Context: Given the well-documented shortage of physicians in primary care and several other specialties, quantitative understanding of residency application and matching data among osteopathic and allopathic medical students has implications for predicting trends in the physician workforce.

Objectives: To estimate medical student interest in neurology and psychiatry based on numbers of applicants and matches to neurology and psychiatry osteopathic and allopathic residency programs. Also, to gauge students’ previous academic experience with brain and cognitive sciences.

Methods: The number of available postgraduate year 1 positions, applicants, and matches from graduating years 2011 through 2015 were collected from the National Matching Services Inc and the American Association of Colleges of Osteopathic Medicine for osteopathic programs and the National Resident Matching Program and the Association of American Medical Colleges for allopathic programs. To determine and compare osteopathic and allopathic medical students’ interest in neurology and psychiatry, the number of positions, applicants, and matches were analyzed considering the number of total osteopathic and allopathic graduates in the given year using 2-tailed $\chi^2$ analyses with Yates correction. In addition, osteopathic and allopathic medical schools’ websites were reviewed to determine whether neurology and psychiatry rotations were required. Osteopathic medical students’ reported undergraduate majors were also gathered.

Results: Compared with allopathic medical students, osteopathic medical students had significantly greater interest (as measured by applicants) in neurology ($\chi^2=11.85$, $P<.001$) and psychiatry ($\chi^2=39.07$, $P<.001$), and an equal proportion of osteopathic and allopathic medical students matched in neurology and psychiatry residency programs. Approximately 6% of osteopathic vs nearly 85% of allopathic medical schools had required neurology rotations. Nearly 10% of osteopathic applicants and matriculants had undergraduate coursework in brain and cognitive sciences.

Conclusion: Osteopathic medical students demonstrated greater interest than allopathic medical students in neurology and psychiatry based on the proportion of residency program applicants but similar interests as measured by matches. Required rotations did not appear to influence students’ interests.

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Medical students pursue postgraduate residency training programs on the basis of numerous factors. For example, surveys of medical students have revealed factors such as patient population served, control of work schedule, financial compensation, job satisfaction, intellectual stimulation, medical school debt, competitiveness, scope of practice, and opportunity for fellowship training as important factors in residency training selection. Osteopathic medical students have also reported dual accreditation as another important factor affecting residency program selection. Given the well-documented shortage of physicians in primary care as well as in several other specialties, understanding the factors that affect specialty selection among medical students has implications for predicting trends in the physician workforce.

Medical students and junior physicians in the United States and around the world report a general perceived difficulty with the science and clinical practice of neurology—a phenomenon called neurophobia. Insufficient exposure to neurologic cases, limited formal instruction, and the complexity of neuroanatomy contribute to neurophobia. Considering these factors, neurophobia may contribute to limited interest by medical students in pursuing postgraduate residency training in neurology and may contribute to a current and forecasted shortage of neurologists.

When compared with neurology, psychiatry is challenged to meet practice needs for completely different reasons. Disorders of mental health constitute a growing public health burden that has intensified the need for increased numbers of psychiatrists domestically and internationally. Whereas the difficulty of clinical neuroscience is thought to contribute to a lack of interest in pursuing a career in neurology, negative attitudes toward psychiatry may contribute to decreased interest in pursuing a career in psychiatry. Medical students perceive psychiatry to have lower prestige and respect among other medical disciplines. This view may be a result of the specialty’s limitations in financial compensation, as well as the perception that it has a weaker scientific foundation compared with other specialties. These attitudes may be due, in part, to the largely negative representation of psychiatrists in popular media.

Interest in a given medical specialty has traditionally been assessed via surveys and questionnaires to medical students. For example, since 2007, the American Association of Colleges of Osteopathic Medicine (AACOM) has administered an annual survey to both entering and graduating osteopathic medical students, and it includes questions regarding students’ planned specialty. Despite its utility, survey research of this type is limited by the number of respondents who choose to complete the survey as well as the accuracy of responses. Therefore, we sought quantitative data regarding interest in neurology and psychiatry.

In the present study, we used publically available national residency application and match data as indicators of interest in neurology and psychiatry among osteopathic and allopathic medical students. In addition, we identified differences in the number of osteopathic and allopathic medical schools that require clerkship rotations in neurology and relate these findings to differences in residency program applications and matches. Using medical school application data, we also examined the extent to which applicants and matriculants to colleges of osteopathic medicine (COMs) have completed an undergraduate major in brain and cognitive sciences–related fields. Our findings have implications for faculty and administrators of COMs as well as the broader community of medical students, residents, and physicians, because understanding the interests of medical students can help determine what resources, curricular changes, clinical experiences, and mentorship opportunities would best benefit this population. For example, our data provide a platform for discussion as to
whether COM administrators and faculty should consider adding a required clerkship rotation in neurology. In addition, our approach demonstrates how quantitative examination of residency application and match data can be used as an indicator of specialty interest.

Methods

This institutional review board–exempted study used a nonexperimental design with a multitier approach. Data were gathered from public websites hosted by nationally recognized organizations for both osteopathic and allopathic undergraduate and graduate medical education. National residency application and match data were obtained from the National Matching Services Inc (NMS; https://natmatch.com/), which was used to track osteopathic medical students matching to osteopathic residency programs, and the National Resident Matching Program (NRMP; http://www.nrmp.org/), which was used to track both allopathic and osteopathic medical students matching to allopathic residency programs. Additional match data for osteopathic residency programs were collected from AACOM’s Osteopathic GME Match Report, and osteopathic applicant data for allopathic residency programs were collected from the Association of American Medical Colleges (AAMC). (Resources available from AACOM and the AAMC upon request.)

The number of postgraduate year 1 (PGY1) residency positions available, number of applicants, and number of matches over a 5-year period from 2011 to 2015 were collected. We chose to limit analyses to PGY1 applicants and matches because PGY1 represents the largest applicant pool compared with other applicants such as PGY2 or international medical school students.

Recognizing that the majority of clinical exposure to patients occurs during clerkship rotations, we investigated which osteopathic and allopathic medical schools required neurology and psychiatry rotations as part of clerkship training. To determine the clerkship rotations required by osteopathic and allopathic medical schools, an institutional website document search was performed of osteopathic and allopathic medical schools. The websites of 36 COMs (including 5 branch campuses) were identified on the AACOM website (http://www.aacom.org/docs/default-source/cib/2016_com-map.pdf?sfvrsn=6). Provisionally accredited COMs (ie, COMs that had not yet graduated their first classes) were included. For US allopathic medical schools, a directory of 145 schools was identified on the website of the Liaison Committee on Medical Education (LCME; http://lcme.org/directory/accredited-u-s-programs/). The respective website of each identified osteopathic and allopathic medical school was reviewed for information regarding whether clerkship rotations in neurology or psychiatry were required.

To identify undergraduate majors among osteopathic medical students, we used self-reported information from a centralized application portal, which AACOM oversees for students applying to any COM in the United States, with the exception of the University of North Texas Health Sciences Center Texas College of Osteopathic Medicine (UNTHSC/TCOM). As part of the application process, students self-report their undergraduate major from 120 possible majors listed on the application form, including majors in the life sciences, math and physical sciences, social sciences, and humanities, as well as an option for no major. We searched the database for self-reported majors of students who completed the AACOM application for admittance during the 2011-2012 through 2013-2014 academic years. These years include data when neuroscience was among the major categories on the application form; the application prior to these years did not include an option for reporting neuroscience as a major. The number of applicants and the number of subsequent matriculants for several major categories were calculated, and the percentage from the total number of applicants and matriculants was computed.

Tables were produced using SigmaPlot (Systat Software Inc), and quantitative analyses were performed using GraphPad (GraphPad Software). In particular, comparisons for the number of residency positions, applications, and matches for a given year were performed proportional to the number of graduates (osteopathic or allopathic) for that same year. Data for the number of graduates were available on and obtained...
from the AACOM\textsuperscript{37} and AAMC\textsuperscript{38} websites. Therefore, a 2×2 matrix was created for each comparison, including the data from the variable tested (eg, residency matches) and number of graduates, which allowed for relative comparisons despite the large difference in the annual number of allopathic graduates compared with osteopathic graduates. All \(\chi^2\) analyses were 2-tailed and performed with Yates correction and a significance level set at \(P<.05\).

Results
Neurology and Psychiatry Residency Positions, Applicants, and Matches
The number of osteopathic and allopathic neurology residency positions has differed substantially from 2011 to 2015 (Table 1). For example, in 2015 there were 22 osteopathic positions available compared with 404 reported allopathic neurology positions. Given the number of graduates in 2015 from osteopathic (5323 students) and allopathic medical schools (18,705 students) relative to the number of residency positions, a greater number of allopathic neurology residency positions existed than osteopathic positions (\(\chi^2=69.74, P<.001\)). In 2015, there was 1 osteopathic neurology residency position for every 242 osteopathic medical students compared with 1 allopathic neurology residency position for every 47 allopathic medical students.

Likewise, the number of osteopathic and allopathic psychiatry residency positions has also differed substantially during the given timeframe (Table 1). For example, 55 osteopathic positions were available compared with 1353 reported allopathic psychiatry positions\textsuperscript{34} in 2015. Relative to the number of graduates from osteopathic and allopathic medical schools in 2015, a significantly greater number of allopathic psychiatry positions than osteopathic positions were available (\(\chi^2=264.52, P<.001\)). In 2015, there was 1 osteopathic psychiatry residency position for every 242 osteopathic medical students compared with 1 allopathic neurology residency position for every 47 allopathic medical students.

Compared with the 15 osteopathic medical students who applied to osteopathic neurology programs in 2012, 130 osteopathic medical students applied to 1 or more allopathic neurology residency programs that same year. Furthermore, in 2015, 169 osteopathic medical students applied to an allopathic neurology residency program. Thus, assuming that all 169 osteopathic medical students in 2015 who applied to an allopathic neurology program also applied to an osteopathic neurology program, then an estimated 3.17% of osteopathic medical students (169 of 5323) expressed sufficient interest in neurology to apply to a neurology residency program. This percentage represents a significantly greater proportion of...
allopathic medical students in 2015, a total of 222 students (1.19%) matched in neurology. No significant differences between the proportion of allopathic vs osteopathic medical students who matched in neurology was found in 2015 ($\chi^2 = 1.44, P = .23$).

Similarly, we examined possible differences between allopathic and osteopathic applicants to psychiatry residency programs. Of 18,705 allopathic medical students in 2015, a total of 881 (4.71%) allopathic medical students applied and 774 (4.14%) matched to allopathic psychiatry programs in 2015, indicating that there were more than 1.5 residency positions available for every applicant (Table 1). Significantly greater numbers of allopathic medical students applied ($\chi^2 = 155.96, P < .001$) and matched ($\chi^2 = 313.16, P < .001$) to an allopathic psychiatry residency program than to a neurology program.

Limited publicly available data could be found on the number of osteopathic medical students who applied to osteopathic psychiatry residency programs. However, we found that 366 osteopathic medical students applied osteopathic than allopathic medical students who applied to a neurology program in that same year ($\chi^2 = 11.85, P < .001$). However, assuming that a portion of osteopathic medical students in 2015 applied to only osteopathic neurology residency programs, the total number of applicants would be greater than 169 and therefore increase the total percentage of osteopathic medical students applying to any neurology residency program to more than 3.17%.

Neurology match data from 2011 to 2015 were reviewed and a comparison between osteopathic and allopathic matches was performed. The number of osteopathic medical students matching to osteopathic neurology programs has remained low, reflecting the small number of osteopathic programs available. In contrast, osteopathic medical students matching to allopathic neurology residency programs has steadily increased and totaled 37 students in 2015. In 2015, a total of 52 of 5323 osteopathic medical students (0.98%) matched to an osteopathic or allopathic neurology residency. Of 18,705 allopathic medical students in 2015, a total of 222 students (1.19%) matched in neurology. No significant differences between the proportion of allopathic vs osteopathic medical students who matched in neurology was found in 2015 ($\chi^2 = 1.44, P = .23$).

Similarly, we examined possible differences between allopathic and osteopathic applicants to psychiatry residency programs. Of 18,705 allopathic medical students in 2015, a total of 881 (4.71%) allopathic medical students applied and 774 (4.14%) matched to allopathic psychiatry programs in 2015, indicating that there were more than 1.5 residency positions available for every applicant (Table 1). Significantly greater numbers of allopathic medical students applied ($\chi^2 = 155.96, P < .001$) and matched ($\chi^2 = 313.16, P < .001$) to an allopathic psychiatry residency program than to a neurology program.

Limited publicly available data could be found on the number of osteopathic medical students who applied to osteopathic psychiatry residency programs. However, we found that 366 osteopathic medical students applied
to an allopathic residency program in 2015 (Table 1). Assuming that all 366 osteopathic medical students who applied to an allopathic psychiatry program also applied to an osteopathic program, we estimate that 6.88% of osteopathic medical students (366 of 5323) applied to a psychiatry residency program in 2015. However, assuming that a portion of osteopathic medical students applied to only osteopathic psychiatry residency programs, the total number of applicants would be greater than 366 and therefore increase the total percentage to more than 6.88%. A significantly greater number of osteopathic medical students than allopathic medical students applied to psychiatry residency programs ($\chi^2_{1}=39.07, P<.001$). In addition, a significantly greater number of osteopathic medical students applied to a psychiatry residency program than a neurology residency program ($\chi^2_{1}=75.61, P<.001$).

In 2015, 183 osteopathic medical students matched to an allopathic psychiatry residency program and 41 matched to an osteopathic psychiatry residency program for a total of 224 of 5323 graduates. Thus, the total number of osteopathic medical students matching to any psychiatry residency program in 2015 constituted 4.21% of osteopathic medical students that year. No significant difference was found between the number of osteopathic medical students and the number of allopathic medical students matching to a psychiatry residency program ($\chi^2_{1}=0.04, P=.85$). However, we found a significantly greater number of osteopathic medical students matching to psychiatry residency programs compared with neurology programs ($\chi^2_{1}=108.77, P<.001$). Taken together, these data indicate that the percentage of allopathic and osteopathic medical students who apply to psychiatry residency programs is greater than that observed for neurology programs. In addition, a greater percentage of osteopathic medical students apply to psychiatry residency programs compared with allopathic medical students; however, a similar percentage of osteopathic and allopathic medical students match in psychiatry.

Undergraduate Exposure to Brain and Cognitive Sciences–Related Coursework

We examined the undergraduate majors of applicants and matriculants to all 36 COMs between academic years 2011-2012 and 2013-2014 on the basis of self-reported data on the AACOM application. During that period, the category neuroscience appeared on the application form in addition to 119 other majors from the life sciences, math and physical sciences, social sciences, and humanities. Over the course of the available data, more than 3% of osteopathic applicants (for example, 798 of 21,575 in 2014) and matriculants (for example, 264 of 7509 in 2014) were neuroscience majors. A similar analysis indicated that more than 6% of osteopathic applicants and nearly as many osteopathic matriculants were psychology majors (Table 2). Additionally, we combined data from several major categories found in the AACOM application, including neuroscience, psychology, and psychobiology (0.61% of applicants and 0.52% of matriculants in 2014), and discovered that more than 10% of applicants (2352 of 21,575) and matriculants (792 of 7509) in 2014 had extensive coursework in the broad field of brain and cognitive sciences.

Discussion

In the present report we used quantitative data to determine possible differences in osteopathic vs allopathic medical student interest in neurology and psychiatry.
based on the number of applicants and matches to residency programs. We found remarkably few osteopathic residency opportunities in neurology. The 20-times fewer number of osteopathic compared with allopathic residency positions available in neurology is likely one reason why many osteopathic medical students apply to allopathic residency programs and why there are consistently more osteopathic matches in allopathic vs osteopathic neurology residency programs. Thus, it is likely that more allopathic neurology positions can accommodate many of the personal and professional factors that osteopathic medical students consider important when choosing a residency program, such as geographic location, salary, and research opportunities. Whether and to what extent the single accreditation system will affect applications and matches to neurology and psychiatry programs by osteopathic medical students is an important subject for future research. One hypothesis is that applications and matches to neurology residency programs will remain at similar levels to that which we describe in the present report. Such a finding would indicate that the previous distinctions between osteopathic and allopathic residency training programs had little influence on the number of osteopathic medical students who pursued neurology training. An alternative hypothesis is that by eliminating real or perceived differences between osteopathic and allopathic postgraduate training, the single accreditation system may result in increased numbers of osteopathic medical students who apply and match to neurology residency programs.

Our quantitative analyses and estimates indicate that a greater proportion of osteopathic medical students apply to neurology residency programs than allopathic medical students and that a similar proportion of osteopathic and allopathic medical students match in neurology programs. Surprisingly, only 2 COMs required neurology clerkship rotations. Thus, increased clinical exposure cannot explain the estimated greater interest in neurology by osteopathic medical students. However, an important caveat to this interpretation is that we do not know what electives osteopathic medical students choose during their clerkship years and whether these electives include neurology. One hypothesis is that osteopathic medical students who are interested in a career in neurology and who attend a COM without a neurology rotation requirement choose to rotate in neurology as part of their elective clerkship rotations. Thus, understanding the elective rotations chosen by osteopathic medical students and how these rotations relate to future residency application choices is another important subject for future research.

Similar to our observations regarding osteopathic medical students applying to neurology residency programs, our estimates indicate that a greater proportion of osteopathic medical students apply to psychiatry residency programs compared with allopathic medical students. Given that a clerkship rotation in psychiatry is required by all 36 COMs and 143 allopathic medical schools, it remains unclear why osteopathic medical students demonstrate greater interest in psychiatry on the basis of applications to psychiatry residency programs.

In the current report, we present findings on the undergraduate major of osteopathic applicants and matriculants based on self-reported data on the osteopathic medical school application form. Our analyses indicate that nearly 10% of osteopathic medical school applicants and matriculants have extensive coursework in brain and cognitive sciences on the basis of the number of majors in areas such as psychology, neuroscience, and psychobiology. The percentage of osteopathic applicants who majored in these areas (approximately 10%) is similar to the percentage of osteopathic medical students who applied to either neurology or psychiatry residency programs. One hypothesis from these observations is that osteopathic medical students who majored in these areas are the students who go on to apply to a neurology or psychiatry residency in pursuit of a medical career in these fields. Thus, a future study could attempt to correlate undergraduate major with residency application and match data for osteopathic as well as allopathic medical students.

Despite its novelty and quantitative nature, our data are limited in several ways. First, our work is largely based on publically available data obtained from the Internet. We found extensive application and match data for allopathic medical students; however, as a result of limited amounts of publically reported data, the number of osteopathic applicants to different osteopathic specialties remains poorly understood. For this reason, our esti-
mates of the number of osteopathic medical students who apply to neurology or psychiatry residency programs are based on the number of osteopathic medical students who applied to allopathic neurology or psychiatry residency programs. Thus, our estimates assume that osteopathic medical students applied to both allopathic and osteopathic residency programs; however, if osteopathic medical students applied only to osteopathic or allopathic residencies, then our data underestimate the number of osteopathic medical students who applied to neurology or psychiatry programs. Second, our data from AACOM are based on the self-reported major of applicants to COMs (except UNTHSC/TCOM), which may not exactly reflect a student’s depth or breadth of coursework in a given area. One way to resolve this possible discrepancy would be to systematically review the academic transcript of every applicant; using this approach, one could also determine how a student’s major as well as other coursework are correlated with specialty interest. Third, we have data from a limited number of years, making it difficult to accurately describe the historical growth and change in applicants and matches in either neurology or psychiatry and in either osteopathic or allopathic programs. Nor can we use our data to accurately predict future growth or change. Finally, we used residency application and match data as a tool to determine levels of interest in neurology and psychiatry, recognizing that numerous factors in addition to interest motivate students to apply to a given residency program.

Table 2. Majors of Applicants and Matriculants to Colleges of Osteopathic Medicine by Academic Year

<table>
<thead>
<tr>
<th>Major</th>
<th>Applicants</th>
<th>Matriculants</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2011-2012</td>
<td>2012-2013</td>
</tr>
<tr>
<td>Biology</td>
<td>6695 (37.4)</td>
<td>7335 (37.3)</td>
</tr>
<tr>
<td>Psychology</td>
<td>1124 (6.3)</td>
<td>1269 (6.4)</td>
</tr>
<tr>
<td>Biochemistry</td>
<td>915 (5.1)</td>
<td>1026 (5.2)</td>
</tr>
<tr>
<td>No major</td>
<td>592 (3.3)</td>
<td>696 (3.5)</td>
</tr>
<tr>
<td>Chemistry</td>
<td>802 (4.5)</td>
<td>858 (4.4)</td>
</tr>
<tr>
<td>Neuroscience</td>
<td>542 (3.0)</td>
<td>673 (3.4)</td>
</tr>
<tr>
<td>Biomedical science</td>
<td>376 (2.1)</td>
<td>523 (2.7)</td>
</tr>
<tr>
<td>Health sciences</td>
<td>371 (2.1)</td>
<td>442 (2.2)</td>
</tr>
<tr>
<td>Premedical</td>
<td>524 (2.9)</td>
<td>445 (2.3)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>17,914</td>
<td>19,684</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Major</th>
<th>2011-2012</th>
<th>2012-2013</th>
<th>2013-2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biology</td>
<td>2488 (38.1)</td>
<td>2923 (38.5)</td>
<td>2848 (37.9)</td>
</tr>
<tr>
<td>Psychology</td>
<td>357 (5.5)</td>
<td>428 (5.6)</td>
<td>489 (6.5)</td>
</tr>
<tr>
<td>Biochemistry</td>
<td>349 (5.3)</td>
<td>389 (5.1)</td>
<td>464 (6.2)</td>
</tr>
<tr>
<td>No Major</td>
<td>237 (3.6)</td>
<td>269 (3.5)</td>
<td>312 (4.2)</td>
</tr>
<tr>
<td>Chemistry</td>
<td>263 (4.0)</td>
<td>353 (4.7)</td>
<td>296 (3.9)</td>
</tr>
<tr>
<td>Neuroscience</td>
<td>221 (3.4)</td>
<td>266 (3.5)</td>
<td>264 (3.5)</td>
</tr>
<tr>
<td>Biomedical science</td>
<td>133 (2.0)</td>
<td>202 (2.7)</td>
<td>191 (2.5)</td>
</tr>
<tr>
<td>Health sciences</td>
<td>132 (2.0)</td>
<td>174 (2.3)</td>
<td>180 (2.4)</td>
</tr>
<tr>
<td>Premedical</td>
<td>192 (2.9)</td>
<td>187 (2.5)</td>
<td>165 (2.2)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>6529</td>
<td>7590</td>
<td>7509</td>
</tr>
</tbody>
</table>

aData are presented as No. (%). Data do add up to given totals because less common majors are not listed.
Despite these limitations, other approaches to determine specialty interest, such as surveys and questionnaires, also have limitations, including low response rate, decreased validity, and uncertain accuracy of responses. Thus, our methodologic approach demonstrates how quantitative examination of residency application and match data can be used as an indicator of specialty interest.

Conclusion
We used a novel quantitative approach to determine medical student interest in neurology and psychiatry residency training. Although fewer osteopathic than allopathic neurology and psychiatry residency programs exist, our analyses indicated greater osteopathic than allopathic medical student interest in these fields on the basis of the proportion of residency applicants. Although required rotations did not appear to influence residency selection, a substantial number of osteopathic applicants and matriculants have undergraduate coursework in brain and cognitive sciences, and we believe this coursework may be related to future interest in pursuing residency training in neurology or psychiatry.

The data reported in the present study are relevant to faculty and administrators of COMs as well as the broader community of osteopathic medical students, residents, and physicians because understanding the interests of medical students can help determine which resources, curricular changes, clinical experiences, and mentorship opportunities would best benefit this population. For example, our data provide a platform for discussion as to whether COM administrators and faculty should consider adding a required clerkship rotation in neurology. Likewise, our data suggest the need for increased residency opportunities in neurology. In addition, our data provide a basis for comparison with future residency application and match data that will emerge with the launch of the single accreditation system for graduate medical education.

Author Contributions
All authors provided substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; all authors drafted the article or revised it critically for important intellectual content; all authors gave final approval of the version of the article to be published; and Dr Ramos agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

References


