PERSPECTIVE

# Remodeling neuroscience education in medical student training: how early exposure and mentorship are promoting student interest in neurology and neurosurgery

Exposure to clinical neurology is an essential aspect of a young clinician's training. Neuroscience forms the cornerstone of a wide variety of clinical pathologies and many believe it is currently under represented in medical education. This phenomenon persists as the rapidly aging population places an increasing burden on neuromedical specialists. This demographic change, compounded by the expected 19% shortage in clinical neurologists by 2025, makes it imperative to reexamine specific aspects of neuromedical education (Dall et al., 2013). These aspects include the timing of pre-clinical neuroscience education, the presence of faculty supported interest groups, the existence of formal mentorship programs, and the availability of neurology and neurosurgical clerkships to 3rd year medical students. Given the increasing importance of neuromedical training, several recent studies have examined the state of neurology training in modern medical education and its impact on medical graduates.

**Assessing the scope of the problem:** A recent review of 128 allopathic and 30 osteopathic U.S. medical schools by Albert et al. revealed that 56% of institutions required a core clerkship in neurology, with 37% and 40% scheduled in the third and fourth year respectively (Albert et al., 2015). This significant finding may shed light on why only 2.9% of U.S. graduates matched in a neuromedical residency in 2015 (NRMP 2010, NRMP 2015). Notably, the number of U.S. and foreign medical graduates matching into neurology has increased during the past several years (**Figure 1**), but it is unlikely that this entry rate will meet the expected increase in demand. Without a core clerkship required in the 3rd year, there is an inherent limitation on the number of talented medical students who seek to match into this growing field. Of all U.S. seniors matching into neuromedical fields from 2011–2014, 67% to 70% graduated from schools with required neurology clerkships (Albert et al., 2015). These results are consistent with a prospective, direct comparison study by Dewey and Agostini (2010) involving 149 third and 157 fourth year medical students. Their study demonstrated that students who take the neurology clerkship during their third year indicated a greater enthusiasm for neurologic learning ($P = 0.004$), as well as greater probability of pursuing a career in neurology ($P < 0.001$).

While the sub-specialty of neurosurgery is well represented as an elective in approximately 80% of US medical schools, a recent study by Fox et al. indicated that only 33% (21 of 64) of evaluated programs offered the elective to 3rd year medical students (Fox et al., 2011; Albert et al., 2015). Furthermore, 62% (52 of 86) of neurosurgical course coordinators responded that fewer than 10 students participated in the clerkship per year, with 33% attracting fewer than 5 students (Fox et al., 2011). Fox et al. also provided commentary on the structure of neurosurgical clerkships and mentorship, revealing that 62% of clerkships do not provide didactic lectures and only 17% of schools have a formal mentorship program to catalyze surgical and research exposure. The lack of student participation in neurosurgery clerkships nationwide may be due to the absence of these designated mentorship programs.

The presence or absence of mentorship programs can have serious implications regarding summer research experiences, residency choices, and match rates. For example, the traditional summer break between the first and second year of medical school represents a critical time when students may elect to pursue a research experience. Research is increasingly becoming an important aspect of a well-rounded neuromedical residency applicant. In 2015, U.S. seniors matching into neurology and neurosurgery reported an average of 2.9 and 4.4 research experiences respectively (NRMP 2015). This statistic parallels results from a recent study by Albert et al. (2016) which analyzed the response of 133 surveys distributed to neurologists across all levels of practice. Their results indicated that 44% of responders listed "opportunity for research" as an important influence in their career choice in neurology. In many medical school curricula, students may not receive appropriate exposure to neuroscience during their first year, and as such are not enticed to pursue neuromedical research during their summer experience. Without this early research experience, matching into neurosurgery, a residency program with limited growth in the past several years (**Figure 2**), becomes more difficult.

There is growing concern that students with insufficient or delayed neuromedical education may ultimately hold feelings of neurophobia. Neurophobia, a term that has emerged from several studies that analyzed the responses of medical students to varying specialties, refers to the daunting perceptions and beliefs many students hold of the neuromedical field. A study by Flanagan et al. (2007) reviewed the results of 457 surveys, of which 411 were medical students attending schools in Ireland, and concluded that neurology was regarded as the most difficult specialty when compared to other specialties ($P < 0.001$). When evaluating the difficult nature of neurology, students cited the complexity of the diagnoses, limited exposure, and neuroanatomy as the three most significant factors.

In a study by Zinchuk et al., (2010) neurology was regarded as the most difficult specialty, and the specialty in

which students held the least knowledge and confidence in their management capabilities. Their study analyzed the results of 152 surveys completed by clinical medical students and internal medicine residents with a response rate of approximately 50%. Similar to the results of Flanagan et al. (2007), Zinchuk et al. (2010) showed that U.S. students found neurology to be the hardest clinical specialty ($P < 0.001$). The reasons for perceived difficulty in the study from Zinchuk et al. (2010) closely mirrored those of Flannagan et al. (2007) and suggested that the challenges of neuroscience education span across multiple continents, and possibly the global neuroscience community based on similar reports published in Asia (Lim and Seet, 2008).

**Addressing the issues:** In order to counteract these realities, some medical schools have begun to reevaluate and reconstruct their curriculum to spark student interest and promote organized involvement in neurology and neurosurgery. These programs offer insight into potential strategies to address both the recruitment of exceptional medical students to the neuromedical specialties, as well as the pending shortage of neuromedical specialists.

In 2013, Agarwal et al. (2013) published a detailed description of their institution's efforts to increase medical student participation in neurologic surgery. Their targeted initiative generated dramatic and rapid results. Between 1995–2006, prior to the implementation of their program, their institution successfully matched approximately 1.1 students into neurologic surgery annually. In the following 6 years from 2007–2012, their department averaged 3.8 matches per year. This improvement in students pursuing neuromedicine warrants further investigation. In their study, the authors outlined a four-step process that highlighted increasing the clinical exposure of medical students to neurosurgery and establishing a pipeline for research opportunities. Specifically, the department incorporated an optional third year neurosurgical rotation into their existing neurology/psychiatry clerkship, allowing 48 third year medical students to rotate within neurosurgery every year. This increased clinical exposure was supplemented by increased neurosurgical elective availability and the involvement of clinical faculty in the preclinical medical student education. The department concurrently established an inclusive program to support neuromedicine research. They promoted a culture where all research projects were expected to have medical student involvement, and they expanded their summer research program to incorporate 12 students annually. These changes resulted in an increase in publications with medical student co-authorship. Prior to implementation the department had 6 abstracts and 4 manuscripts with student co-authorship in 2007. By 2012 these numbers had increased to 12 and 28 respectively (Agarwal et al., 2013).

In 2011, Zuzuárregui and Hohler (2015) implemented a program at their institution with a vision to increase the number of medical students pursuing neurology. Their efforts to promote mentorship, research, and teaching were successful. After their program implementation in 2011, the number of students matching into neurology significantly increased from 14 between 2006–2010 to 30 students between 2011–2014 ($P < 0.05$). At the core of their program lies a formal mentorship initiative, which stipulates that students have organized meetings with faculty members and residents every 8–12 weeks. These meetings ensure residency preparedness and promote participation in ongoing research projects. Students are mentored on topics such as IRB submissions, data collection, and manuscript writing. Since medical students were involved and guided through research earlier in their education, publications by medical students significantly increased from 7 publications between 2006–2010, to 22 publications between 2011–2014 ($P < 0.05$). Furthermore, third and fourth year students were encouraged to take part in organized peer-to-peer teaching in preparation for pre-clinical neurology and shelf examinations. Through this experience, students gained insight into the expectations of academic neurologists while also serving as junior mentors for their fellow classmates (Zuzuárregui and Hohler, 2015).

The success of the programs implemented by Agarwal and Zuzuárregui offer promise for the future recruitment of aspiring physicians into neuromedicine (Agarwal et al., 2013; Zuzuárregui and Hohler, 2015). It is likely that both of these initiatives benefited from broad based institutional support as they both involved large-scale changes that can be difficult to implement in a large academic institution. Increased exposure for students implicitly implies an increased role of faculty teaching. Accommodating this increased work-load requires the cooperation of not only clinician-scientists, but also clinician-educators, a term not widely used when discussing recruitment and advancement of faculty positions. However, the role of clinician-educators cannot be understated, provided that Agarwal and Zuzuárregui have demonstrated how much can be accomplished with dedication and institutional support. These educational frameworks could also be extended to other medical specialties, such as medical or surgical oncology, which will continue to have a large impact on the healthcare system, but largely do not emphasize early experience with clinician-educators (Mattes et al., 2015).

Overall, we see several areas where concentrated effort on the behalf of medical educators and neuroscience specialists can improve the recruitment of exceptional medical students to neuromedicine fields. At a curriculum level, we encourage early exposure to neuroscience coursework. Ideally, this would occur within the first year of medical education in order to promote interest before the crucial summer period between first and second year. We also believe that active introduction to neuroscience research can help bolster interest in the field and the competitiveness of residency applications. As shown by Agarwal et al., (2013) a structured program that requires

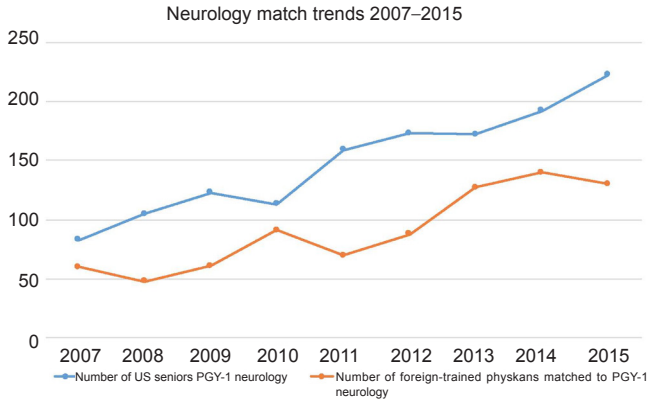


**Figure 1 Neurology match trends in U.S. seniors and Foreign-Trained Physicians.**
Based on data gathered from the National Resident Matching Program (NRMP) from 2007 to 2015. The number of U.S. seniors and foreign-trained physicians matching into neurology has increased 2.7× and 2.2× respectively (NRMP 2010, NRMP 2015). Note that even with these substantial increases in neurology residency positions, Dall et al. estimates a 19% shortage in clinical neurologists by 2025 (Dall et al., 2013).

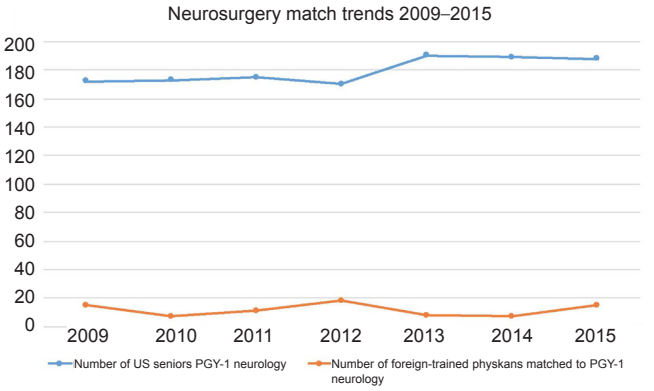


**Figure 2 Neurosurgery match trends in U.S. seniors and Foreign-Trained Physicians.**
Based on data gathered from the National Resident Matching Program from 2009 to 2015. The number of U.S. seniors matching into neurosurgery has increased 1.1× (NRMP 2010, NRMP 2015). There has been no recent increase in foreign-trained physicians matching into neurosurgery. In comparison to neurology, the number of neurosurgical residency positions has failed to react to the future demand for neurosurgical specialists

medical student involvement in all research projects is beneficial for both the student and the department, as it results in increased research productivity. Most importantly, we support guiding continued access to quality mentors. Mentorship is an essential aspect of professional development and key to promoting entrance into a specific field. We are strongly encouraged by the work of Zuzuárregui and Hohler (2015) and believe their work can be broadly applied, not only to neuromedical specialties, but to any specialty. Moreover, we are motivated by their efforts to include senior students in the mentorship process, as this equips them with the skills needed to mentor medical students and residents throughout their careers.

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