

RESEARCH

Open Access



Neurophobia among medical students and resident trainees in a tertiary comprehensive hospital in China

Fei Han¹, Yao Zhang¹, Ping Wang², Dong Wu³, Li-Xin Zhou¹ and Jun Ni^{1*}

Abstracts

Background Medical students and residents have been revealed to have extraordinary difficulties in managing patients with neurological complaints. However, specific information on Chinese trainees is scarce. Herein, we aimed to uncover the presence of, contributing factors for, and potential solutions to neurophobia among medical students and resident trainees in China.

Methods Questionnaires were administered to the medical students of Peking Union Medical College and residents of the Internal Medicine Residency Training Program at Peking Union Medical College Hospital. We asked about perceived difficulty, knowledge, interest, and confidence in neurology in contrast to six other specialties. The reasons why neurology is regarded as difficult and approaches for improving neurological teaching have been appraised.

Results A total of 351 surveys were completed by 218 medical students and 133 residents. The response rate exceeded 70% in both groups. The prevalence of neurophobia was 66.1% and 58.6% among medical students and residents, respectively. Respondents declared that greater difficulty was observed in neurology than in other specialties, and the management of patients with neurological problems was the least comfortable ($p < 0.0001$). Neurophobia has various perceived causes, and neuroanatomy is regarded as the most important contributor. Nearly 80% of medical students felt that improvements in neurology teaching could be achieved through further integration of preclinical and clinical neurological teaching.

Conclusions The findings of the first survey on neurophobia in China are in accordance with those of previous studies. Neurophobia is highly prevalent in Chinese medical students and residents. Strategies to improve teaching, including enhanced integration of teaching and more online resources, are needed to prevent neurophobia.

Keywords Neurophobia, Medical students, Resident trainees, China

Background

As the population ages, the burden of neurological diseases is intensifying [1]. Given the prevalence and influence of neurological disorders, more demand is placed on hospitals to deliver high-quality medical care. Therefore, it is critical for physicians to feel comfortable and capable of managing patients with neurological diseases.

Neurology is considered as a challenging component of the medical curriculum [2]. In 1994, the term neurophobia was proposed by Jozefowicz for describing 'the fear of

*Correspondence:

Jun Ni

pumchnijun@163.com

¹ Department of Neurology, Peking Union Medical College Hospital, Chinese Academy of Medical Sciences, Beijing, China

² Department of Respiratory Medicine, Peking Union Medical College Hospital, Chinese Academy of Medical Sciences, Beijing 100730, China

³ Department of Gastroenterology, Union Medical College Hospital, Chinese Academy of Medical Sciences, PekingBeijing, China



© The Author(s) 2023. **Open Access** This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>. The Creative Commons Public Domain Dedication waiver (<http://creativecommons.org/publicdomain/zero/1.0/>) applies to the data made available in this article, unless otherwise stated in a credit line to the data.

neuroscience and clinical neurology' [3]. Since then, risk factors of and potential solutions for neurophobia among medical trainees and doctors in different countries have been investigated [4–8]. Based on these studies, neurophobia seems to be a global phenomenon that influences one-third to half of medical students and physicians at all stages of medical education. However, intervention measures in neurology education remain inadequate, and therefore, high-quality research is urgently needed to develop regimens to address this issue [9].

To date, no study has examined neurophobia in Chinese medical students or resident trainees. China's medical education system differs from those of the United States and European countries. Despite the disproportionate burden of neurological disorders in China, they are underrepresented in neurophobia literature. Further recognition of neurophobia in China is warranted to customize medical education programs, thereby recruiting future neurologists and giving non-neurologists confidence to deal with common neurological symptoms.

With this cross-sectional survey, we aimed to ascertain whether neurophobia exists among undergraduate medical students and resident trainees in a Chinese tertiary teaching hospital and, if so, why do they have difficulty in managing neurology? This study also investigated ways to prevent and overcome neurophobia by improving teaching. This is the first such study in the Chinese context.

Methods

China has gradually established a clinical medical education system with Chinese characteristics and includes a 5-year and an 8-year program [10, 11]. The 5-year medical program forms the basis for clinical medicine education. The training plan includes basic and clinical medicine courses and internships. Undergraduates can continue their studies to earn a master's or doctoral degree. The 8-year program aims to produce high-level innovative medical professionals. The 8-year program originated at Peking Union Medical College and has expanded to 14 colleges to date. The training plan includes basic science and clinical medical education, together with scientific research training. After graduation, most students obtain a Doctor of Medicine degree. Medical students in both programs must complete three years of standardized residency training after graduation to become qualified doctors.

This was a single-center study. We conducted a cross-sectional survey with two groups of respondents: undergraduate medical students and resident trainees in internal medicine. The first group included fifth- to eighth-year medical students from the Peking Union Medical College 8-year medical program. The second group comprised resident trainees who entered

the standardized residency training program for internal medicine at Peking Union Medical College Hospital (PUMCH). The Ethics Board of PUMCH approved the study (reference number: K3821), and informed consent was obtained from all participants. All methods were performed in accordance with the relevant guidelines and regulations.

An online anonymous survey consisting of multiple-choice, 5-point Likert scale, and open-ended questions was re-designated from previous analogous studies ([Supplementary material](#)). The questionnaires were designed to appraise the degree of perceived difficulty, interest, knowledge, and confidence in neurology, compared to six other specialties (cardiology, gastroenterology, respiratory medicine, endocrinology, rheumatology, and nephrology). Furthermore, the questionnaire revealed possible contributors to neurophobia and probable strategies to improve neurology education for medical students and residents. All surveys were conducted in February 2023.

Based on previous studies [7], perceived difficulty and a lack of confidence are central features of neurophobia. Thus, neurophobia was defined as a combined confidence and difficulty score of less than or equal to 4 points. We also examined the presence of phobias in the six other medical specialties using a similar definition.

We analyzed the data as two independent datasets for undergraduate medical students and resident trainees. The data were processed using SPSS v24 for Windows statistical software package (SPSS Inc., Chicago, Illinois, United States). Replies to the Likert scale were tabulated into average scores. Values of $p < 0.05$ were considered significant. An independent t-test with the Bonferroni correction for multiple comparisons was used for comparison and significance.

Results

A total of 351 surveys were completed (Table 1). The response rates for medical students and residents were 218/302 (72.2%) and 133/185 (71.9%), respectively, giving an overall response rate of 351/487 (72.1%). Among the medical students, 114 (52.3%) were female, and the mean age was 23.9 ± 1.3 years. For residents, 91 (68.9%) were female and the mean age was 27 ± 2.3 years.

Neurophobia, difficulty, and confidence

According to our proposed definition, a higher prevalence of neurophobia was observed in medical students than in residents (144/218, 66.1% vs. 78/133, 58.6%; $p = 0.007$) (Fig. 1). The participants not only ranked neurology as the most difficult discipline but stated that it was far more difficult than the other six subjects (Table 2, $p < 0.0001$). This was equally clear among both medical students (difficulty score, mean \pm standard error,

Table 1 Demographic characteristics of the respondents

Medical students (n=218)	
Age (years)	23.9±1.3
Gender	
Male	104 (47.7%)
Female	114 (52.3%)
Subgroup	
5 th year medical student	60 (27.5%)
6 th year medical student	65 (29.8%)
7 th year medical student	52 (23.9%)
8 th year medical student	41 (18.8%)
Possibility of pursuing neurology as a future career	
Unlikely	86 (39.5%)
Moderate	67 (30.7%)
Likely	25 (11.5%)
Have not decided	40 (18.4%)
Resident trainees (n = 133)	
Age (years)	27±2.3
Gender	
Male	42 (31.6%)
Female	91 (68.4%)
Subgroup	
Residents in the 1 st year	30 (22.6%)
Residents in the 2 nd year	34 (25.6%)
Residents in the 3 rd year	22 (16.5%)
Residents in the 4 th year	13 (9.8%)
Residents in the 5 th year	16 (12.0%)
Residents in the 6 th year and above	18 (13.5%)

1.7±0.05) and resident trainees (1.68±0.06). Participants had minimal confidence in evaluating, diagnosing, and managing patients with neurological problems versus other medical conditions in both groups (confidence score 2.25±0.05 for medical students and 2.51±0.08 for resident trainees).

Interest and knowledge

The gap in the level of interest between neurology and other medical specialties was small, except for nephrology, which had a significantly lower interest rating ($p < 0.0001$) (Table 2, Fig. 1). In contrast, a large gulf was observed in the knowledge scores (Table 2, Fig. 1). Respondents rated their neurology knowledge as the lowest among the seven medical specialties for medical students (2.63±0.05). For residents, they also had significantly less knowledge in neurology (2.63±0.08) compared to all other specialties, except for endocrinology.

Factors for perceived difficulty with neurology

Various factors were associated with perceived difficulty in neurology (Fig. 2). Neuroanatomy was considered the

most common factor contributing to making neurology difficult (78.9% for medical students; 79.7% for resident trainees), followed by a large number of rare disease diagnoses (70.6% for medical students; 71.4% for resident trainees) and diagnostic complexity (62.8% for medical students; 70.7% for resident trainees).

Suggestions for improving neurology education

The responses indicated that approaches for improving neurology teaching for medical students consisted of more integrated teaching (79.4%), more lectures in clinical neurology (50%), and more effective neuroanatomy teaching (36.2%) (Fig. 3-a). In addition, residents mentioned having more online resources for self-directed learning (63.9%) and more bedside teaching during residency rotation (48.1%) (Fig. 3-b).

Discussion

This study was the first structured survey of neurophobia among Chinese medical students and resident trainees, comprising 351 respondents from a tertiary teaching hospital in Beijing, China. Our results showed high difficulty and low confidence scores for neurology. This is in line with the results of prior studies in different parts of the world, including the United States, United Kingdom, Canada, South America, and Asian and African countries, revealing that neurophobia is a global issue across diverse educational systems [4–8, 12–15] (Table 3).

In this study, both medical students and residents agreed that neurology was the most difficult medical discipline, and they felt the least confident in dealing with patients with neurological problems, in contrast to the six other specialties in primary care settings. Two-thirds of the medical students and more than half of the resident trainees had neurophobia. This prevalence is higher than previous estimates by Jozefowicz [3] and a survey conducted in Singapore [7], indicating that neurophobia should be taken seriously in China. Over the past 30 years, neurology perception has remained unchanged in contrast to the rapidly changing requirements for neurological care in an aging population. Medical education authorities and neurology educators should pay particular attention to these issues.

Consistent with previous studies [4, 6, 8], neuroanatomy was the main reason for difficulty in neurology. In the digital era, neuroanatomy education can be improved from conventional sectional images by employing innovative strategies, such as computer-based instructional 3-dimensional models, web-based neuroscience and neurology teaching videos, blended and flipped strategies, and problem-based effective teaching in neuroanatomy.

The poor integration of preclinical and clinical neurological teaching is another major complaint. Almost

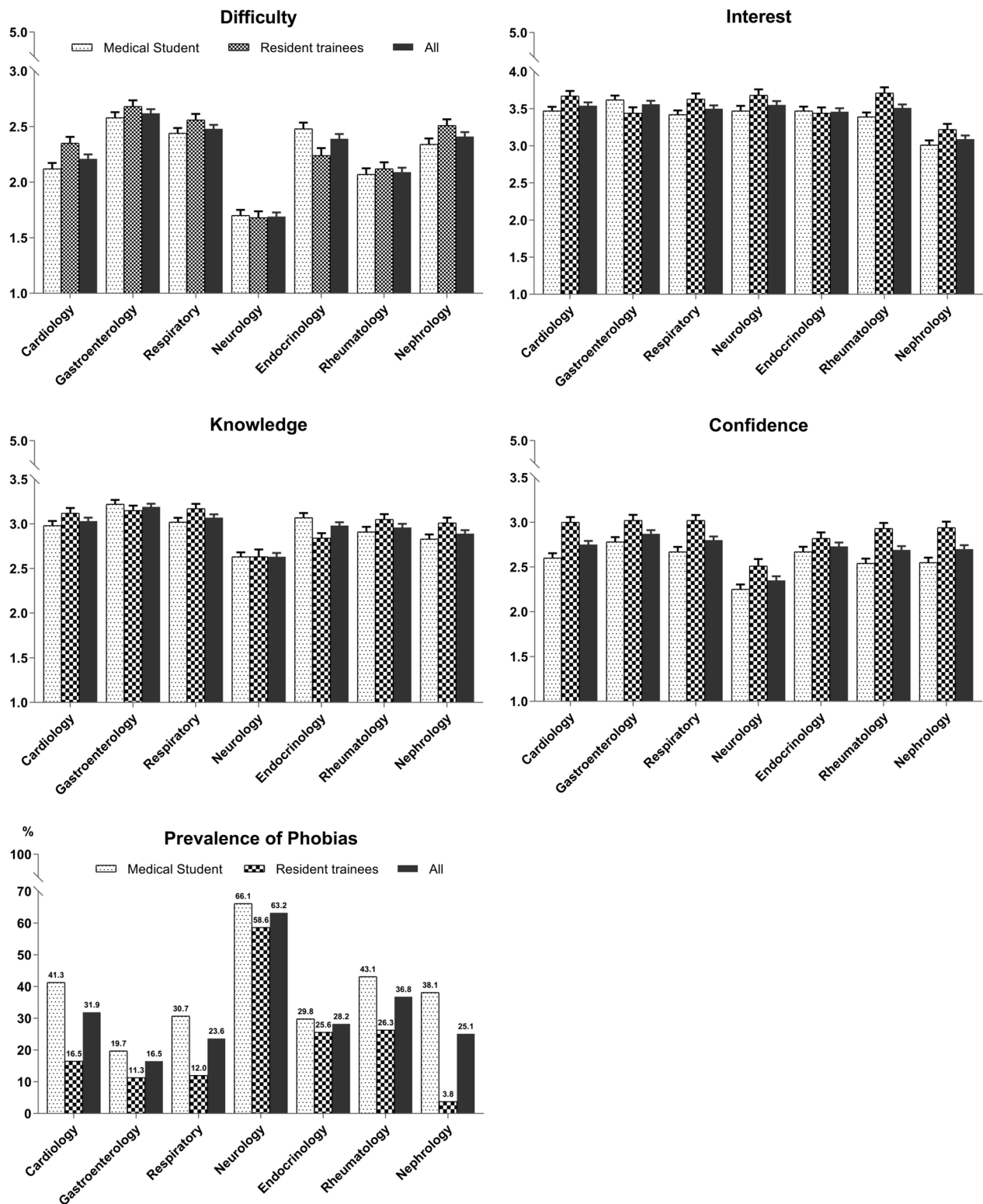


Fig. 1 Mean survey score results and prevalence of phobias across six medical specialties. Difficulty ratings: 1 = very difficult, 2 = difficult, 3 = moderate, 4 = easy, 5 = very easy; Interest ratings: 1 = none, 2 = little, 3 = moderate, 4 = some, 5 = great; Knowledge ratings: 1 = very limited, 2 = limited, 3 = moderate, 4 = good, 5 = very good; Confidence ratings: 1 = very uneasy, 2 = uneasy, 3 = moderately confident, 4 = confident, 5 = very confident

Table 2 Ratings of difficulty, interest, knowledge, and confidence for seven medical specialties

Specialty	Difficulty		Interest		Knowledge		Confidence	
	Mean (SE)	p value	Mean (SE)	p value	Mean (SE)	p value	Mean (SE)	p value
Medical students (n = 218)								
Cardiology	2.12 (0.05)	< 0.0001	3.47 (0.06)	0.96	2.98 (0.05)	< 0.0001	2.60 (0.05)	< 0.0001
Gastroenterology	2.58 (0.05)	< 0.0001	3.62 (0.06)	0.09	3.22 (0.05)	< 0.0001	2.78 (0.05)	< 0.0001
Respiratory	2.44 (0.05)	< 0.0001	3.42 (0.06)	0.54	3.02 (0.05)	< 0.0001	2.67 (0.05)	< 0.0001
Neurology	1.70 (0.05)	n/a	3.47 (0.07)	n/a	2.63 (0.05)	n/a	2.25 (0.05)	n/a
Endocrinology	2.48(0.06)	< 0.0001	3.47 (0.06)	0.99	3.07 (0.05)	< 0.0001	2.67 (0.06)	< 0.0001
Rheumatology	2.07 (0.05)	< 0.0001	3.39 (0.06)	0.34	2.91 (0.06)	0.0003	2.54 (0.05)	0.0001
Nephrology	2.34 (0.05)	< 0.0001	3.01 (0.06)	< 0.0001	2.83 (0.05)	0.007	2.55 (0.05)	< 0.0001
Resident trainees (n = 133)								
Cardiology	2.35 (0.06)	< 0.0001	3.67 (0.07)	0.94	3.12 (0.06)	< 0.0001	3.00 (0.06)	< 0.0001
Gastroenterology	2.68 (0.06)	< 0.0001	3.44 (0.08)	0.04	3.15 (0.06)	< 0.0001	3.02 (0.06)	< 0.0001
Respiratory	2.56 (0.05)	< 0.0001	3.63 (0.07)	0.68	3.17 (0.05)	< 0.0001	3.02 (0.06)	< 0.0001
Neurology	1.68 (0.06)	n/a	3.68 (0.08)	n/a	2.63 (0.08)	n/a	2.51 (0.08)	n/a
Endocrinology	2.24(0.07)	< 0.0001	3.44 (0.08)	0.04	2.84 (0.06)	0.034	2.82 (0.07)	0.003
Rheumatology	2.12 (0.06)	< 0.0001	3.71 (0.08)	0.79	3.05 (0.06)	< 0.0001	2.93 (0.06)	< 0.0001
Nephrology	2.51 (0.06)	< 0.0001	3.22 (0.08)	< 0.0001	3.01 (0.06)	0.0002	2.94 (0.07)	< 0.0001

Difficulty ratings: 1 = very difficult, 2 = difficult, 3 = moderate, 4 = easy, 5 = very easy

Interest ratings: 1 = none, 2 = little, 3 = moderate, 4 = some, 5 = great

Knowledge ratings: 1 = very limited, 2 = limited, 3 = moderate, 4 = good, 5 = very good

Confidence ratings: 1 = very uneasy, 2 = uneasy, 3 = moderately confident, 4 = confident, 5 = very confident

The significance threshold was adjusted for multiple comparisons using Bonferroni correction ($p < 0.008$ denotes significance). n/a, not applicable; SE, standard error

80% of the medical students stated that a combination of neuroanatomy, neuroscience, and clinical neurology would be the best approach. Fragmentation in the learning of basic neuroscience with clinical neurology should be tackled by integrating basic neuroscience learning with early, effective, and multiple clinical exposures more efficiently under a neuro-mentorship program. Furthermore, introducing preclinical revision courses in areas such as neuroscience and neuroanatomy through case-based learning when students enter clinical training could be another useful approach.

In Peking Union Medical College, medical students are required to be involved in a total of 8 weeks neurology attachment in the clerkship year (6th year) and internship year (7th year). The internal medicine residency training program included a 4-week rotation in the Department of Neurology at PUMCH. Some respondents suggested that the lack of rotation time and restricted exposure to neurological patients led them to consider neurology a difficult subject, which should be addressed urgently. In such a limited rotation time, multiple novel educational interventions would help students organize, re-engage, and manage their learning approaches for a deeper understanding through self-directed, problem-based, and team-based learning.

In our study, a high proportion of the residents expected more online self-directed learning resources. Utilization of online resources in neurology teaching and its distinct success over other teaching approaches has been signified in prior studies [18–21]. Online teaching has been revealed to enhance neurology knowledge at the final clinical attachment and residency rotation stages compared to textbooks. The incorporation of video tutorials as part of the online educational approach could offer a reasonable addition to increasing patient exposure and bedside teaching for residents.

It is noteworthy that neurology is regarded as a difficult and challenging subject, but this did not reduce students' interest in or enthusiasm for neurology, and a substantial number of medical students tended to pursue neurology in their future careers. However, once resident trainees begin clinical practice, they may become less neurophobic. Although there was a relatively wide range of neurophobias among medical students and young residents, a trend toward gradual improvement was observed. We speculate that ongoing neurological education and clinical exposure to overcome neurophobia will initially target medical students and then seamlessly continue via post-graduate education.

Owing to the unique, difficult, and complex nature of neurology, neurophobia has long existed worldwide, and

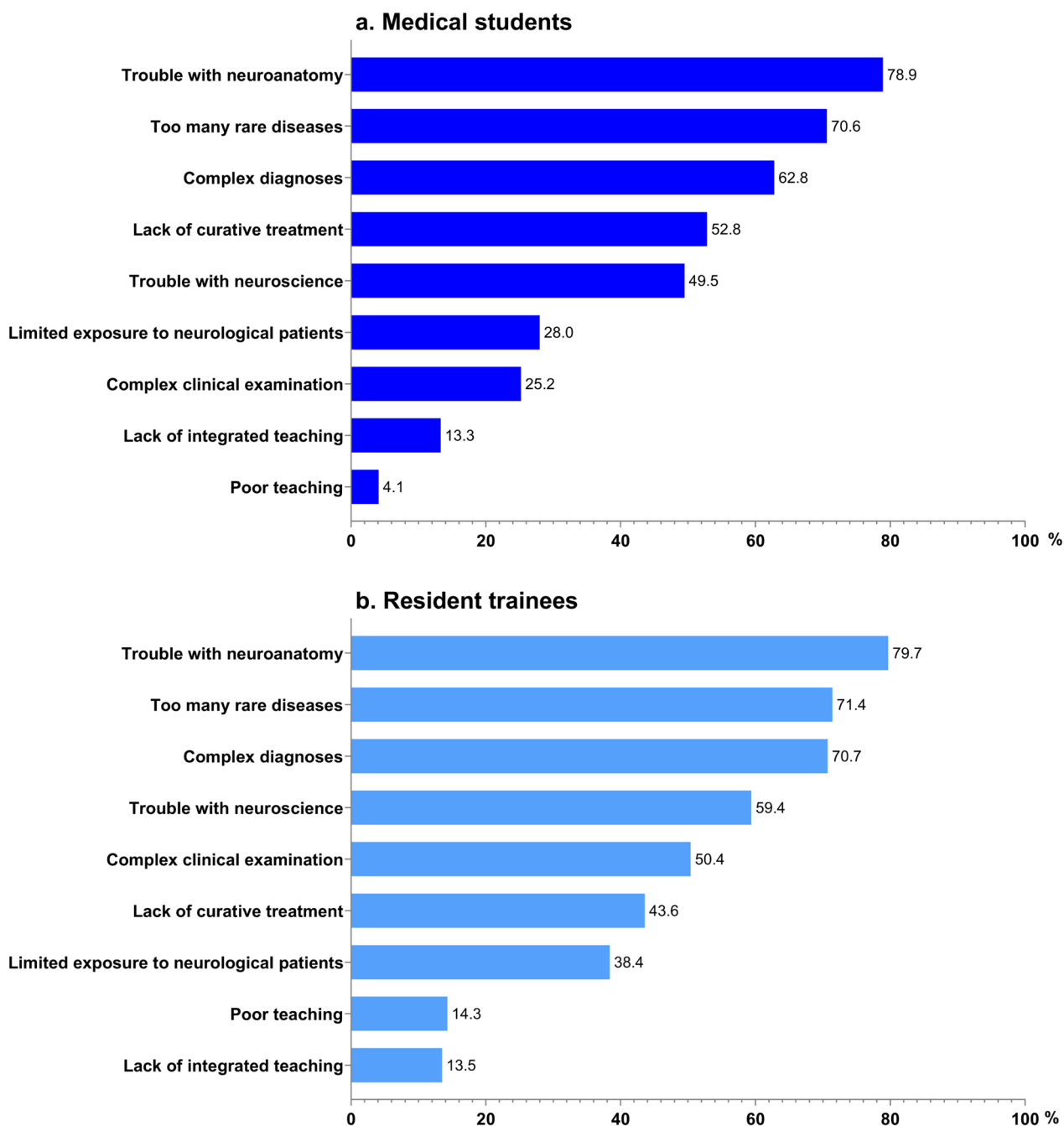


Fig. 2 Reasons why medical students **a** and resident trainees **b** find neurology difficult

our research reached the same conclusions. The presence of neurophobia in various medical communities around the globe raises concerns about its adverse effects on the quality of patient care and management. Researchers have presented several evidence-based recommendations for overcoming neurophobia. Neurology education curriculum reforms, a paradigm shift from a traditional knowledge-based curriculum to a student-centered, and

competency-driven education [22], neuro-mentorship programs, evidence-based effective educational interventions, and problem-based and integrated learning, would be the way forward to removing neurophobia.

As China continues to grow, the need for physicians to adequately address the health needs of its population has become increasingly important. In the future, the government should provide more political support and

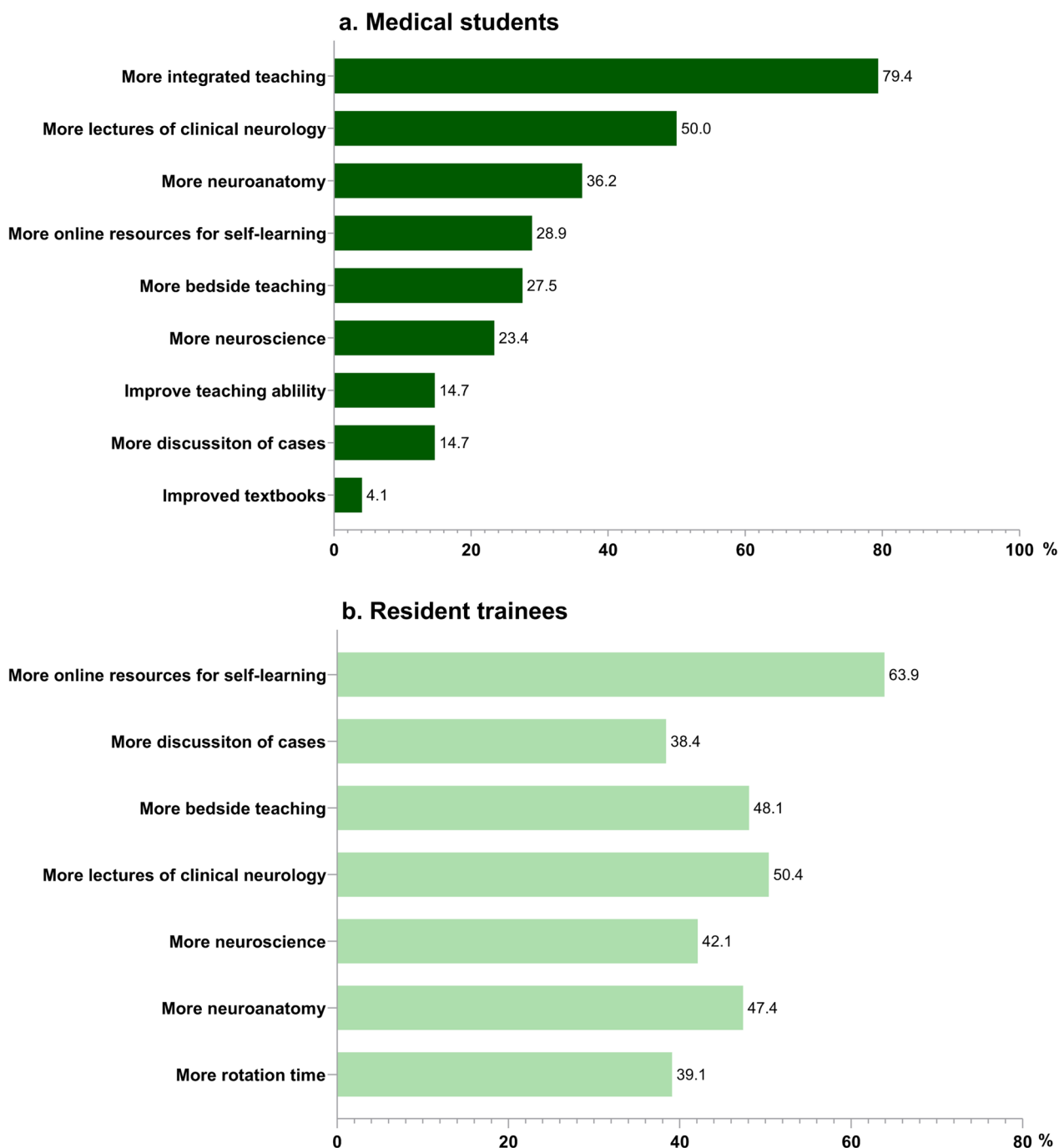


Fig. 3 Percentage of respondents rating each approach to improve teaching. **a** medical students; **b** resident trainees

financial investments to improve the overall capability of global cooperation and communication in neurology education, reinforce partnerships and cultures, identify differences between China and the rest of the world, propose targeted improvement measures to solve neurophobia, and ultimately provide excellent talent reserves for brain science in the twenty-first century.

This study had several limitations. This study was conducted in a single medical institution. PUMCH is a tertiary comprehensive teaching hospital in China and a national referral center offering diagnostic and therapeutic care for complex and rare disorders. Therefore, it may be difficult to generalize our findings to other Chinese medical schools and hospitals. Therefore, multi-center

Table 3 Previous surveys on neurophobia

Country	Subjects	No	Difficulty	Three most common reasons of difficulty
United Kingdom [4]	medical students, senior house officers, general practitioner	345	Rank 1 st among the 7 medical specialties	Poor teaching Trouble with neuroanatomy Trouble with clinical examination
Ireland [5]	medical students and junior doctors	457	Rank 1 st among the 8 medical specialties	Limited patient exposure Complex diagnosis Not enough teaching
Trinidad & Tobago [16]	medical students	167	Rank 1 st among the 7 medical specialties	Need to know basic sciences Complex clinical examination Large number of diagnoses
United States [6]	medical students, residents	152	Rank 1 st among the 8 medical specialties	Limited patient exposure Neuroanatomy Insufficient teaching
Singapore [7]	medical students, junior doctors	289	Rank 1 st among the 7 medical specialties	-
Sri Lanka [14]	medical students, non-specialist doctors	248	Rank 1 st among the 7 medical specialties	1. Neuroanatomy 2. Complex clinical examination
United Kingdom [8]	medical students	2877	Rank 1 st among the 7 medical specialties	Neuroanatomy Basic neuroscience Lack of diagnostic certainty
Northern Ireland [12]	general practice trainees	118	Rank 1 st among the 7 medical specialties	Limited opportunity to work with a neurologist Not enough teaching Limited patient exposure
Canada [13]	medical students	187	24% afraid of clinical neurology 32% afraid of academic neuroscience	-
Saudi Arabia [17]	medical students, junior physicians	422	84.4% found neurology difficult	-
Fifteen countries in Africa [15]	medical students	294	Rank 1 st among the 7 medical specialties	Neuroanatomy Inadequate diagnostic tests Lack of diagnostic certainty

studies are required to confirm these conclusions. Investigations are also warranted to estimate whether intervention measures such as increased patient exposure, more online resources, and enhanced integration of neuroanatomy, neuroscience, and clinical neurology may result in better performance in neurology education.

Conclusions

Neurophobia is prevalent, and both medical students and resident trainees consider neurology to be the most difficult specialty in Chinese tertiary comprehensive hospitals. This study sheds light on the factors that contribute to neurophobia and possible preventive approaches, which will be an essential step in training clinicians to cope with the growing challenges of managing patients with neurological disorders.

Abbreviation

PUMCH Peking Union Medical College Hospital

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s12909-023-04812-1>.

Additional file 1.

Acknowledgements

The authors thank all study participants for their contribution.

Authors' contributions

FH analyzed the data and wrote the main manuscript text. YZ, PW, DW and LXZ acquired and interpreted the data. JN interpreted the data and revised the manuscript for intellectual content.

Funding

None.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The study was approved by the Ethics Committee of Peking Union Medical College Hospital (reference number: K3821), and informed consent was obtained from all the participants.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Received: 13 April 2023 Accepted: 27 October 2023
Published online: 02 November 2023

References

1. Collaborators GBDN. Global, regional, and national burden of neurological disorders, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet Neurol.* 2019;18(5):459–80.
2. Solorzano GE, Jozefowicz RF. Neurophobia: a chronic disease of medical students. *Neurology.* 2015;85(2):116–7.
3. Jozefowicz RF. Neurophobia: the fear of neurology among medical students. *Arch Neurol.* 1994;51(4):328–9.
4. Schon F, Hart P, Fernandez C. Is clinical neurology really so difficult? *J Neurol Neurosurg Psychiatry.* 2002;72(5):557–9.
5. Flanagan E, Walsh C, Tubridy N. 'Neurophobia'—attitudes of medical students and doctors in Ireland to neurological teaching. *Eur J Neurol.* 2007;14(10):1109–12.
6. Zinchuk AV, Flanagan EP, Tubridy NJ, Miller WA, McCullough LD. Attitudes of US medical trainees towards neurology education: "Neurophobia" - a global issue. *BMC Med Educ.* 2010;10:49.
7. Kam KQ, Tan GS, Tan K, Lim EC, Koh NY, Tan NC. Neurophobia in medical students and resident trainees—blame the GIK. *Ann Acad Med Singap.* 2013;42(11):559–66.
8. Pakpoor J, Handel AE, Disanto G, Davenport RJ, Giovannoni G, Ramagopalán SV, et al. National survey of UK medical students on the perception of neurology. *BMC Med Educ.* 2014;14:225.
9. Mccarron MJ, O'N, Neurosurgery, Psychiatry. 034 A systematic review of neurology education interventions. 2012;83(3):e1-.
10. Wang W. Medical education in china: progress in the past 70 years and a vision for the future. *BMC Med Educ.* 2021;21(1):453.
11. Liu X, Feng J, Liu C, Chu R, Lv M, Zhong N, et al. Medical education systems in China: development, status, and evaluation. *Acad Med.* 2023;98(1):43–9.
12. McCarron MO, Stevenson M, Loftus AM, McKeown P. Neurophobia among general practice trainees: the evidence, perceived causes and solutions. *Clin Neurol Neurosurg.* 2014;122:124–8.
13. Fantaneanu TA, Moreau K, Eady K, Clarkin C, DeMeulemeester C, Maclean H, et al. Neurophobia inception: a study of trainees' perceptions of neurology education. *Can J Neurol Sci.* 2014;41(4):421–9.
14. Matthias AT, Nagasingha P, Ranasinghe P, Gunatilake SB. Neurophobia among medical students and non-specialist doctors in Sri Lanka. *BMC Med Educ.* 2013;13:164.
15. McDonough A, Chishimba L, Chomba M, Zimba S, Mwendaweli N, Asukile M, et al. Neurophobia in Africa: Survey responses from fifteen African countries. *J Neurol Sci.* 2022;434: 120161.
16. Youssef FF. Neurophobia and its implications: evidence from a Caribbean medical school. *BMC Med Educ.* 2009;9:39.
17. Abulaban AA, Obeid TH, Algahtani HA, Kojan SM, Al-Khathaami AM, Abulaban AA, et al. Neurophobia among medical students. *Neurosciences (Riyadh).* 2015;20(1):37–40.
18. Chhetri SK. E-learning in neurology education: principles, opportunities and challenges in combating neurophobia. *J Clin Neurosci.* 2017;44:80–3.
19. Lim EC, Ong BK, Seet RC. Using videotaped vignettes to teach medical students to perform the neurologic examination. *J Gen Intern Med.* 2006;21(1):101.
20. Jao CS, Brint SU, Hier DB. Making the neurology clerkship more effective: can e-Textbook facilitate learning? *Neurol Res.* 2005;27(7):762–7.
21. McManus IC, Richards P, Winder BC, Sproston KA. Clinical experience, performance in final examinations, and learning style in medical students: prospective study. *BMJ.* 1998;316(7128):345–50.
22. Merlin LR, Horak HA, Milligan TA, Kraakevik JA, Ali II. A competency-based longitudinal core curriculum in medical neuroscience. *Neurology.* 2014;83(5):456–62.

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Ready to submit your research? Choose BMC and benefit from:

- fast, convenient online submission
- thorough peer review by experienced researchers in your field
- rapid publication on acceptance
- support for research data, including large and complex data types
- gold Open Access which fosters wider collaboration and increased citations
- maximum visibility for your research: over 100M website views per year

At BMC, research is always in progress.

Learn more biomedcentral.com/submissions

