Neurological education calls for a targeted integration: A study based on scores of multiple disciplines

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**Abstract**

**Objective:** The aim of this study was to identify the disciplines that strongly correlated with neurology, and to compare the differences between neurology and other disciplines in targeted integration.

**Method:** Scores of 18 disciplines (six clinical disciplines, seven basic disciplines, and five social science/humanities disciplines) and college entrance examinations of 275 eight-year program medical students from Sun Yat-Sen University were collected. Correlation between any two subject scores were determined.

**Results:** Student scores in neurology had significant correlation with the scores of four clinical subjects, five basic subjects, and one social science/humanities subject. Internal medicine scores showed significant correlation with the scores of three clinical subjects and two basic subjects. Scores from obstetrics and gynecology, pediatrics and psychiatry significantly correlated with one to three clinical subjects scores. No significant correlation was found between surgery scores and other subjects. With the exception of medical statistics, there was no significant correlation between scores from social science/humanities subjects and scores from either clinical or basic subjects. No subject scores significantly correlated with the college entrance examination scores.

**Conclusion:** Neurology is associated with more clinical and basic disciplines than other subjects. Neurological education should involve a targeted integration with other closely related disciplines.

**Keywords:** Nervous system; Core; Integrated; Multiprofessional; Options
Introduction

The Medical Doctor degree in China is awarded after completion of a rigorous eight-year clinical medicine program. Competitive high school students are admitted to the medical program combining undergraduate and graduate studies leading to completion of the Medical Doctor degree. The program offers pre-medical courses, basic medical/biological courses, clinical medicine courses, and scientific training. The eight-year program represents the highest level of medical education in China.

Among courses taught in the eight-year program, neurology is one of the most difficult, and most important. Compared to other body systems, the nervous system has an extremely complicated anatomy, and the most precise physiology. Neurology involves the integration of other disciplines, including clinical and basic science subjects, earning it the reputation among medical students of being extremely difficult[1,2]. In fact, many medical students have reported anxiety in studying neural sciences and clinical neurology for this reason[3]. Jozefowicz[1] has defined this condition as "neurophobia." Students' overall neurophobia could strongly reduce their interest in the subject, and their confidence in neurology; this could negatively affect their grades, and even prevent them from pursuing a career in this field[4,5]. However, with our aging population, neurological disease would form a significant component of future clinical practice. In fact, the American Academy of Neurology estimates that shortage of practicing neurologists in U.S.A will worsen from one neurologist for every 18,000 population to 21,000 by year 2020[6]. Similar trends towards a decline in trained neurologists have gradually become problematic in China as well.

To solve these issues, a new strategy for neurology education in medical programs is needed. A well-designed curriculum would help medical students gain confidence and develop a positive attitude, rather than feel apprehensive, toward neurology as a discipline and as a future career[2,4,6-8]. In this study, we investigated the correlations between multiple disciplines directly through scores, and identified the targeted disciplines that should be combined with neurology.

Methods

Scores from 275 eight-year program medical students from Sun Yat-Sen University were collected. The 18 courses examined in this study were as follows: neurology, internal medicine, surgery, pediatrics, obstetrics and gynecology, psychiatry, histology and embryology, anatomy, medical immunology, medical microbiology, pathology, physiology, pharmacology, medical statistics, epidemiology, philosophy, medical ethics, and medical English. In addition, college entrance examination scores were also collected. The correlation between any two courses was determined using Pearson $r$. Significant correlation between two courses was established by a correlation index $r \geq 0.6$. Statistical significance was established by a 2-tailed value of $P < 0.05$. Data were analyzed using IBM SPSS 22.0.

Results

The correlation between clinical subjects and other academic scores is shown in Table 1-3 and Figure 1. Scores of neurology courses revealed significant correlation with ten subject areas. These included a) four clinical subjects (internal medicine, $r=0.618$; obstetrics and gynecology, $r=0.640$; pediatrics, $r=0.628$; psychiatry, $r=0.626$), b) five basic subjects (anatomy, $r=0.601$; medical immunology, $r=0.647$; medical microbiology, $r=0.614$; pathology, $r=0.616$; physiology, $r=0.631$), and c) one social science/humanities subject (medical statistics, $r=0.601$). Scores of
internal medicine were significantly correlated with five subjects, including a) three clinical subjects (neurology \( r=0.618 \); obstetrics and gynecology, \( r=0.627 \); pediatrics, \( r=0.634 \)), and b) two basic subjects (medical immunology, \( r=0.625 \); physiology, \( r=0.653 \)). There was no significant correlation found between scores of surgery and other subjects. Obstetrics and gynecology showed significant correlation with three subjects, all of which were clinical subjects (neurology, \( r=0.640 \); internal medicine, \( r=0.627 \); pediatrics, \( r=0.616 \)). Pediatrics showed significant correlation with three subjects, all of which were clinical subjects (neurology, \( r=0.628 \); internal medicine, \( r=0.634 \); obstetrics and gynecology \( r=0.616 \)). Scores of psychiatry showed significant correlation with one clinical subject (neurology, \( r=0.626 \)). There was no significant correlation between scores of other courses and medical English, philosophy, medical ethics and epidemiology. No statistically significant differences were found between college entrance examination scores and all clinical, basic, social sciences and humanities subjects.

**Discussion**

This study shows that neurology test scores ranked the highest in correlation among other courses in the medical program. These data suggest that the medical practice of neurology, compared with other clinical disciplines, requires more foundational knowledge bridging other medical and biological subjects. This is consistent with current recommendations that neurology should be taught by way of an integrated curriculum with other neuroscience disciplines rather than as a single topical discipline[9-11]. Many studies have shown that an integrated curriculum of this kind could significantly improve students’ confidence and achievement in neurology[9,12-15]. Results from this present study show that the range of neuroscience disciplines that should be integrated with neurology is larger than previous studies indicated.

Although the integration of clinical disciplines is considered essential[11,16], there is’t sufficient evidence of the use and implementation of an integrated neurology curriculum with any other clinical disciplines in addition to psychiatry[17]. Our research implies that the integration of neurology and internal medicine, obstetrics and gynecology, pediatrics, and psychiatry is necessary for improving student learning and outcomes in medical programs. This may be due to the occurrence and development of many neurological diseases that are medically related to non-neurological physiological processes studied in other clinical disciplines. For example, in the case of cerebral infarction, a neurological disorder, there are many non-neurological causes such as hypertension, diabetes mellitus, atrial fibrillation, systemic lupus erythematosus, and polycythemia vera. Likewise, congenital heart disease and right-to-left shunt disorder can cause cerebral embolism in infants and children, while the hypercoagulable state of oral contraceptives can cause cerebral venous infarction in reproductive age females. On the other hand, cerebral infarction can also cause psychiatric symptoms and a variety of medical conditions, such as acute myocardial injury and arrhythmia, pulmonary and urinary tract infections, gastrointestinal stress ulcer and electrolyte disorders.

Consequently, medical school teaching of neurology will need to integrate multiple clinical and basic disciplines in order to best train physicians for medical and clinical practice. The rank of clinical and basic disciplines is much larger than previous studies, and the demand of integrating so many clinical and basic disciplines is much stronger than other clinical subjects. This may be one of the reasons why so many medical students find it hard to understand and master. Therefore, the neurological education calls for more real-world cases and comprehensive patient management in order to present integrated and complex neurological problems for the student to analyze. In this way, students will be trained to develop critical and integrated thinking strategies and to establish their own unique system of clinical thinking for neurological diseases. A targeted integration of neurological curriculum would serve to improve clinical skills more effectively, while giving medical students increased confidence when facing professional challenges.
One such example is in the Harvard Medical School-Cambridge Integrated Clerkship (HMS-CIC)[18]. Courses in this program take a case-study approach and integrate basic science, neurology, internal medicine, pediatrics, obstetrics and gynecology, and psychiatry. Compared with students who have studied in a traditional medical program, medical students who have studied in the integrated curriculum grasp knowledge better and have reported a higher course satisfaction. These students are interested in having more contact with patients, while taking the initiative to seek feedback and supervision from experienced teachers. They are also more likely to treat patients with more serious medical challenges. This is largely due to their increased confidence having been presented unexpected cases during their medical education.

The present study also revealed a correlation among the scores of clinical disciplines examined. In addition to surgery, there was a significant correlation between the disciplines of neurology, internal medicine, pediatrics, and obstetrics and gynecology. These data suggest that the curriculum design of the four clinical subjects should integrate the other three clinical disciplines. This is supported by a recent study showing that pediatric residents who received both pediatric and internal medicine training scored higher on national qualification tests than those with pediatric training alone[19]. Another study[20] showed that obstetrics and gynecology residents, while demonstrating a high level of specialist knowledge, lack a sufficient understanding of internal medicine. However, after seven weeks of internal medicine training, these residents were more confident in their ability to deal with the patient's overall medical situation. These results, indicating the benefit of integrated training in clinical medicine, are consistent with our findings.

In the present study, however, there was no significant correlation between surgery written examination scores and other clinical disciplines. This phenomenon can be explained in two ways. First, the type of knowledge that is evaluated on a written examination is based on textbook knowledge, rather than surgical hands-on skill. For example, non-surgical disciplines, such as neurology, internal medicine, and pediatrics, primarily underscore medical knowledge with very little surgical technique. While obstetrics and gynecology is a surgical discipline, the surgical skills necessary are minimal. Conversely, surgical skill is the most important content of surgery as a discipline in medical education. A study[21] have attempted to find a correlation between the mode of learning in each discipline and results on the national medical examination. This study indicated that students who began their medical training in surgery typically scored lower; this trend was not observed in non-surgical disciplines. This interesting trend may reflect the innate differences in student learning by classroom and textbook study in comparison to learning hands-on surgical techniques. In other words, assessment of surgical knowledge and skill cannot be limited to merely a written test format. Second, these results may indicate a trend among medical students interested in surgery who may focus on surgical training and skill, while downplaying the need for more comprehensive medical study. In the clinic, surgeons often seek consultation for even simple medical or neurological cases. Based on these findings, we propose a curriculum that strengthens positive attitudes and integration in non-surgical subjects, especially for those students who aspire to study surgery. Such an integrated curriculum may broaden their medical training in order to meet the demands of clinical practice.

The findings in this study also indicated no significant correlation between the social sciences/humanities and written test scores of all clinical subjects, in addition to statistics and neurology. However, as mentioned above regarding the HMS-CIC curriculum[18], integration is not only needed in basic and clinical courses, but is also important in self-reflection, communication, skills, ethics, population sciences, cultural competence and other social science courses. As mentioned above, students trained through an integrated curriculum have more patient contact and are able to actively meet varying professional challenges. The many benefits of student learning outcomes in this type of curriculum cannot be ignored. Medical students participating in the present study have been only exposed to theoretical knowledge without the advantage of practicing their knowledge in the classroom. Additionally, the fact that the written examination does not reflect the humanities gives the impression that skills and knowledge in the
humanities are not of value in an actual medical environment. However, the value of this knowledge becomes significant after they are actively practicing in the clinic. Moreover, education in the humanities, which is important in clinical settings, may prove to be more important than previously thought in other clinical disciplines.

Furthermore, compared with other diseases, the morbidity rate in neurological diseases is high, and effective treatment methods are limited. As a result, patients face serious psychological, economic, and family burdens for many years after disease onset. Not only are patients affected, but there can also be a diminished sense of achievement for the neurologist when a patient’s health does not improve. This indicates the importance for neurologists to fully understand the value of integrated training in order to best serve their patients.

Additionally, the correlation between medical college entrance examination scores and scores in all subjects was examined. Results showed no significant correlation. This finding may suggest that medical knowledge is far more complex than the level of coursework in high school. Consequently, college entrance examination results cannot predict the level of academic achievement in medical school.

**Conclusion**

Neurology is a highly complex discipline, one that requires advanced knowledge in many other areas of human biology and medicine. However, current medical education does not provide an evidence-based interdisciplinary curriculum needed for proper training. In addition, teaching the value of the humanities in medical education, particularly in neurology, is limited. The findings in this study suggest that a targeted integration for neurological curriculum will help medical students to excel in their medical training in neurology without fear or confusion. This in turn will produce well-trained physicians and result in optimum patient care.

**Practice Points**

1. Neurological education should involve a targeted integration with closely related disciplines.

2. There are ten targeted disciplines, including four clinical subjects and five basic subjects, that should be integrated in the neurology course, the number of which is larger than other studies.

3. Most clinical subjects need a targeted integration with other clinical subjects, while their demand for integrating basic disciplines is not as strong as neurology.

4. "A whole person" approach to medicine is not valued enough in the stage of medical education when students are merely exposed to theoretical knowledge.

5. Medical school performance could not be predicted by scores on the college entrance examination.

**Take Home Messages**

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Bibliography/References

1. Jozefowicz RF. Neurophobia: the fear of neurology among medical students. Vol. 51, Archives of neurology. United States; 1994. p. 328–9.

2. Schon F, Hart P, Fernandez C. Is clinical neurology really so difficult? Vol. 72, Journal of neurology, neurosurgery, and psychiatry. England; 2002. p. 557–9.

3. Giles J. Clinical neuroscience attachments: a student’s view of "Neurophobia". Clin Teach. 2010 Mar; 7(1):9–13.
   https://doi.org/10.1111/j.1743-498X.2009.00330.x

4. McColgan P, McKeown PP, Selai C, Doherty-Allan R, McCarron MO. Educational interventions in neurology: a comprehensive systematic review--reply to letter. Vol. 20, European journal of neurology. England; 2013. p. e123.

5. Solorzano GE, Jozefowicz RF. Neurophobia: a chronic disease of medical students. Vol. 85, Neurology. United States; 2015. p. 116–7.

6. Kamour AH, Han DY, Mannino DM, Hessler AB, Kedar S. Factors that impact medical student and house-staff career interest in brain related specialties. J Neurol Sci. 2016 Oct; 369:312–7.
   https://doi.org/10.1016/j.jns.2016.08.046

7. Hudson JN. Linking neuroscience theory to practice to help overcome student fear of neurology. Med Teach. 2006 Nov; 28(7):651–3.
   https://doi.org/10.1080/01421590600726409

8. Ghosh S, Pandya H V. Implementation of Integrated Learning Program in neurosciences during first year of traditional medical course: perception of students and faculty. BMC Med Educ. 2008 Sep; 8:44.
   https://doi.org/10.1186/1472-6920-8-44

9. Glick TH, Armstrong EG, Waterman MA, Hundert EM, Hyman SE. An integrated preclerkship curriculum in neuroscience, psychiatry, and neurology. Acad Psychiatry. 1997 Dec; 21(4):212–8.
   https://doi.org/10.1007/BF03341434

10. Cabral GA. Neuroimmune pharmacology as a sub-discipline of immunology in the medical school curriculum. J Neuroimmune Pharmacol. 2011 Mar; 6(1):57–62.
   https://doi.org/10.1007/s11481-010-9230-y

11. Brauer DG, Ferguson KJ. The integrated curriculum in medical education: AMEE Guide No. 96. Med Teach. 2015 Apr; 37(4):312–22.
   https://doi.org/10.3109/0142159X.2014.970998

12. Sivam SP, Iatridis PG, Vaughn S. Integration of pharmacology into a problem-based learning curriculum for
medical students. Med Educ. 1995 Jul; 29(4):289–96.

https://doi.org/10.1111/j.1365-2923.1995.tb02851.x

13. Giffin BF, Drake RL. Gross anatomy of the head and neck and neuroscience in an integrated first-year medical school curriculum. Anat Rec. 2000 Apr; 261(2):89–93.

https://doi.org/10.1002/(SICI)1097-0185(20000415)261:2<89::AID-AR9>3.0.CO;2-4

14. Grunze H, Strupp M, Ronneberg T, Putz R. [Problem-based learning in medical education. Integrated "Nervous System and Behavior" course at the Munich Ludwig Maximilian University]. Nervenarzt. 2004 Jan; 75(1):67–70.

https://doi.org/10.1007/s00115-003-1572-8

15. Mehr SE, Hassanzadeh G, Zahmatkesh M, Seyedian M, Arbabi M, Mirzazadeh A, et al. Medical students' viewpoint regarding the integrated module of basal ganglia. Acta Med Iran. 2011; 49(11):753–9.

16. Harden RM. The integration ladder: a tool for curriculum planning and evaluation. Med Educ. 2000 Jul; 34(7):551–7.

https://doi.org/10.1046/j.1365-2923.2000.00697.x

17. Trappler B. Integrated problem-based learning in the neuroscience curriculum--the SUNY Downstate experience. BMC Med Educ. 2006 Sep; 6:47.

https://doi.org/10.1186/1472-6920-6-47

18. Ogur B, Hirsh D, Krupat E, Bor D. The Harvard Medical School-Cambridge integrated clerkship: an innovative model of clinical education. Acad Med. 2007 Apr; 82(4):397–404.

https://doi.org/10.1097/ACM.0b013e31803338f0

19. Falcone JL. Residencies with dual internal medicine and paediatrics programs outperform others on the American Board of Pediatrics Certifying Examination. Clin Pediatr (Phila). 2014 Aug; 53(9):854–7.

https://doi.org/10.1177/0009922814533407

20. Parsey KS, Bastian LA, Couchman GM, Slack KD, Simel DL. The development of a primary care curriculum for obstetrics/gynaecology residents. J Am Med Women's Assoc. 1998; 53(3 Suppl):137–9.

21. Hampton HL, Collins BJ, Perry KGI, Meydrech EF, Wiser WL, Morrison JC. Order of rotation in third-year clerkships. Influence on academic performance. J Reprod Med. 1996 May; 41(5):337–40.

Appendices

Table 1. Correlation coefficients(r) between clinical subjects
Table 2. Correlation coefficients (r) between clinical and basic subjects

|                  | Neurology | Internal medicine | Surgery | Obstetrics and gynecology | Pediatrics | Psychiatry | Total* |
|------------------|-----------|-------------------|---------|----------------------------|------------|------------|--------|
| Neurology        | 1         | 0.618             | 0.433   | 0.640                      | 0.628      | 0.626      | 4      |
| Internal medicine| 0.618     | 1                 | 0.380   | 0.627                      | 0.634      | 0.472      | 3      |
| Surgery          | 0.433     | 0.380             | 1       | 0.270                      | 0.355      | 0.443      | 0      |
| Obstetrics and gynecology | 0.640  | 0.627             | 0.270   | 1                          | 0.616      | 0.557      | 3      |
| Pediatrics       | 0.628     | 0.634             | 0.355   | 0.616                      | 1          | 0.536      | 3      |
| Psychiatry       | 0.626     | 0.472             | 0.443   | 0.557                      | 0.536      | 1          | 1      |

* The number of subjects (r ≥0.600)

Table 3. Correlation coefficients (r) between clinical and social sciences/humanities subjects

|                  | Medical English | Philosophy | Medical ethics | Statistics | Epidemiology | Total* |
|------------------|-----------------|------------|----------------|------------|--------------|--------|
| Neurology        | 0.424           | 0.175      | 0.413          | 0.601      | 0.471        | 1      |
| Internal medicine| 0.469           | 0.117      | 0.431          | 0.569      | 0.361        | 0      |
|                | Surgery   | Obstetrics and gynecology | Pediatrics | Psychiatry |
|----------------|-----------|---------------------------|------------|------------|
|                | 0.121     | 0.330                     | 0.349      | 0.285      |
|                | 0.153     | 0.093                     | 0.145      | 0.207      |
|                | 0.068     | 0.377                     | 0.378      | 0.172      |
|                | 0.280     | 0.497                     | 0.495      | 0.443      |
|                | 0.370     | 0.381                     | 0.469      | 0.475      |

* The number of subjects (r ≥0.600)

**Figure 1. The number of subjects correlated with clinical subjects closely**

**Declarations**

The author has declared that there are no conflicts of interest.

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