

Preventing “Neurophobia”: Remodeling Neurology Education for 21st-Century Medical Students through Effective Pedagogical Strategies for “Neurophilia”

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Abstract

Neurology has a reputation, particularly as a complex “head-to-toe” discipline for undergraduate medical students. Neurophobia syndrome, a global phenomenon, fundamentally stems from pedagogical deficiencies during the undergraduate curriculum, the lack of vertical integration between basic neurosciences and clinical bedside neurology, the lack of clinical reasoning exercises, cognitive heuristics, and clinical problem-solving, errors in diagnostic competence, and hyposkilia. This ultimately results in poor clinical competence and proficiency in clinical neurology and causes attrition in nurturing a passion for learning the neurology discipline. This article explores plausible factors that contribute to the genesis of neurophobia and multifaceted strategies to nurture interest in neurosciences and provide possible solutions to demystify neurology education, especially the need for evidence-based educational interventions. Remodeling neurology education through effective pedagogical strategies and remedial measures, and using the Miller’s pyramid, would provide a framework for assessing clinical competence in clinical bedside neurology. Technology-enhanced education and digital classrooms would undoubtedly stamp out neurophobia in medical students of the 21st century. It will not frighten off another generation of nonneurologist physicians to empower them to hone expertise in order to tackle the increasing burden of neurological disorders in India. Furthermore, promoting neurophilia would facilitate the next generation of medical students in pursuing career options in neurology which would be quintessential not only in closing India’s looming neurologist workforce gap but also in fostering interest in research imperatives in the next generation of medical students.

Keywords: Clinical reasoning skills, cognitive heuristics, educational interventions, educational research, evidence-based education, Holmesian reasoning, mentorship, Miller’s pyramid, neurological diagnosis, neurology education, neurophilia, neurophobia, pedagogical strategies, pedagogy, technology-enhanced learning

“The successful teacher is no longer at a height, pumping knowledge at high pressure into passive receptacles... he is a senior student anxious to help his juniors.”

– Sir William Osler

“The task of the modern educator is not to cut down jungles, but to irrigate deserts.”

– C. S. Lewis

BACKGROUND

The Global Burden of Disease Study^[1,2] reflects an ever-increasing trend of neurologic disorders and

cerebrovascular diseases in low- and middle-income countries. There is a substantial double burden of noncommunicable disorders as well as communicable diseases.^[3-6] It is prudent to realize that neurological disorders need to be considered as a public health issue since neurological afflictions do certainly have the potential for disastrous outcomes on the mental capital, premature mortality, and well-being of nations.

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Neurological disorders such as dementias, traumatic brain injury, and stroke are now the hidden epidemic of “neurologic disability” in India.^[4] The World Health Organization has estimated the magnitude of neurologic disorders for 2030, i.e., the number of disability-adjusted life years to be 7% of the total of all diseases, 12% of deaths worldwide, and 14% of total years lost due to disability which is to be attributed to neurologic disorders. This magnitude of the total burden of neurologic disorders would thus mandate a substantial need for trained health workforce to provide quality service and delivery of neurologic care.^[5,6]

In India, there are <1200 neurologists with a ratio of 1 neurologist to 1,250,000 Indians. In contrast, the USA has a neurologist for 26,000 population and Canada has 1 for 53,000 population. India is facing a public health crisis in providing neurological services, particularly in the districts, taluks, and primary health-care settings. It is evident that the organization of neurology services in India has tremendous challenges and there is an urgent need to increase the neurology care delivery workforce.^[7] From another perspective, it is disappointing to note that there are only 90 institutes in India providing training to 200 neurology residents annually. Thus, there is a high priority need to increase the number of teaching institutions to provide neurology training (DM and DNB in neurology), create more opportunities for doing neurology fellowships, and yet maintain high standards of education and training in neurology. Until that time, it will be the nonneurologist physicians who will be challenged to tackle the widely prevalent neurological disorders in India.^[3-6,8] In India, at present, 90% of neurological cases are treated by nonneurologist physicians, and so it is imperative to ensure early and multiple clinical neurology exposures to those who do not become neurologists. To address the malady of neurophobia and promote neurophilia among Indian medical graduates, we need to first understand the magnitude, plausible factors, and its determinants so that evidence-based effective remedial measures can be initiated.

WHAT IS THE “SYNDROME” OF NEUROPHOBIA?

Understanding genesis and extent of the problem of neurophobia

“Neurophobia,” a term coined in 1994 by Dr. Ralph Józefowicz, a professor of neurology in the United States, is, unfortunately, a well-documented global phenomenon. It is an endemic chronic “disease” among medical students and junior doctors.^[9] However, it is interesting to note that this entity was reported as early as 1959 by Poser in undergraduate medical students.^[10] An analogy to neurophobia is the irrational fear of mathematics described by Tobias as “mathphobia.” How can we understand the genesis of neurophobia? This untoward educational phenomenon quintessentially reflects medical students’ daunting perceptions and beliefs, their negative preconceptions associated with neurological education, their apprehensive emotional sentiments of neuroanxiety, dislike, intimidation, and eventual disinterest emanating from their perceived

difficulty to apply basic science knowledge to clinical scenarios. Students with neurophobia express their “fear of neurology” as (i) neurology to be ranked as far more difficult than any other discipline in a theoretical context; (ii) having less comfort and least confidence to handle neurology “at the bedside” in clerking neurology patients, (iii) neurology to be the discipline where they felt least knowledgeable about since the integration of basic neurosciences was not early during their clinical training, and to have inadequate and less frequent clinical neurology exposure, and (iv) avoidance of examination of the nervous system and a cynical and nihilistic attitude toward neurological diseases.

There is a considerable variation in the panorama of neurology teaching in India with respect to the extent and weight given to medical undergraduate learning about clinical neurology topics. In this context, the cornerstone of teaching clinical neurology to undergraduates is an attachment to the department of neurology for medical students to become proficient in the performance of the neurological examination and to see enough patients with the common neurological conditions, emergencies, and disabilities supervised and mentored by neurologists. The teaching by nonneurologists and the lack of “role models” and mentorship programs are also incriminated as plausible determinants in the genesis of neurophobia. A nonneurologist physician who had been trained in his/her formative careers by nonneurologists could potentially pass neurophobia to his/her students. Spending time on shadowing a neurologist in the outpatient clinic or on the inpatient ward, or attending bedside teaching conferences, is worthwhile. It is quintessential to assess the spectrum of neurophobic tendencies when teaching neurology is done by neurologists vis à vis teachers in other specialties such as general medicine. A succinct example of such a comprehensive questionnaire survey did focus upon the provision of neurological undergraduate teaching among the undergraduate students in 28 medical schools in the UK.^[11] Such studies, if undertaken in Indian medical schools, would certainly give us thorough insights into the dynamics of neurophobia and effective pedagogies to remodel neurology education in the 21st century.

To what extent does neurophobia exist among selected undergraduate medical students? Many studies have documented this “fear of the neural sciences and clinical neurology and the medical students’ inability to apply their knowledge of basic sciences to clinical situations” to be a global “pandemic” and is said to affect 50% of medical students at one point during their undergraduate training. Studies establishing neurophobia to be a well-documented phenomenon worldwide come from the United States,^[12-14] Canada,^[15] India,^[16] Sri Lanka,^[17] China,^[18] Singapore,^[19] Saudi Arabia,^[20] the United Kingdom,^[21] Ireland,^[22] Finland,^[23] and the Caribbean.^[24] There are also similar studies from Australia, New Zealand, and Europe. All these studies do point out that medical students did rank neurology as the most difficult of the subspecialties, perceived poor quality neurology teaching, perceived poor confidence, comfort level, and difficulty with clinical neurological examinations,

and did experience limited exposure to neurological patients during their medical training. It is also interesting to note that apart from the students' perceived knowledge levels and difficulties with neurology, negative preconceptions did exist that predated medical schools about neurology too. A study among undergraduate medical students at the University of Ottawa did reveal another interesting finding that the students' perceptions of neurology did differ significantly by the year of study. The level of comfort toward clinical neurology was the least in their 1st year of study, highest in the 2nd year, but paradoxically a "wear off" was noted by the 3rd year. This study finding does give insight into the need for a more sustained reinforcement of neurological concepts across the length of the curriculum of students' undergraduate medical education.^[15] The integration of the preclinical undergraduate medical curriculum in order to facilitate applications of basic neuroscience to clinical scenarios, as well as frequent and effective exposure of neurology rotation teaching, is quintessential. This would certainly reduce medical students' neurophobia, improve their performance with aspects of their neurological knowledge, and augment their comfort levels with neurological examination and clerkship.

NEUROPHOBIA: AN INDIAN PERSPECTIVE

Although the specialty of neurology was established in India for more than six decades, there is a dearth of studies on neurophobia. However, it is worthwhile to take note of a single seminal study from India that was conducted from various medical colleges under Maharashtra University of Health Sciences (surveying medical colleges in Mumbai, Pune, Sholapur, Miraj, and Thane districts).^[16] This unique study explored contributory factors that determined career choices in neurology of postgraduate students using a structured 13-item questionnaire. The study done in 2013 on postgraduate students' attitude and perception in pursuing a future career option in neurology reveals that 19% preferred neurology as their first career choice while an additional 16% kept neurology as the 2nd choice and 18% considered neurology to be their last career option against career opportunities in other branches of medicine.^[16] The barriers to choosing neurology as their career choice were attributed to the perceived difficulties in cognitive and metacognitive skills and clinical reasoning skills in addition to the lack of "role model" and mentorship. Other factors that predisposed their reluctance to the choice of a career in neurology were attributed to the inadequacy of clinical neurological exposure to common neurological cases and emergencies as well as less-sound basic neurosciences' knowledge, especially with neuropharmacology.

The paucity of similar studies from other parts of India is undoubtedly a lacuna that certainly needs to be addressed through a national survey of Indian undergraduate and postgraduate medical students on their perception of basic neurosciences and clinical neurology. Medical educators must envisage research approaches to generate and provide scientifically sound, valid, and reliable data to assess the

prevalence and plausible factors contributing to neurophobia in our country. As a research imperative, we would need to assess the magnitude of neurophobia in India by restructuring questionnaire-based studies as envisaged in the University of Ottawa study,^[15] the Maharashtra University of Health Sciences Study,^[16] and to assess whether teaching of neurology done by neurologists ameliorates neurophobia as done in medical schools in the UK.^[11] Only then will we be equipped with preventative and remedial measures to effectively address this issue and pave the way forward for remodeling neurology undergraduate and postgraduate education in India.

There are societal implications for such research imperatives in India. Breaking down neurophobia would not only increase medical students' interests in neurology, but also promote neurophilia in the next generation of nonneurologists who will have to deal with the intensifying burden of neurological disorders in India. The syndrome of neurophobia is not merely restricted to the "classroom" but indeed has downstream consequences undermining the neurologic competence of doctors in the field of neurology in terms of their timely and early recognition of neurologic disorders with grave consequences for health-care organizations and delivery of neurological services and the "neurologic well-being" of our citizens. The downside of "neurophobia" that develops during undergraduation may persist into their postgraduate training and later in their professional careers. Selecting a career option in neurology is one of the most important professional decisions one will have to make, and many students compile a list of advantages and disadvantages for each specialty they are considering to make that decision a bit easier. It is vital to encourage potential neurologists from the very earliest stages of their careers in medical schools and continue through medical training with direct exposure to clinical neurology. Future career choices are still strongly influenced by both the experience of a subject as a medical student and the emotional and experiential learning imparted by "role model" teachers and enthusiastic and proactive departments during their formative clinical years.

WHAT MAKES CLINICAL NEUROLOGY LEARNING DIFFICULT?

Traditionally, the subject of neuroscience and clinical neurology has been one of the most difficult courses for medical students in undergraduate medical education. Is clinical neurology so difficult?^[12] Perhaps, it is not. A panoply of causes [Table 1] does set the stage for negative sentiments of anxiety, dislike, and lack of passion in gaining competency in the principles of neurology.

As educators and clinical teachers, there is a need to reinvent and quicken up our pedagogical competence ("Teachers of Tomorrow" programs), to introduce an Integrated Learning Program for the preclinical phase of undergraduate medical education, and most importantly to integrate students' exposure to neurological diseases through student-patient interaction in the 1st year of undergraduate medical curriculum.^[25] In addition,

Table 1: Plausible determinants in the genesis and inception of neurophobia

Deficiencies in teaching neurology and training exposure through undergraduate curriculum
The lack of vertical integration of basic neurosciences knowledge and clinical neurology into a cohesive whole which leads to a nonintegrated and fragmented working knowledge in basic neurosciences and clinical neurology
The lack of a formal neurology clinical reasoning skills' curriculum based on cognitive theories
The lack of educational strategies for clinical diagnostic reasoning and formulation
The lack of a focused and targeted clinical reasoning and clinical hypothesis-oriented neurologic examination
Lack of clinical neurology competence assessment on the Miller's pyramid
Lack of assessment of neurology competence and proficiency based on structured work-based assessments
The lack of instructional approaches to nurturing medical students' passion for understanding neurology through narrative medicine and cinemeducation
The lack of a formal neuro-mentorship program that would promote a positive learning experience
The lack of a novel and flexible pedagogical teaching-learning multidimensional strategies in the 21 st -century classroom

there needs to be a shift of educational paradigms from a highly teacher-centered, knowledge-focused, discipline-based Flexnerian curriculum with the “traditional educational strategy” to a “competency-based” educational model^[26] so that students see the relevance of preclinical subjects in the context of their link to professional tasks they would be required to discharge upon graduation. The time has come for medical teachers to “un-learn and re-learn” our perceptions and assumptions about teaching and learning (for self-reflection and self-enhancement) processes. Thus, as 21st-century teachers, there is an absolute need to re-strategize our pedagogical competence^[23] based on learning principles, multiple intelligences, brain-based learning, and the educational process in its entirety. Such a transformation in remodeling neurology education for the 21st-century undergraduate medical students in neurosciences would indeed guarantee quality of neurology education and development of both competence and proficiency of the young Indian medical graduate and junior doctors.

“Different from all other medical specialties, save perhaps psychiatry, the neurologist is heavily dependent on listening to and interpreting what the patient tells us... If you don't know what is happening by the time you get to the feet you are in real trouble.” These were the words echoed by Professor Jerome B. Posner, during Presidential Plenary session at the 65th Annual Meeting of American Academy of Neurology. This statement does indeed stamp the centrality of meticulous and skillful history taking in neurology. Despite the tremendous advances in diagnostic neuroimaging in the 21st century, the key to the diagnostic formulation of neurological semiology rests on the fundamental principles of clinical reasoning and examination, the so-called “*méthod anatomo-clinique*” of Charcot. It is

quintessential to master the “art and science” of history taking and harness effective focused “clinical skills” in deciphering the panoply of neurologic semiology. This determinant has led to the perception of neurology as difficult since the principles of neurologic competency lie in clinical rationalism, in the art and science of clinical history taking, the simultaneous processing of information, formulating a hypothesis or multiple hypotheses, and rejecting some as further historical data appear. With the hypothesis formulation, the medical student should be able to plan for a focused and targeted neurological examination to verify and confirm the data obtained from history taking and to learn which symptoms and signs “should be present” and also importantly which “should not be present” in a syndromic diagnosis and pattern recognition skills.

The seminal study by the students of Lord Platt and other studies do emphasize the centrality of history taking and the examination of patients, which is the quintessential cornerstone in the neurological interview and bedside clinical neurological diagnostic formulation.^[27-29] Recently, a study from India did attempt to quantify the relative contributions of history taking, physical examination, and laboratory investigations in making medical diagnoses.^[29] History taking was responsible for the diagnoses of 78.6% of all patients, physical examination was responsible for another 8.2%, and laboratory investigation a further 13.2% of all diagnoses. These studies underscore the essentiality and fundamental role of history taking and a cognitive theory-based, “hypothesis-driven” targeted neurological examination, rather than the time-intensive, lengthy routine “screening” neurological examination. In the minds of the novice medical students, they may be disillusioned by skills needed for bedside clinical neurology, especially when neurogenetics, imaging, and computational neuroscience are readily available. Why, then, do we need to examine the patient? An elegant and systematic neurological examination certainly is pivotal to establishing a bond between physician and patient, preventing the dehumanization of clinical therapeutic encounter and genesis of a therapeutic empathy. The neurologic examination restores the physician-patient relationship. Sir William Osler in his textbook of medicine in 1892 quotes “The student begins with the patient, continues with the patient, and ends his studies with the patient, using books and lectures as tools, as means to an end.” This does unequivocally underscores the crucial role of history taking that undoubtedly underpins all neurology diagnoses. Thus, the present generation of neurologists in medical schools should emphasize on the skills' training through clinical bedside teaching in the 21st century so as to propagate the skills of the neurological examination to medical students in neurology rotations and young doctors.^[30-33]

Clinical expertise and proficiency in neurology are very much analogous to the skills of observation, inquiry, and inductive and abductive reasoning used to solve a crime puzzle as portrayed in the fictional crime novel of Sherlock Holmes. Holmesian reasoning underlines the observational skills, close attention to details, unbiased systematic scrutiny of data, rigorous process of reasoning, and problem-solving in

the relentless and compulsive pursuit of diagnostic prowess, truly reminiscent of the “modus operandi” of an effective neurologist clinician. Thus, the discipline of neurology did earn the reputation as the “queen of clinical disciplines.” Medical students had difficulties with clinical reasoning skills (analytical and nonanalytical skills), facing the cognitive and metacognitive challenges of systematic and analytical thinking, hypothesis generation, logico-deductive analysis for the complex decision-making, and neurologic diagnostic formulation. This understanding must pave the way for clinical reasoning curriculum and clinical reasoning exercises (CREs) during the undergraduate medical curriculum in neurology.

Quoting Sir William Osler, “Medicine is learned by the bedside and not in the class room. Let not your conception of manifestations of disease come from work heard in the lecture room or read from the book: See and then research, compare and control. But see first.” This lack of completeness of neurological examination by medical staff was reflected in a recent “The TOS UK Study” (2012) where 33% and 48% of inpatients said that they had not been examined with tendon hammer and an ophthalmoscope, respectively, before they were referred to the neurologists.^[34] Teaching our students the examination patterns and to tactfully combine “hypothesis-driven” examination style with that of the traditional “screening” neurologic examination proves to be a challenging task. It is astonishing to note that clinical reasoning skills are not usually explicitly taught to learners, yet are fundamental to medical education and thus are a major challenge for medical educators. Teaching clinical reasoning should be central to medical teaching–learning process (through a clinical reasoning curriculum) rather than a passive by-product of clinical experience. Such clinical reasoning curriculum will attract students to the “science and art of bedside medicine” by removing their “clinical bedside neurophobia” and nurture the passion for clinical neurology in the young generation of medical students. A neurological examination is similar to solving a three-dimensional (3D) jigsaw puzzle, where a diagnosis is reached by the clinical problem-solving that is based on neuroanatomical knowledge and a proficient clinical thinking ability to convert abstract concepts into concrete reasoning. An undergraduate (and postgraduate) medical student being trained in clinical neurology must need to be trained in the fundamental principles of cognitive psychology to use faculties of cognitive heuristic representativeness of “pattern recognition” approach, Bayesian approach to probability assessment, and in the principles of Occam’s razor, Hickam’s Dictum, and Crabtree’s bludgeon to help them sort through complex clinical information and formulate diagnoses and treatment strategies efficiently. The two primary theories designed to explain the process of clinical reasoning include the “dual-process” theory and the “cognitive continuum” approach. Both theories mostly promulgate cognitive heuristics of “pattern recognition” and “hypothetico-deductive reasoning” to be the basis for the intuitive and analytical systems, respectively. In the

cognitive continuum theory, it posits a vast middle ground of “Quasirationality” between the two poles. This is because clinical reasoning in medicine is not purely intuitive or analytical since it involves both intuitive and analytical processes in hypothesis generation and hypothesis testing.^[35,36]

Devising appropriate instructional approaches for teaching clinical reasoning is a daunting task, even when teachers are clinical reasoning experts themselves. Problems with clinical reasoning often occur because of inadequate knowledge of the disease, failure to activate prior knowledge, flaws in data gathering, and improper approaches to information processing. Hence, undergraduate educational and curricular reforms must be centered on the various phases of clinical skill training. Clinical reasoning is difficult to define, understand, observe, teach, and measure. Clinical reasoning skills in neurology encompass both the acquisition of medical knowledge (i.e., content-oriented learning) as well as the integration of sufficient clinical experience (i.e., process-oriented learning).^[37] The clinical reasoning learning experience occurs in four parts: synthesis of medical data from the history taking and physical examination, localization of the problem within the neuroaxis, development of a differential diagnosis, and initial steps in the diagnostic investigation. This clinical rationalism sets the stage to answer three fundamental questions: where is the lesion (neuro localization)?, what is the nature of the lesion (pathology), and why is the lesion (etiology)? The cognitive errors made in answering these fundamental questions of diagnostic formulation will result in the surrogate use of expensive and unnecessary investigations. An incomplete neurological interview and a slipshod clinical bedside neurological examination will result in a poor diagnostic formulation that often leads to unnecessary tests or scans to be used as surrogates for diagnosis or excluding neurological disorders. One such clinical misadventure is the risk of overenthusiastic imaging resulting in “victims of modern imaging technology” which further leads to unwarranted and ominous referrals based on the results of such unnecessary investigations.^[38]

What are the instructional or pedagogical strategies that would facilitate fostering of an effective clinical neurological competence? Some of the instructional approaches to nurturing medical students’ clinical reasoning skills include exposure to a wide variety of clinical cases, activation of previous knowledge, development of illness scripts (script theory), and sharing expert strategies to arrive at a diagnosis such as CREs, script concordance test, and diagnostic thinking inventory in addition to scenario-based multiple choice questions and key feature test during small group learning sessions.^[39,40] In addition, forcing students to prioritize differential diagnoses through “structured reflection” approach, flipped classroom approach, promoting metacognition, deliberate practice, self-explanation concept, and availability of formative feedback is required. Yet another novel method of enhancing clinical reasoning skills and in understanding and analyzing illness scripts in medical students

is through the use of “neuro-novels” (British neurologist Oliver Sacks books), nonmedical fiction books^[40] such as “The Adventures of Sherlock Holmes,” and neurocinemas (The Diving Bell and the Butterfly on Locked in Syndrome, Awakenings on Encephalitis lethargica, and Born on the Fourth of July on Spinal cord injury). These narrative medicine and cinemeducation approaches will also be instrumental in developing empathy, professionalism, and communication skills resurrecting the “humane touch” not only with patients, but also with each other and ourselves.

WHERE ARE WE AND WHERE SHOULD WE BE ON THE MILLER’S PYRAMID?

“Knowing is not enough; we must apply. Willing is not enough; we must do.”

Goethe

The training should be aimed on moving up the Miller’s pyramid for assessing clinical competence, i.e., “knows, knows how, shows how, and does.” During the period of their training, the medical students’ proficiency progression must be measured against the progression in performance levels depicted in the pyramid. As they successfully progress from the “knows” (knowledge of basic neurosciences) to “know how” (integrating basic knowledge to clinical problems) to “shows how” (neurological examination demonstrated by the learner and observed by the neurology tutor in a patient with a problem), and “does” (independently having the proficiency to examine and reach a diagnosis) through repeated deliberate practice and supportive formative feedback by the tutor, the novice students would have tackled their neurophobic attitudes to gain a tendency for “neurophilia.” As educators, we should employ evidence-based integrative and instructional strategies to facilitate the shift and acquisition of competence upward through the Miller’s pyramid to prevent “neurophobia.”^[33] Such competency-based training will help to move the medical students from “collectors and reporters” of clinical information (meticulous history taking) to “interpreters” of the gathered information (clinical reasoning skills, decision-making and clinical judgment, and diagnostic decision-making) for diagnosis formulation. It trains students to be “information processing managers” who become proficient in constructive effective management plans and communicate and share decision-making with patients (clinical management skills). The assessment of competency and proficiency should be implemented through structured performance evaluation/workplace-based assessments (WBA-OSCE, OSPE, OLSER, Mini-CEX, DOPS, etc.).^[41,42] Such paradigm shifts in teaching neurology will indeed provide not only concrete evidence of clinical competence, but also drive medical students’ learning.

A “NEURO-MENTORSHIP” PROGRAM

Another challenge that faces the problem of neurophobia is the lack of a formal curriculum mandating a designated

faculty for a one-on-one mentorship program to guide medical students aimed at enhancing student productivity in clinical neurology, clinical research, and fostering student interest in neurosciences. It is critical to realize the multidimensional perspective of an intensive “mentors-medical students-the undergraduate medical course” network in the fabric of imparting medical education. Such programs will undoubtedly be an effective strategy and opportunity for not only academic growth at an early stage in their medical undergraduate career, but also will be pivotal for developing interest in neurology discipline. A helpful definition of medical mentoring is “a personal process that combines role modeling, apprenticeship, and nurturing.”^[43] In most countries, there is a formal mentorship program in neurology for undergraduate (and postgraduate) medical students. Indeed, this should be taken as a challenge for educators to establish a framework for an effective formal neurology mentorship curriculum in the academic culture of undergraduate medical schools in India.

Mentoring is an essential catalyst not only for a successful training and medical career, but also instrumental in imparting a positive experience for both personal and professional development. The lack of multiple, early preclinical neuroscience education with clinical integration and absence of mentorship programs would certainly lead to inception of feelings of neurophobia. To combat neurophobia syndrome, evidence-based educational intervention to improve neurology teachings in addition to effective quality mentorship programs would certainly provide a positive educational journey in fostering neurophilia. The implementation of mentorship programs^[44,45] would be a “specific pathway” to facilitate student productivity in clinical research and personal growth. It will also notably garner interest in the 3rd and 4th year undergraduate medical students and motivate them to pursue an academic career in neurology, thus enabling increased medical student recruitment into neurology specialization in India.

PROMOTING NEUROPHILIA: EDUCATIONAL INTERVENTIONS AND PEDAGOGICAL STRATEGIES

The main thrust area of this review, apart from understanding its magnitude, studies on neurophobia worldwide, and plausible factors to its genesis, is to formulate solutions to stamping out neurophobia and foster neurophilia. The main impetus as far as the remedial measures are concerned would be to focus on the need for novel and flexible pedagogical teaching–learning multidimensional strategies in the 21st-century classroom for reinventing effective and quality neurology education in the undergraduate medical curriculum. Literature suggests that innovative pedagogical practices and instructional strategies must be adopted including blending of collective fields of digital technology (technology-enhanced learning [TEL]), brain-based education, adult and active learning theories, learning styles, and multiple intelligence theory.^[46-49]

Innovative teaching–learning methodologies to develop critical thinking on the higher levels of Bloom’s cognitive taxonomy,

the cognitive psychology of thinking,^[50] problem-solving and decision-making, clinical judgment, clinical diagnostic reasoning,^[51] skill development, self-regulated and self-directed learning (SDL), appreciative inquiry and learning styles, problem- and case-related learning, reflective learning and practice, experiential learning, and transformative learning are pivotal. There is absolutely an urgent need for early introduction of training clinical skills in the curriculum organized in a cascade of logical sequences at the very beginning of medical undergraduate curriculum. This will effectively ensure the implementation of a student-centric competency-based education and training by reinforcing the Socratic teaching method and collaborative learning. Such approaches will not only foster a passion and attraction toward clinical bedside neurology, but also produce a competent physician with all prerequisite skills mastered.

The learning experience of neuroanatomy in the undergraduate curriculum is fraught with apprehension and intimidation, learning and memorizing facts for passing the examination, and is thus devoid of a deeper understanding of central nervous system systems as they relate to the clinical reality to clinical experiences. Two important questions for neuroscience educators in this context would be: (i) How best can we remodel neurology curriculum to deliver basic neurosciences education for 21st-century learners efficiently? (ii) What are the educational interventions which would optimize integration of “clinically relevant” basic neurosciences with clinical neurology in the 21st century? The answers will lie in the implementation of learning strategies focused on a student-centric interactive teaching–learning process engaged in “discussion pedagogy” to be integrated via the employment of efficient and effective TEL models.^[52,53] A structured mandatory integration of clinical neurology and neuroanatomy (and basic neurosciences) through case-based teaching and caring for a “virtual neurological patient” would be instrumental in improving teaching basic neurosciences and reducing neurophobia.^[54,55] These strategies of early and frequent clinical exposure would not only break down neurophobia but also ensure the implementation of a student-centric competency-based education and training by reinforcing the Socratic teaching method and collaborative learning.

The fragmentation in the learning of basic neurosciences with clinical neurosciences should be tackled by integrating learning of basic neurosciences with early, effective, and multiple clinical exposures most efficiently under a neuro-mentorship program. A curriculum redesign is imperative that will ensure and foster such longitudinal learning experiences building upon the 1st year basic neuroscience foundation through dedicated weeks of clinical neurology learning during clinical rotations at the bedside and ambulatory settings with mandatory attainment of targeted milestones from the 1st year to graduation and internship. Furthermore, the other complexities involved in learning neuroanatomy are rooted to difficulties with the spatial reasoning skills needed to make mental conversions between two-dimensional images of the

brain and the 3D reality of neural structures. In a digital era, neuroscience educators of the 21st century need to synergize and integrate technology (the Internet, information and communication technology, and mobile technologies) with innovative pedagogical strategies to remodel and redesign undergraduate neurology and basic neurosciences’ curricula to enhance teaching–learning effectiveness and quality of neuro-education. Neuroanatomy education can, therefore, be improved from the conventional sectional images to employing innovative strategies such as computer-based instructional 3D models, using web-based neuroscience/high-quality video tutorials (neurology teaching videos), using blended and flipped strategies and problem-based effective teaching in neuroanatomy. Interestingly, the integration of neuroanatomy and basic neurosciences with clinical skills training can be enhanced by using neurology web-based virtual patient learning modules (the Medical Virtual Patient Simulator).^[51] Incorporating TEL with the novel approach to “blended learning and flipped” teaching–learning strategy into the 21st-century classrooms would certainly re-invent and re-design curriculum for a student-centered, teaching–learning environment.^[56] Novel flipped classroom curricula focused on neurological disorders using preclass web-based videos have been documented not only to promote active learning, but also for teaching clinical reasoning knowledge and skills. These novel educational interventions would certainly help students organize, re-engage, and manage their learning approaches for deeper understanding through SDL, problem-based learning (PBL), and blended-PBL in neurology. Other effective teaching methods also include team-based learning (TBL), small group teaching, and case-based teaching modalities during students’ rotations in neurology in the undergraduate medical curriculum. Compared to the traditional “lecture-based” method, TBL is unquestionably an active learning strategy that should be implemented for teaching not only basic neurosciences, but also clinical neurology in undergraduate neurology postings. TBL has been well documented to help break down learners’ neurophobia and a novel teaching methodology to facilitate in-class learner engagement, reinforced SDL, enhanced knowledge retention, and skills application.^[48]

The face-to-face teaching versus technology-based teaching would reinvigorate and enhance the modern-era tech-savvy medical students’ learning experiences to develop their neurological observational and analytical skills using a blend of traditional classroom activities and computer-based materials (such as web course tools, web-based interactive methodologies, and e-learning resources combined with a wide range of video clips of patients with neurological disorders on CD-ROM). Thus, it is imperative to formulate an evidence-based approach to enhance the quality of neurology education and to improve the understanding of neurological semiology using innovative strategies.^[43] Such multidimensional innovative modalities include computer-based medical teaching, 3D

Table 2: The main thrust areas for educational interventions to promote neurophilia

Statement of the problem: The causes and challenges leading to neurophobia	Remodeling neurology education strategies and remedial interventions: Promoting neurophilia
Flexnerian traditional knowledge-based curriculum Lack of integration of basic neurosciences and clinical neurosciences	<p>Outcome-based and competency-driven education: A curriculum that is student centered, oriented toward equipping students to become job-ready professionals and fostering self-directed lifelong learning, do deliberate practice, and reflect on practice to improve performance of entrustable professional activities</p> <p>Integrated learning of basic sciences and early clinical exposure</p> <ul style="list-style-type: none"> Case-based learning of basic neurosciences Problem-based learning Case-stimulated learning of basic neurosciences Reflective diary connecting learning of basic sciences to practice <p>A curriculum that bridges the gap from theory to the bedside; to motivate the students to learn and understand the basic neuroscience and its practical use</p> <p>Translate from the bench to the bedside: To empower basic neurosciences, clinical and translational research in the next generation of medical students in India</p> <p>Encourage basic science faculty to engage in translational research in basic neurosciences as they apply to clinical treatment of neurological disorders</p> <p>Align the neurology training in medical schools with national health priorities</p> <p>Curriculum redesign so that students get longitudinal learning experiences building upon the 1st-year basic neuroscience foundation through dedicated weeks of clinical neurology learning during clinical rotations at the bedside and ambulatory settings with mandatory attainment of targeted milestones from the 1st year to graduation and internship</p> <p>Neurology electives for those who want to “catch up” or improve their skills in neurology within the undergraduate core curriculum</p> <p>Reforming and to intensify the clinical neurology rotation in undergraduate core curriculum, from the 1st-year basic neuroscience courses to the 4th-year clinical electives through multiple effective sessions</p>
Lack of a formal “neuro-mentorship” program	Identifying, recognizing, and rewarding “role model clinical mentors” and “role model neurology educators” within the formal medical student mentorship programs; pivotal for undergraduate medical students in developing interest in neurology discipline and pursue an academic career in neurology
Lack of a formal “clinical reasoning skills” training curriculum	<p>Within the competency-driven curriculum to include and improve clinical reasoning curriculum; teach cognitive and metacognitive skills of analytical and nonanalytical approaches; student assessment methods that score and value for “hypothesis-driven” history taking and physical examination for differential and definitive neurological diagnosis and including the traditional “screening” neurologic examination</p> <p>Kindling interest in clinical reasoning using nontraditional approaches such as encouraging extracurricular reading of medical nonfictional (neuro novels, neuro cinemas) and nonmedical crime novels such as “The Adventures of Sherlock Holmes” to understand Holmesian reasoning that inculcates the skills of observation, inquiry, inductive and abductive reasoning, and attributes essential for an “effective clinical neurologist”</p>
Lack of effective, objective assessment of clinical competency and proficiency during UG training	Including the student learning of neurology in the student’s competency attainment portfolio showing progress through the scores obtained on the mini CEX performance assessment/WBA during the different phases of the MBBS curriculum and internship
Traditional didactic classroom pedagogy	To implement innovative instructional strategies to promote active enriched learning through SDL, PBL, “blended learning and flipped” teaching–learning strategies, blended-PBL and implementation of TBL using small group discussion for teaching basic neurosciences, clinical reasoning skills, and clinical neurology
Traditional classroom educational paradigms	21 st -century digital and virtual classroom – implementing, integrating, and synergizing the experiential learning experience in neurology through innovative novel evidence-based pedagogical strategies with TEL
Traditional teachers’ pedagogical lack of competence in teaching competency-based education	<p>Formulating and designing “TOT” programs to enhance pedagogical competence for “teaching neurology in the 21st century”</p> <p>Implementing and designing educational research in neurology education for effective and economical educational interventions in the field of neurology education</p>

WBA=Workplace-based assessment, CEX=Clinical evaluation exercise, SDL=Self-directed learning, PBL=Problem-based learning, TBL=Team-based learning, TEL=Technology-enhanced learning, TOT=Teachers of tomorrow

neuroanatomy teaching computer programs (simulation-based Anatomage table), simulation-based medical education programs (SBMEs);^[57] simulation-based mastery learning, technology-enhanced simulation training; web-based virtual learning environment, web-based blended learning, online neurology e-learning, online collaborative learning, and Moodle e-learning platform. SBME is certainly sufficient for the integration of both clinical neurology and basic sciences such as neuroanatomy.

These blueprints for remodeling neurology education with TEL will unquestionably transform the teaching–learning landscape for neurology in the undergraduate medical curriculum. It will also not only prevent the next generation of medical students and young doctors to develop negative preconceptions on neurology education, but also attract and encourage medical students to undertake specialization in neurology as their career option. Notwithstanding the current repertoire of flexible pedagogical teaching–learning

multidimensional initiatives alluded to so far, from an educationalist's perspective, it is prudent to be cognizant of a recent, comprehensive systematic review (16 randomized controlled trials, nine nonrandomized cohort/follow-up studies, and 33 case series) of educational interventions in neurology. This PRISMA-based systematic review using the Centre for Evidence-Based Medicine criteria and the Kirkpatrick Educational Outcome Quality Criteria, unfortunately, revealed very little high-quality evidence of demonstrably effective neurology education.^[49] This study unequivocally reiterates the further need to formulate evidence-based strategies to ensure remodeling of neurology education in medical schools that would be effective in learning of basic neurology as well as overcoming neurophobia. This caveat also paves the way for addressing challenges in teaching neurology for the next generation of aspiring neurologists.^[58]

At the end of this article, we summarize in Table 2 some of the prioritized useful educational principles, educational research imperatives, and interventions for neurology education that would facilitate a more engaged, active, enriched learning environment which is required to address the educational challenge of neurophobia among medical students.

OVERCOMING CHALLENGES: RESTRUCTURING CURRICULUM AND THE WAY FORWARD

“Every challenge has become an opportunity, every hurdle a bridge”

William Ruto

Akin to the story of “The Parrot’s Training” by Rabindranath Tagore published in 1918, we as medical educators should not throttle and snuff out the innate qualities by giving undue importance to the golden cage, its architecture, its grandeur; instead, we should envision evidence-based educational reforms to nurture interest and passion in medical students in neurology and neurosciences as the way forward to stamp out neurophobia. In conclusion, the challenges facing medical education of the 21st century are truly enormous. Medical education has been under a constant state of “challenge for innovation” to reconfigure and remodel medical (neurology) curriculum for the 21st century during the span of the past several years. Remodeling and reinventing neurology education for the undergraduate curriculum will not be effective using a “one-size-fits-all” approach. We need to seek solutions using a “hybrid approach” and “Connectivist, Cognitivism, and Constructivist Models” for enriching the teaching–learning process facilitated by a “Neurology Curriculum Committee” to help Indian medical students cope better and tackle neurophobia. Given the lacunae in the knowledge about the prevalence of neurophobia in India, it is absolutely imperative to tackle this knowledge gap by conducting national surveys in Indian medical schools, at undergraduate and postgraduate levels of education.

Neurology education curriculum reforms, paradigm shift from traditional knowledge-based curriculum to a student-centered

outcome-based and competency-driven education,^[59] clinical reasoning curriculums, neuro-mentorship programs, narrative medicine and Neurocinema to nurture passion in bedside clinical neurology, evidence-based effective educational interventions, novel pedagogical initiatives prioritized on SDL, critical thinking skills, and problem-based and integrated learning would certainly be the way forward to stamping out neurophobia as discussed in this review. We do reiterate the need for robust educational research in order to generate the evidence to inform decision makers to initiate medical education reforms, undertake curricular shifts away from a nonintegrated, divisive neurology discourse to re-model neurology education in tandem with our national health priorities centered on a competency-based paradigm, and also ensure quality education. The remodeling of neurology education will then not frighten off another generation of nonneurologist physicians and, at the same time, be conducive in attracting future neurologists in India.^[60] This review article challenges the notion that neurology is a discipline for which only “young Einsteins need apply” and emphatically underscores the evidence-based educational strategies and other innovative strategies to eradicate neurophobia and the misperception that clinical neurology is difficult.^[60]

“A good teacher can inspire hope, ignite the imagination, and instill a love of learning.”

Brad Henry

“An academic who only presents facts is not a teacher; a teacher is one who nurtures the learning process and thereby modifies behavior and patterns of thinking for a lifetime.”

Woosley, 1997

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