery. The search was applied to the following four electronic databases: Ovid MEDLINE, Embase, Cochrane Library and Education Resources Information Center (ERIC). Searches were performed for each database on June 29, 2020. No limits were applied (Table A.1).

Study selection and reliability

Articles were selected for inclusion in the review if they were, published in a peer-reviewed journal in any language, and reported neurosurgery education in medical

school curricula. Papers published from 1999 onwards were included to elucidate the current medical education landscape.

Since this scoping review aimed to broadly capture available evidence, we included original research, narrative or systematic reviews, editorials, commentaries, opinion papers, letters, conference abstracts, protocols, reports, theses or book chapters as these could potentially contain sufficient detail to evaluate the current medical school education for neurosurgery.

All titles and abstracts were screened independently by two reviewers (KSL and JJYZ) against a set of pre-defined eligibility criteria. Potentially eligible studies were selected for full-text analysis. To ensure literature saturation, the reference lists of the included studies were scanned. A summary of the inclusion and exclusion criteria is presented in Table 1. Due to the exploratory of this scoping review, the exclusion criteria were kept lenient – studies that did not report on the provision of neurosurgery in the medical school curriculum were excluded. Disagreements were resolved by consensus or appeal to a third senior reviewer (AC). Agreement among the reviewers on study inclusion was evaluated using Cohen's kappa.[17]

[Insert Table 1 here]

Risk of bias assessment

Since this review did not aim to synthesize data about intervention effectiveness, it was not necessary to carry out an assessment of risk of bias.

Data charting

The data extraction process in a scoping review is known as 'data charting'. Key variables were screened and extracted from the papers. These data were inputted into a Microsoft Excel Document, which was the basis of the data charting form. This was continuously updated in an iterative process, as heterogeneity of data and reported outcomes meant often non-contiguous data points.

A proforma was developed to conduct systematic data extraction with fields relating to i. study design, ii. country, iii. participants, iv. intervention assessed, v. comparators against which interventions are compared, vi. data collection method, vii. perceptions of medical students, viii. perceptions of clinicians. Disagreements were discussed, and a third reviewer (AC) facilitated decision-making where required. The third reviewer continued to check data extraction until consistency was achieved.

However, if the data was important and remained an essential component to report on in this paper, it was added to the charting process. Two reviewers independently (KSL and JJYZ) charted data from each eligible article. Any disagreements were resolved through discussion between the two reviewers or further adjudication by a third reviewer (AC).

Outcomes

Outcome variables were not predefined in this study, due to its exploratory rather than hypothesis-led nature.

Synthesis of results

A narrative synthesis of data, with descriptive analyses where appropriate was undertaken, to enable the analysis of the relationships within and between studies, as well as assessing gaps in the literature. Critical appraisal of the articles was unnecessary because the aim of this review was to reveal the neurosurgery education and themes available in the broad spectrum of the literature.

An analytical framework of quantitative and thematic approach was used to collate various themes that emerged from the existing data. The articles were also coded according to the categories identified in the data charting stage. Discrepancies in coding and synthesis of final frequency statistics were adjudicated by discussion.

Results

Characteristics of included studies and themes

340 citations were identified from searching the four electronic databases. After removal of duplicates, 283 unique citations were identified. A thorough review of titles and abstracts and full text retrieved 10 articles eligible for inclusion (Figure 1, Table 2). Reliability of study selection between observers was substantial at both the title and abstract screening stage (Cohen's $\kappa = 0.94$) and the full-text review stage (Cohen's $\kappa = 1.00$).[17] Six were from the UK, two from the US, and one each from Canada and Ireland. Six were mixed-methods, and four were quantitative. Seven studies reported perceptions of medical students and five reported perceptions of clinicians (Table 2). Three main themes were identified: perceived importance of neurosurgery, amount and type of neurosurgical exposure received, and interest in neurosurgery as a career.

[Insert Figure 1 here]

[Insert Table 2 here]

Perceived importance of neurosurgery

Neurosurgery education was perceived as important by both medical students and neurosurgery programme directors (NPDs) but less so by medical school deans. Clinical medical students in the UK thought that neurosurgery was an important subject (mean score 4.08 ± 0.69 on a 1-5 Likert scale), should be taught as part of an undergraduate degree (3.26 ± 1.38) and that neurosurgery placements should form a part of medical school education (3.78 ± 0.82).[18] The majority (95.2%) of NPDs agreed that neurosurgery should be a core aspect of the curriculum.[19] However, responses from medical school deans were less favourable with 17.5% agreeing that increased neurosurgical education was not important,[19] and 59% thinking that it should not be a core rotation for students.[20]

Amount and type of neurosurgical exposure received

The amount and type of neurosurgery exposure was reported in all 10 studies (Table 2). Five studies surveying UK and Irish medical students found that most had experienced some form of neurosurgical teaching in medical school, but perceptions of time spent on neurosurgery education among respondents were highly variable.[3] One study reported 39.7% of UK students had had neurosurgical experience during their medical education,[21] whilst in another, 49% had attended neurosurgical operating theatres, 80.2% had attended classroom teachings, 7.6% had attended

wards/ clinics/ student selected components/ surgical society events/ electives.[22] Between 5.8% and 80% reported no exposure to neurosurgical teaching. [21-24] Importantly, 82.8% of students agreed that the neurosurgical sessions they attended contributed to their learning.[25]

In the US, NPDs and medical school deans reported different amounts of time dedicated to neurosurgical education (68.2 vs 23.6 hours/year respectively) .[19] Only one program had a mandatory neurosurgical rotation for all medical students.[19] Whilst 90% have a recommended/required textbook, only 62% have a syllabus and 38% deliver didactic lectures.[20]

A majority of medical students (60.5% - 67.7%), agreed that an increase in operating theatre time as the most optimal format to receive greater neurosurgical training.[22, 25] Other suggestions included having more tutorials (49.1%) seeing more patients (45.8%), more classroom teachings (29.9%), more objective structured clinical examination practices (29.5%) and more student selected components (21.4%).[22]

Interest in neurosurgery as a career

Four studies evaluated medical students' interest in neurosurgery,[18, 21, 23, 25] each reporting a different summary metric of the same Likert scales that precluded pooling of results (Table 2). One study had 22.4% of penultimate-year medical students who agreed or strongly agreed that they were considering a career in neurosurgery.[25] In Ireland, 78% of students agreed they would consider neurosurgery as a future career, but 87% also believed neurosurgery can impede family life.[23]

Discussion

This work represents the first attempt to comprehensively review the available evidence pertaining to the provision of neurosurgery education at medical schools worldwide, and perceptions of this education by both medical students and clinicians.

Importance of exposure to neurosurgical education in medical school

Primary and secondary care physicians often encounter patients with common neurosurgical conditions, such as back and neck pain, radiculopathy, head injury, hydrocephalus and space-occupying lesions of the central nervous system. They provide the first contact to these patients and are required to have an adequate knowledge to assess, investigate and often, initiate management appropriately. Given the limited access to neurosurgical expertise in most countries, generalists are expected to care for an expanding volume of both pre-operative, post-operative and non-operative neurosurgical patients; for example, a recent study of traumatic brain injury patients in the UK revealed that only 17% of patients referred to the neurosurgical center were transferred for specialist management.[26-28] This can be particularly true in LMICs where neurosurgical provision is scarce.[4, 5] Estimates show that the poorest third of the world's population receive only 3·5% of all major surgeries undertaken worldwide.[29] Approximately five million essential neurosurgical cases are unmet worldwide, with Southeast Asia contributing to half of this.[30, 31] Such global disparities will also be reflected in the non-operative management and it is therefore imperative that all qualifying doctors have the basic knowledge and skills to be able to manage common neurosurgical conditions well.

Yet, core neurosurgical teaching is often delivered by non-specialist clinicians, who may not have the adequate expertise to optimally manage the early stages of neurosurgical conditions.[3] The reduced focus on neurosurgical education and skills in medical school curricula may leave newly qualified doctors at risk of being unable to undertake this safely and confidently, as reflected in the finding that a third of final year students find neurosurgery the most difficult specialty to refer to.[22, 32, 33] Whether this lack of confidence translates to actual issues in practice has not been assessed.

Amount and type of neurosurgical exposure received

Based on this scoping review, medical students are proponents of neurosurgery being part of their formal curriculum, a notion that is supported by NPDs. However, the challenge remains for curriculum developers and deans to equitably allocate a fair proportion of the medical school curriculum to a relatively small, yet vital specialty, particularly when competing against larger disciplines such as general practice, general surgery and internal medicine.[34] Current surgical teaching for undergraduates at most medical schools revolves around orthopedics and general surgery, interspersed with small amounts, if any, neurosurgery.[34] It may be argued that knowledge of neurosurgical conditions is not essential at medical school level and could be taught in post-graduate curricula, tailored to the particular specialty. However, patients with neurosurgical diagnoses may come into contact with a wide range of specialties and, therefore, appropriate assessment and management of these patients, especially in the emergency setting, forms a critical component of being a safe doctor.

With the assumption that neurosurgical teaching is essential, there remains the question of how neurosurgical teaching should be delivered. Whilst exposure to neurosurgical operating theatre sessions was a popular option amongst students,[22] it remains to be assessed if this would, in fact, improve the level of understanding of neurosurgical conditions that are assessed and managed by the generalist. In addition, not all medical schools have an affiliated neurosurgical center, which raises the question of who should deliver such teaching. Identifying areas of weakness from the perspective of medical students, clinicians and neurosurgeons would allow the tailoring of teaching programs to counter these; for example, targeted teaching on how and when to refer to neurosurgery may mitigate some of the difficulties perceived in referring to neurosurgery.[22]

Interest in neurosurgery as a career

Neurosurgery across the world remains very competitive.[35-37] Doctors choose their career based on the specialties to which they have been exposed to and it is therefore important to maintain exposure to neurosurgery in order to sustain this interest.[38] Early exposure to neurosurgery is not only effective in improving knowledge but can debunk spurious stereotypes that can intimidate from potentially pursuing it as a career.[39]

Moving forward

This scoping review suggests that there is a large variability in neurosurgery training in medical schools,[40] and not all medical schools offer students formal neurosurgery education and assessments.[3, 20] A formal study would be the first step in assessing neurosurgery exposure at medical school, and characterize the extent of teaching,

as has been done recently at a more general level in the UK.[40] Another avenue would be to evaluate the standards of medical graduates in managing neurosurgical conditions or identifying the appropriate patients to refer to neurosurgical services. If current curricula are subsequently deemed inadequate for the practicing doctor, expert agreement from various stakeholders (neurosurgeons, medical educators, GPs and hospital specialists) of learning outcomes and formal neurosurgical curriculum for undergraduates is required. National neurosurgical societies and international bodies such as the World Federation of Neurosurgical Societies (WFNS) are aptly positioned and established to facilitate this process, advocating for the coverage of neurosurgery in medical school curricula, following on from the examples of other specialties.[9, 10]

Our review also offered the reassuring finding that 95% of NPDs in the US and 70% in the UK believe that neurosurgery should be a required aspect of the medical school curriculum, and would be willing to contribute more to medical education.[3] However, we acknowledge that similar curricula in these countries might not be applicable in different healthcare systems across the world that are structured differently. Using the hub-and-spoke delivery model of neurosurgery in the UK as an example, primary care and secondary care generalists act as gatekeepers to neurosurgical care, and it is mandatory for patients to be referred via these channels. It is crucial that these clinicians are well-equipped with neurosurgical education and skills to know when to (and when not to) refer to a neurosurgeon for further management. This may not be the case in other healthcare systems.

None of our screened and included studies came from LMICs. Reasons could include that neurosurgery is a relatively new, resource intensive specialty and is not widely available in many LMICs.[4, 5] Nonetheless, a neurosurgery component of the medical curriculum might be particularly important in such settings as routine access to safe, timely and affordable neurosurgical care is lacking.[4, 41, 42] For example, with one neurosurgeon per 3.1 million people in Sub-Saharan Africa,[43] a large burden of basic neurosurgical care is borne by general physicians and general surgeons. It is therefore vital that advocacy work to include neurosurgical topics in medical school curricula span across the globe, with special attention given to LMICs. Social Media-based neurosurgical channels can also play a prominent role in providing structured neurosurgical case-based discussion that is curated by neurosurgeons. Certain groups such as the UK charity Brainbook have made inroads into providing open access undergraduate neurosurgical education via the medium of Twitter, to a global audience.[44] From a postgraduate perspective The Neurosurgical Atlas by Aaron Cohen-Gadol has provided excellent open access resources for neurosurgery residents and aspiring neurosurgeons.[45] Such a resource could be emulated for the undergraduate population.

Strengths and limitations

The findings are derived from a thorough search of four electronic databases. By including all study designs and lenient inclusion criteria, a comprehensive review of research evidence was achieved. Despite this, only 10 studies qualified for inclusion. Furthermore, the use of questionnaires to collect data in each study may have limited the opportunity for participants to express their perspectives, limiting our ability to further identify themes of this review. Nevertheless, we were still able to

collate results in a structured manner and draw conclusions that represent a starting point for more robust future studies. We identified specific gaps in the existing literature, which are outlined in the 'Moving Forward' section above.

Conclusions

This scoping review provides a starting point to better understand the provision of neurosurgery education in medical schools across the world. Our review demonstrates the paucity in evidence relating to education on neurosurgical topics, especially in LMICs. In addition to mapping what is taught to students and the mode of teaching, we highlight the need to systematically determine whether this is adequate from the perspective of multiple stakeholders, including neurosurgeons, medical educators, GPs and the variety of specialists that play a crucial role in the management of patients with neurosurgical conditions. Ultimately, we as neurosurgeons need to play an active role in advocating for education pertaining to our specialty.

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Disclosure of interest

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Table 1. Inclusion and exclusion criteria used to assess eligibility of studies.

Inclusion criteria	Exclusion criteria
• Any published primary studies (using quantitative, qualitative or mixed methodology), narrative and systematic reviews, editorials, commentaries, opinion papers, letters, education papers, conference abstracts, protocols, reports, theses or book chapters • Studies on neurosurgery in the medical curriculum, published from 1999 onwards (i.e. within the past 20 years)	• Not human subjects • Studies not reporting data on the provision of neurosurgery education at all • Studies reporting data on the provision of neurosurgery education but not in the medical school curriculum ie. pre-medical education • Studies reporting data on the provision of neurosurgery education but not in the medical school curriculum ie. neurosurgery speciality training

Table 2: Summary of findings from the included studies

Authors and year	Country	Study design	Data collection method, sample size, types of participants	Main findings relating to medical school education in neurosurgery		
				Perceived importance of neurosurgery from the perspective of the medical student/ medical school dean and NPD	Amount and type of neurosurgical exposure received	Interest in neurosurgery as a career
Hanrahan et al. (2019)	United Kingdom	Quantitative	Likert scale questionnaires to 57 pre-conference medical students, and 63 post-conference medical students	NA	• 33.3% previously attended a neurosurgical conference/course. • 39.7% experienced neurosurgery in medical school • 31.6% completed an additional degree, SSC or project related to neurosurgery. • 26.3% received neurosurgical teaching during their medical education.	• 'I am interested in a career in neurosurgery' (Median score 4, IQR 4-5 both pre- and post-conference) • 'I understand what a career in neurosurgery involves' (Median score 3, IQR 3-4 pre-conference and 4, IQR 4-5 post-conference) • 'I understand what is required of me to obtain a training number in neurosurgery' (Median score 3, IQR 2-4 both pre- and post conference).
Hanrahan et al. (2018)	United Kingdom	Quantitative	Likert scale questionnaires to 38 clinical medical students	• 'I have experienced neurosurgical teaching before this conference.' (Median score 1, IQR 1)	• 'I have experienced neurosurgical teaching before this conference.' (Median score 1, IQR 1) • 'Ex vivo workshops should be integrated as part of the medical school curriculum' (Median score 5, IQR 0).	• 'This workshop has increased my interest in Neurosurgery' (Median score 4, IQR 1) • 'This workshop motivates me to pursue a career in Neurosurgery' (Median score 5, IQR 2)
Hill et al. (2011)	United Kingdom	Mixed-methods	Likert scale questionnaires to 100 medical students, and 100 doctors prior to ST post application	• 'Neurosurgery is an important subject' (Mean score 4.08 ± 0.69) • 'Neurosurgery should be taught as part of an undergraduate degree' (Mean score 3.26 ± 1.38) • 'Placements in neurosurgery should form part of medical training' (Mean score of 3.78 ± 0.82)	• 'Neurosurgery is/was taught as part of my undergraduate medical degree' (Mean score 3.23 ± 1.48)	• 'Neurosurgery is an interesting specialty' (Mean score 4.29 ± 0.73) • 'I would consider a career in neurosurgery' (Mean score 2.94 ± 1.27)
Knight et al. (2017)	United Kingdom	Mixed-methods	Face-face structured interview and questionnaire with 201 medical students	• 82.8% of students agreed/ strongly agreed that the neurosurgical sessions they attended contributed to their learning, with only 8.5% disagreeing. • 67.7% of students agreed/strongly agreed that attending at least one neurosurgical theatre session was beneficial, while 22.9% disagreed or strongly disagreed.	• NA	• 22.4% agreed or strongly agreed they were considering a career in neurosurgery.
Skarparis et al. (2016)	United Kingdom	Quantitative	Structured questionnaire to 357 medical students	• 33% identified neurosurgery as the surgical specialty they had the most concern referring patients to on grounds of identifying the appropriate patients.	• 49% attended neurosurgical theatres • 80.2% attended classroom teachings, • 7.6% attended wards / clinics / SSCs / Surgical Society Events / Electives • 5.8% had no exposure at all.	NA
Whitehouse et	United	Mixed-	Survey of 28	• 100% of NPDs and 72% of MSRs thought	• 94% of MSRs and 80% of NPDs said neurosurgery	NA

al. (2015)	Kingdom	methods	doctors (10 NPDs and 18 MSRs).	neurosurgery exposure should be a required component in medical school curriculum. • 70% of NPDs and 61% of MSRs thought a national curriculum or guidance for undergraduate neurosurgical training would be useful for students.	topics were taught. • 56% of MSRs and 70% of NPDs offered optional neurosurgical modules. • 6% of MSRs reported neurosurgical topics were not taught at all. • 67% of MSRs and 90% of NPDs reported 100% of students had some form of neurosurgery teaching. • 10% of NPDs reported only 13% of students had formal neurosurgical teaching.	
Akhigbe et al. (2014)	Ireland	Quantitative	Likert scale survey of 60 medical students	• 90% agreed that neurosurgical history is difficult to obtain, neurosurgical signs are difficult to elicit.	• 80% of the students agreed that their neurosurgery teaching is inadequate. • 90% agreed that neurosurgical history is difficult to obtain, neurosurgical signs are difficult to elicit.	• 78% would consider neurosurgery as a future career. • >90% believed that neurosurgery training is long, neurosurgical illnesses have poor outcomes • 87% believed neurosurgery can impede family life.
Boggild et al. (2012)	Canada	Mixed-methods	Survey of 52 medical students, 17 neurology residents and eight neurosurgery residents	• The lack of physician and public knowledge of concussion, and the subtleties of its clinical diagnosis, were the most frequently cited reasons for the challenges physicians face when diagnosing and managing a concussion	• 8% of the students and residents had never learned about concussions during medical school	NA
Resnick (2000)	United States	Mixed methods	Survey of 65 NPDs and 57 medical school deans.	• 95.2% of NPDs expressed the belief that a neurosurgery component should be a required aspect of the curriculum in medical student education. • 70.2% of deans thought that neurosurgeons should be more involved in the education of undergraduate medical students.	• Only one program in North America reported having a required neurosurgical rotation for all medical students • Deans dedicated an average of 23.6 neurosurgery-related personnel hours/year to medical students (range 0–436, median 5, standard deviation 70.1 hours/year). • NPDs reported an average of 68.2 hours/year (range 0–436, median 33, standard deviation 33 hours/year).	NA
Fox et al. (2011)	United States	Mixed-methods	Questionnaires to 86 neurosurgery course coordinators or directors and 64 medical school deans.	• 59% of deans felt that neurosurgery should not be a required rotation.	• 62% of NSCs described having fewer than 10 medical students completing their clerkship per year • 33% of NSCs described having fewer than five. • 97% of NSCs allowed visiting medical students to complete clerkships at their institutions. • NSCs provide didactic lectures (38%), a syllabus or educational handouts (62%), or have a recommended/required textbook (90%).	NA

MSR = medical school representative. NA = not available. NPD = neurosurgery program director. NSC = neurosurgery clerkship (medical student rotation). OSCE = objective structured clinical examination SSC = student selected component. ST = specialty training

Figure Legends

Figure 1. PRISMA flow diagram for studies included and excluded from the scoping review.

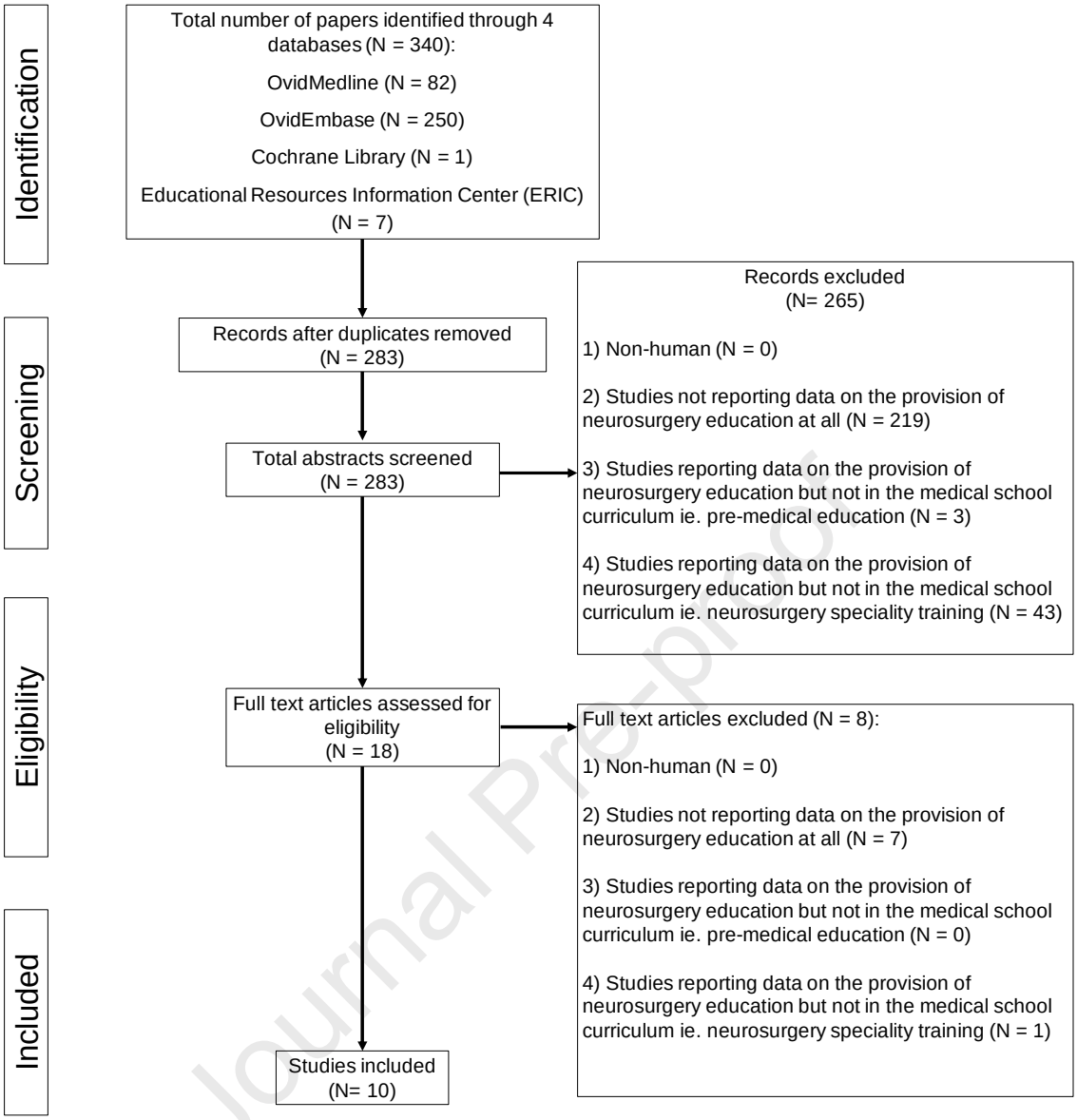


Figure 1. PRISMA flow diagram for studies included and excluded from the scoping review.

Table A.1: Search strategies across the four electronic databases

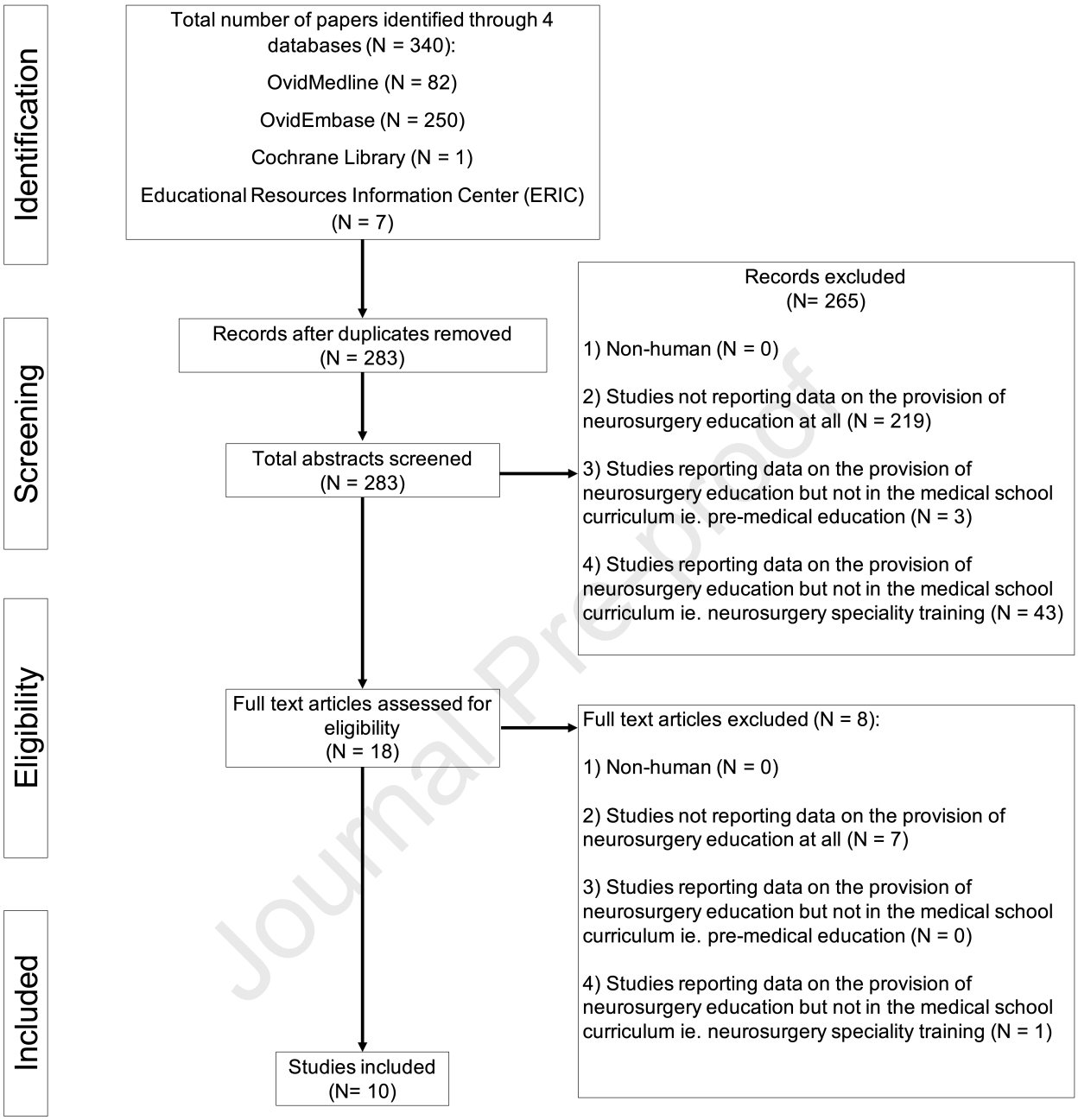
Medline	
No.	Search term
Medical student concept	
1	Exp Students, Medical/
2	Medical student*.tw
3	1 OR 2
Clinician concept	
4	Clinician*.tw
5	Exp Physicians/
6	Physician*.tw
7	Doctor*.tw
8	Trainee*.tw
9	Exp Consultants/
10	Consultant*.tw
11	Attending*.tw
12	Exp Surgeons/
13	Surgeon*.tw
14	4 OR 5 OR 6 OR 7 OR 8 OR 9 OR 10 OR 11 OR 12 OR 13
Neurosurgery concept	
15	Exp Neurosurgery/
16	Neurosurg*.tw
17	15 OR 16
Medical curriculum concept	

18	Exp Schools, Medical/
19	Medical School*.tw
20	Exp Education, Medical/
21	Medical education*.tw
22	Exp Curriculum/
23	Curricul*.tw
24	Teaching*.tw
25	18 OR 19 OR 20 OR 21 OR 22 OR 23 OR 24
Combined concept	
26	3 AND 14 AND 17 AND 25
OVID Embase	
No.	Search term
Medical student concept	
1	Exp medical student/
2	Medical student*.tw
3	1 OR 2
Clinician concept	
4	Exp Clinician/
5	Clinician*.tw
6	Exp Physician/
7	Physician*.tw
8	Doctor*.tw
9	Trainee*.tw
10	Consultant*.tw

11	Attending*.tw
12	Exp Surgeon/
13	Surgeon*.tw
14	4 OR 5 OR 6 OR 7 OR 8 OR 9 OR 10 OR 11 OR 12 OR 13
Neurosurgery concept	
15	Exp Neurosurgery/
16	Neurosurg*.tw
17	15 OR 16
Medical curriculum concept	
18	Exp medical school/
19	Medical School*.tw
20	Exp medical education/
21	Medical education*.tw
22	Exp curriculum/
23	Curricul*.tw
24	Exp teaching/
25	Teaching*.tw
26	18 OR 19 OR 20 OR 21 OR 22 OR 23 OR 24 OR 25
Combined concepts	
27	3 AND 14 AND 17 AND 26
Education Resources Information Center (ERIC)	
1	(medical students or medical education or medical school) AND neurosurgery
Cochrane Library	

No.	Search term
Medical student concept	
1	MeSH descriptor: [Students, Medical] explode all trees
2	(medical student*):ti,ab,kw
3	#1 OR #2
Clinician concept	
4	MeSH descriptor: [Physicians] explode all trees
5	(physician*):ti,ab,kw
6	(doctor*):ti,ab,kw
7	(clinician*):ti,ab,kw
8	MeSH descriptor: [Consultants] explode all trees
9	(consultant*):ti,ab,kw
10	(attending*):ti,ab,kw
11	MeSH descriptor: [Surgeons] explode all trees
12	(surgeon*):ti,ab,kw
13	#4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12
Neurosurgery concept	
14	MeSH descriptor: [Neurosurgery] explode all trees
15	(neurosurger*):ti,ab,kw
16	#14 OR #15
Medical curriculum concept	
17	MeSH descriptor: [Education, Medical] explode all trees
18	MeSH descriptor: [Curriculum] explode all trees
19	(Medical education*):ti,ab,kw

20	#17 OR #18 OR #19
Combined concepts	
21	#3 AND #13 AND #16 AND #20



Abbreviations

AANS: Association of Neurological Surgeons

ASiT: Association of Surgeons in Training

CNS: Congress of Neurological Surgeons

GCS: Glasgow Coma Scale

GMC: General Medical Council

ERIC: Education resources information center

GP: General practitioners

NPD: Neurosurgical program directors

NSC: Neurosurgery clerkship

OSCE: Objective structured clinical examination

PRISMA-ScR: Preferred Reporting Items for Systematic Reviews and Meta-Analysis extension for Scoping Reviews

RCSEng: The Royal College of Surgeons of England

UK: United Kingdom

US: United States

WFNS: World Federation of Neurosurgical Societies