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A survey study examining the motivations, concerns, and perspectives of medical students engaging in neurosurgical research

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ABSTRACT

Background: In a competitive landscape for neurosurgical residency admission, research productivity is increasingly important. Medical school applicants to neurosurgery report high numbers of "scholarly products" as published by the National Residency Match Program. Despite increased student involvement in research and productivity, to the best of our knowledge, no previous reported studies have examined student perspectives on their involvement in neurosurgical research.

Methods: For 2 consecutive years (February 2019 and February 2020), medical students ($n = 55$) from around the United States presented original research at the Student Neurosurgical Research Conference. Participants were administered a mixed-method survey designed to assess experiences and perspectives on engaging in neurosurgical research. Survey responses were analyzed independently by two researchers to assess for common themes and perspectives.

Results: Medical students engaged in all types of research work across nearly every neurosurgical subfield with "Basic/Bench Lab work" (38.5%) and "Chart Review" (23.1%) representing the majority of projects. Students commonly cited "curiosity/interest," and "residency application competitiveness" as main reasons for participation in research. About 66% of respondents reported experiencing anxiety/concern about research productivity "often" or "very often." Thematic analysis revealed that sources of research-related stress were (1) having enough publications to match into residency, and (2) having enough time in medical school to engage in research.

Conclusion: Medical students engaging in neurosurgical research are highly motivated students driven by scientific curiosity and pressure to prepare for competitive residency applications. Students experience anxiety due to time constraints in medical curricula and increasing demands for scholarly productivity.

Keywords: Medical education, Medical student research, Medical student well-being, Neurosurgical medical education, Neurosurgical research

INTRODUCTION

Research production and output by medical students have been increasing steadily over time, particularly in highly selective fields such as neurosurgery. The competitive nature of the

residency match process, need to distinguish between applicants, and emphasis on research has led to an increased number of publications by residency applicants.[10,21] This perceived importance of research in competitive specialties is corroborated by the National Resident Matching Program's "Charting Outcomes in the Match," which shows trending increases in research products from year to year, with neurosurgery applicants having the highest number of "scholarly products" among highly competitive specialties, a factor seen to correlate with successful matching.[11] Wadhwa *et al*. describe the increasing number of publications as an "arms race" for applicants, and in their analysis of neurosurgical applicants, the temporal trend toward increasing productivity has been driven primarily by an increase in non-indexed research (i.e. abstracts, presentations, chapters), which may point to pressure and expectations to produce a certain quantity of work.[21] This may prove especially true in the coming years, as it has been speculated that a pass-fail Step 1 examination will increase the importance of research productivity in residency selection.[9] Applicant productivity has been shown to be positively correlated with attending highly productive research institutions with large amounts of NIH funding and research output, a "top 20" medical school, and/or hold a PhD.[21]

Increasing demands in scholarly research have led to student-reported increases in stress and anxiety in general.[13] Moreover, students note that resources, capacity, time, and competition are the most significant factors impacting research productivity.[4] However even with the pressure to produce research, medical students site various barriers to undertaking research in medical school including a perception among students around lack of support to publish or present their work to the academic community, limited availability of research mentors, limited formal research methodology training, the perception that students will not receive appropriate recognition for their work, and limited time or designated time for research.[4,13] Pressure to produce high volumes of research in neurosurgery, in particular, may even lead to erroneous publication reporting (e.g. reporting nonexistent papers, incorrectly reporting applicant as the first author, and reporting non-peer-reviewed papers) that has been noted to be present in as many as 45% of applicants.[10]

At present, minimal research has been done to examine the medical student experience of acquiring research experiences and conducting research while in medical school, and no formal research of these questions, to the best of our knowledge, has been conducted on medical students doing research in neurosurgery. Given increasing demands in a competitive field such as neurosurgery, we sought to elucidate how medical students interested in neurosurgery rise to the challenge, how a competitive climate impacts the experience of pursuing and doing research, what motivates students to engage in research projects, and what challenges students face along the way. In this study, we surveyed medical students from around the nation attending the Student Neurosurgical Research Conference (SNRC) held at the Warren Alpert Medical School of Brown University in 2019 and 2020 to get a broad sense of both the practicalities of how medical students interested in neurological surgery acquire and complete research as well as explore student motivations, concerns, and experiences surrounding research.

MATERIALS AND METHODS

Setting and survey distribution

In 2019 and 2020 medical students (n = 55) across the United States convened at the SNRC, a student-run national research conference specifically tailored for medical students interested in pursuing neurosurgery as a career, hosted at The Warren Alpert Medical School of Brown University.[1] This survey was administered to students who attended the conference and presented research that had been previously accepted for poster or oral presentation based upon abstract submissions prior to the conference. This setting allowed for the relatively rapid assessment of medical students interested in neurosurgery who had prepared and completed some neurosurgical or neuroscience research.

The surveys were distributed to participants using SurveyMonkey Inc., a web-based survey platform. All surveys were completed anonymously by participants who were given a link to complete the survey at the end of the conference.

Survey design

Our research team developed a survey tool constructed to assess medical student experiences engaging in research [Appendix 1]. The survey study tool had a mixed-method design, consisting of both multiple choice and free response questions to allow for both quantitative and qualitative analysis. The free responses were specifically included to elicit participant perspectives and experiences in their own words.

Analysis

We conducted descriptive statistical analyses on the completed surveys. Free-responses were read by two independent reviewers (ABA and JA). Reviewers first noted common language and concepts in the free-responses and coded the responses separately to reduce individual reviewer bias. The coding scheme and subsequent analyses were developed using Grounded Theory, a well-established method for qualitative analysis that has been effectively used

to assess survey response data.[5] Both reviewers discussed the coding and results for free-response to the survey to identify conceptual recurrences or patterns in the data.

Ethics statement

This study protocol was conducted after approval by the Institutional Review Board of Brown University and is in accordance with the World Medical Association Declaration of Helsinki. All participants provided informed consent to participate in this study.

RESULTS

The survey was administered to medical students who attended the SNRC either in 2019 or 2020, and there was a 100% response rate. Survey respondents included medical students from accredited medical schools in the United States representing all medical class years, with a predominance of students in their 2nd year of medical training (51.0% $n = 25$).

Medical student research profiles

Survey respondents were asked to provide information about the research projects they had engaged in and prepared for presentation at the SNRC. Survey respondents indicated that they had completed various types of research projects including basic science research and several clinical research study approaches [Table 1]. Basic science research had the greatest representation among respondents (38.5%; $n = 15$), with chart review research representing the second most common research project presented by respondents (23.1%; $n = 8$).

Medical student researchers surveyed indicated that the on-going or completed research projects presented at the SNRC included research in all the major subfields of neurosurgery, with neuro-oncology (37.5%; $n = 15$), traumatology (32.5%; $n = 13$), and spine surgery (30.0%; $n = 12$) representing the sub-specialties with the greatest representation in the study sample [Table 1]. Of note, students were asked if they anticipated sub-specializing in the subfield or subspecialty most closely associated with their presented research. About 43.8% ($n = 21$) of respondents to this prompt indicated that they did anticipate specializing in the subspecialty closely associated with their research, while 12.5% ($n = 6$) did not anticipate doing so. Notably, the remaining 48% ($n = 21$) of respondents indicated that they were "unsure" of whether they would subspecialize in the field most closely associated with their presented research projects.

How do medical students acquire and complete research projects?

Student researchers were asked how their research projects were selected. About 82% ($n = 32$) of respondents indicated that they chose the type of research project they completed and presented at the conference. Students were asked to describe how their project was selected or developed, and thematic analysis revealed that 47% of student research efforts developed from student-led initiatives or ideas ($n = 16$), 38% from faculty or resident-led research ($n = 13$), and 15% ($n = 5$) of projects were described as being born from collaborative or combined efforts between faculty or residents and the students themselves. For instance, one student developed their research project after "finding an abnormality in (their) cadaver lab," while another "chose a mentor" who "had several projects for (the student) to start working on."

To assess how students were acquiring and completing research projects, we asked students how they found a research mentor, and when they were completing their research projects.

Survey respondents acquired their research mentors through a variety of unique methods. Notably, the most commonly cited method involved an initial, self-described "cold" email/contact to a department head or neurosurgical faculty member (35%; $n = 14$). Some students also reported that research programs or databases at their home

Table 1: Profile of research projects presented by survey respondents.

Research study type†	n (%)*
Basic/bench lab work	15 (38.5)
Chart review	9 (23.1)
Data analysis from a national database	5 (12.8)
Case report/case series	5 (12.8)
Cohort study	4 (10.3)
Meta-analysis	3 (7.7)
Prospective analysis	2 (5.1)
Literature review	2 (5.1)
Qualitative research	1 (2.6)
Data analysis from a clinical trial	1 (2.6)
Research Sub-field or subspecialty	
Neuro-oncology	18 (39.1)
Traumatology	13 (28.3)
Spine	14 (30.4)
Pediatric neurosurgery	9 (19.6)
Socioeconomic/legal/ethical issues in neurosurgery	9 (19.6)
Cerebrovascular	9 (19.6)
Basic neuroscience	9 (19.6)
Functional neurosurgery	8 (17.4)
Skull-based surgery	6 (13.0)
Medical education in neurosurgery	4 (8.7)
Pain medicine	3 (6.5)
Headache	2 (4.3)
Neurocritical care	1 (2.2)

*% represents the percent of the total number of responses to the question or prompt selected by survey participants who could select one or more categories to classify their research

institution facilitated connections with mentors (20.0%; n = 8). While other students highlighted encountering faculty through clinical rotations or from academic lectures (12.5%; n = 5). Notably, 100% of surveyed students indicated that their medical school had an affiliated neurosurgical department.

Survey respondents were asked when they had completed "most of the work" for the research project they presented at the SNRC. Students indicated that they completed their research work at various points during and before medical school with the most common time cited in our sample being "during a summer break in medical school" [Table 2]. Notably, more than half of students completed their research as a part of an organized research fellowship or program (52.5%; n = 21).

Why medical students decide to pursue research

In order to broadly capture student motivations for participating in research in their own words, we collected free responses to the question, "What are your main reasons for participating in your research work?" Our thematic analysis of free responses revealed that students participated in research for reasons that all fell into a few broad categories including *scientific curiosity/interest*, *increasing residency competitiveness*, and *networking with neurosurgical faculty*. Overall, the most common emerging theme was *scientific curiosity/interest*, which was listed by 100% (n = 35) of respondents who indicated they sought research due to their "interest in learning more about cutting edge work in the field" and "intellectual curiosity." About 51.4% (n = 18) of respondents indicated that *increasing residency competitiveness* was one primary reason for participation in research, noting that "enhancing residency applications" and "becoming a more competitive applicant" were primary motivators. About 8.6% (n = 3) of respondents highlighted the importance of *networking with neurosurgical faculty* through research participation.

Table 2: Timing of medical student research work.

	n **(%*)**
During a summer break in medical school	15 (37.5)
During the pre-clinical school years	10 (25.0)
During a medical school gap year (i.e., fellowship, research year)	7 (17.5)
Before medical school	4 (10.0)
During the clinical school years (i.e., while on rotations)	2 (5.0)
During a dedicated research time built into the curriculum (i.e., research elective)	2 (5.0)

*% represents the percentage of responses to this question, n=14 persons did not answer this question

Concerns and challenges

Our survey also sought to assess whether student anxiety or concerns related to their research, given increasing literature alluding to this phenomenon among medical students, as well as parse out exactly what challenges students faced when conducting research.

Students were asked what were sources of concern or anxiety related to research efforts. Thematic analysis revealed that *insufficient time*, *having enough publications*, *producing significant results through quality research*, *limited funding and resources*, and *competitiveness* were all common concerns among survey respondents [Table 3].

Having *insufficient time* represented one of the most common sources of concern and anxiety for respondents who highlighted that during medical school there was limited "time to work on research" due to daily "time constraints." For some, the notion of *insufficient time* took on a slightly broader meaning who noted stress and anxiety about "The amount of time (they) have left in med school to do research." For some, interest in neurosurgery or the neurosciences developed "later" in medical school and they found themselves with not enough "time to do legitimate and important research instead of something light.'" Notably, both manifestations of the theme of *insufficient time* were representative of students sampled from all class years.

Having enough publications was another common theme and source of concern for survey respondents. Students described pressure due to perceived "publish-or-perish style" stress related to preparing for residency applications. Students described the "quantity of research projects required" and the "number (of publications) required to match into residency" as particularly concerning. Notably, some described how this specific pressure impacted their decisions to participate in research with some students noting that they were often torn between "picking projects based on interests versus publication timeline." Survey respondents were also specifically asked to rate how often they experience concerns or stress about having enough research experiences, publications, and presentations. About

Table 3: Themes of student concerns and sources of anxiety related to participating in research.

	n **(%*)**
Insufficient time	11 (28.2)
Not having enough publications	11 (28.2)
Producing significant or meaningful results	8 (20.5)
Limited funding or other resources	7 (17.9)
Competitiveness of residency application	4 (10.3)

*% represents the percent of the total number of responses to the question or prompt selected by survey participants who could select one or more categories to classify their research

66.0% (n = 29) of respondents noted that they experience anxiety and stress related to having a high enough number of research experiences and output "often"(36.4%) or "very often"(29.6%). 27.3% (n = 12) of respondents experience such stress "rarely," and 6.8% (n = 3) "never" do. A related and often co-occurring theme was that of *competitiveness* of matching into a neurosurgery residency program. Students expressed that anxiety related to research participation and production was directly tied to "being competitive for the match."

About 20.5% (n = 8) of survey respondents also expressed concerns related to *producing significant results through quality research*. In particular, students expressed concerns about whether or not they were doing work that would yield "significant" or "meaningful" results that could "impact" the field or "clinical care." Issues related to *limited funding and resources* needed to conduct research were also a source of anxiety for some respondents (17.9%; n = 7).

In addition to assessing sources of concern or anxiety, we also assessed for challenges student respondents faced. When respondents were asked in an open-ended format "what challenges they face" when conducting research, the overwhelming majority indicated that "limited time" in medical school (78.6%; n = 33) was a major challenge. Other challenges that thematic analysis of responses revealed include "difficulty finding research mentors or opportunities" (23.8%; n = 10), and "difficulty with research-related tasks such as data collection, analysis, and publication" (23.8%; n = 10). Some students noted that "generating ideas" for research was a challenging feature of conducting research (16.7%; n = 7), while a smaller number indicated that limited "funding" was a significant challenge they faced when conducting research (7.14%; n = 3).

DISCUSSION

This report represents a preliminary effort to assess the perspectives and experiences of medical students conducting research who are interested in neurological surgery as a future specialty. This survey employs a mixed quantitative and qualitative approach to assessing a broad sample of medical students who conducted research in clinical neuroscience and expressed interest in neurological surgery as a future career. This study specifically sought to characterize what kind of research medical students pursue in the field, how and why medical students decide to pursue research, what concerns or stressors they have related to research, and what challenges they face in the research process.

First, our sample demonstrates that medical students are pursuing research in all subspecialties and subfields of neurological surgery and engaging in research broadly from basic science to clinical research. Research in trauma, spine, and neuro-oncology was more represented in our study sample, and further study is needed through larger studies to uncover whether these trends are consistent with most medical students pursuing neurosurgery research. Our survey uncovered that while some students anticipated they may pursue a career subspecializing in the area of neurosurgery most closely associated with their research, a relatively comparable percent of students were unsure about their future sub-specialization. This suggests that while research projects may influence medical students about subspecialties in neurological surgery, participating in certain subspecialty-specific research is not perceived by medical students as a definitive deciding factor about their eventual career goals. It is also possible that research may provide medical students with exposure that helps them decide against the subspecialty or neurosurgery in general, which may be the case for the 12.5% of students that did not anticipate going into the subfield related to their research.

Our study team was interested in learning from this sample of students how exactly students are going about selecting research, acquiring mentors, and completing research projects. Our data show that students are selecting their research topics or areas and that specific projects are devised in a variety of ways including student-initiated ideas, faculty or resident-led projects, and as collaborative efforts. Thus, a critical component to initiating research for many medical students included finding research mentors.

Indeed, mentorship in medicine and research can be critical for enhancing and supporting the next generation of clinician-scientists, and has been shown to significantly enhance medical student success.[6,20] Our data showed that most commonly participants found mentors by initiating contact with neurosurgical faculty at their institutions through "cold emails" or by reaching out without a prior established relationship. This is significant because, these data suggest both that students are successfully able to establish relationships with neurosurgical faculty who are open to becoming mentors, and that students often must take the initial step to establish said relationships. Recent research suggests that medical students are unsatisfied with the amount of mentorship they receive in medical school by-in-large,[3] and numerous reports have suggested that acquiring mentors and differential access to mentors can contribute to barriers in pursuing certain medical specialties, especially for students underrepresented in medicine.[12,15,19] Notably, over half of the students in our sample reported completing their research projects as a part of a facilitated fellowship program. Indeed, mentorship programs, especially research-focused mentorship programs, have been shown to facilitate student success in acquiring meaningful mentoring relationships, participating and completing research, as well as improving overall career success.[7,15,18]

Motivations and concerns

In this paper, our study group was particularly interested in the motivators and challenges medical students faced when pursuing research in neurosurgery. In recent years, there has been a notable rise in the number of scholarly products and publications by medical students in neurosurgery.[21] Many argue that this increase is directly tied to the increasing competitiveness of the residency application process for the specialty; however to date, no formal study has examined what drives medical students to participate in neurosurgical research.

Our survey data suggest that medical students interested in neurosurgery are a highly motivated and intellectually curious cohort, who consistently expressed language that fell into the theme of *scientific curiosity/interest* identified through qualitative analysis. Indeed, 100% of respondents to the question "What are your main reasons for participating in your research work?" indicate that interest in the specific project, advancing the field through research, and/or fascination by the process of scientific investigation was a primary motivator for their participation in research. This suggests that students are driven to participate in neurosurgical research in part by an interest in the scientific process and specific research questions.

Our thematic analysis also uncovered that a majority of respondents cited a primary motivator for neurosurgical research participation is *increasing residency competitiveness*. These data make sense when considering the rising average number of scholarly products for neurosurgery applicants and the clearly articulated importance of research in the residency selection process in neurosurgery. [14,21] Therefore, in addition to the near-universal motivator of scientific curiosity, students also appear to be significantly motivated by the desire to prepare competitive applications for neurosurgery residency programs.

In the process of conducting research in neurosurgery, students report considerable anxiety related to conducting research, in particular the notions of having "enough" time to do research and acquiring "enough" research publications were reported as a consistent source of stress for survey respondents. These data suggest that medical students interested in pursuing neurological surgery as a specialty, like many of their peers as reported in the literature, feel pressure during medical school to complete a significant amount of research.[13,21] In addition, our respondents reported they often feel anxiety concerning their research productivity, which is undoubtedly linked to the growing number of publications neurosurgical programs are seeing, and thus, coming to expect from applicants.[21]

Conducting research in medical school brings accompanying challenges for medical students. Our survey respondents noted that "limited time" to devote to research, "difficulty finding research mentors," and "difficulty with research-related tasks such as data collection, analysis, and publication" were among the most common challenges faced. Many of these difficulties are faced by all researchers in any field, and at nearly all levels of training.[8,17] With that noted, survey respondents did point to some specific issues related to medical students conducting neurosurgical research such as the challenge of having "limited time" to do research with accompanying medical course work, especially when students reported gaining exposure to neurosurgery "later" in their medical school careers. It is notable, that while all surveyed students came from medical schools with neurosurgical departments a significant proportion of respondents reported stress around acquiring mentors. These challenges are significant to note because they provide insight into a potential need among students for targeted approaches to better support students in conducting research.

Many of the challenges described affected other facets related to their research such as selecting mentors and deciding on research projects, with some students explicitly stating that their research or mentors were selected with "project time-to-publication" in mind. While there is valuable practical learning associated with engaging in research with the end in mind, there may be important research efforts that medical students can and should participate in and learn from with timelines that may not yield publication during medical school. Further, publication timelines are often out of medical students' control, and factors such as medical school and department research output have been shown to significantly affect medical student productivity.[21]

Limitations

One limitation is the relatively small sample size of the study population, which may not be representative of all medical students interested in neurosurgery. The benefits of this study, however, lie in the inherent specificity of the studied population. For instance, by virtue of attending the conference as presenters, all survey respondents had expressed-interest in neurosurgery and documented evidence of having engaged in a research project in neurosurgery or neuroscience.

Certainly, limitations inherent to survey methodology are present in this study, such as the possible introduction of bias through specific questions. Our team attempted to gather broad data from student perspectives through the use of open-ended questions and subsequent qualitative analysis, which also has the possibility of introducing bias. To mitigate this bias, we utilized an established method of qualitative analysis and agreed on respondent themes based upon a detailed process that involved two independent reviewers. In addition, this survey study represents a single snapshot of

medical student perspectives and motivations that may very likely change over time, and further work to elucidate how students continue to view research experiences and challenges as they transition to residency after admission is needed.

In addition to inherent biases present in qualitative research, there were also limitations in the surveyed sample population studied. For instance, our sample population studied at the SNRC consisted of mostly 2nd-year medical students, and likely due to the location of the conference, had a greater representation of students from the east coast. It is also important to note that, 100% of respondents to this survey, and indeed all SNRC conference attendees reported having a home neurological surgery department. While this is a limitation, it may also be telling that those students who were able to attend the SNRC all had neurosurgery departments at their home medical schools. We did not gather significant demographic data in an effort to maintain the anonymity of study participants in the conference, however further research examining these perspectives in groups of students such as MD/PhD students, international medical graduates, and students underrepresented in neurosurgery such as women and certain minority groups is critical.

CONCLUSION

This survey study represents a preliminary effort to study the medical student perspective of engaging and conducting research in neurosurgery or with the career goal of specializing in neurosurgery in mind. Our data show that medical students interested in neurosurgery are a highly motivated and engaged cohort that is participating in all facets of neurosurgical and neuroscience research. Motivating factors for medical students include genuine scientific curiosity, and many students desire to produce high-quality research that has an impact on the field. Students also express concern and anxiety related to having insufficient time to achieve a high level of research output in the increasingly competitive landscape of applying to neurosurgical residency programs. With students describing "publish-or-perish" pressure that poses unique challenges for learners who are balancing early medical education, efforts to support medical students in engaging in meaningful research are important. Further research is critical to assess the impact of this type of stress on medical students interested in neurosurgery, especially in the context of rising medical student stress and anxiety rates on the international scale.[2,16,22] Similar work among neurosurgical residents would also be of value as residents also face challenges of time constraints and often feel pressure to balance clinical learning with research output and other factors. In addition, reconsidering and communicating the value and approach to how residency programs assess student research efforts and experience beyond publication number may be an important step in supporting students interested in neurological surgery.

Declaration of patient consent

Institutional Review Board (IRB) permission obtained for the study.

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Conflicts of interest

There are no conflicts of interest.

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APPENDIX

Appendix 1: Survey questions.

What year are you in your medical training? (M1/M2/M3/M4/Other)
Does your home institution have a neurosurgery department? (Yes or No)
Please select the broad area (s) of neurosurgical or neuroscience research to which your project pertains (may select all that apply)?
- Basic neuroscience
- Cerebrovascular
- Functional neurosurgery
- Medical education in neurosurgery
- Neurocritical care
- Neuro-oncology
- Pain medicine
- Pediatric
- Skull-based surgery
- Socioeconomic/legal/ethical issues in neurosurgery
- Spine
- Traumatology
- Other (please specify)

Please select the broad area (s) of neurosurgical or neuroscience research to which your project pertains (may select all that apply)? (Yes/No/Not Sure or Undecided)
Please select what type of research project you are presenting today? (Please select all that apply)
- Basic/bench lab work
- Case report/case series
- Chart review
- Cohort study
- Data analysis form a clinical trial
- Data analysis from a national database
- Literature review
- Meta-analysis
- Prospective analysis
- Qualitative research
- Other

Did you choose the type of research project you worked on? (Yes/No/Other)
If yes, what drew you to this project; if not, how was the project decided upon/developed? (i.e., professor/resident suggestion and individual assessment)
What concerns/anxieties might you have about your research project, engaging in research in general, or research as it pertains to your future residency goals? (free response)
How often do you notice or experience concerns about having enough research experience, publications, presentations, etc.? (Never/Rarely/Often/Very Often)
What are the biggest challenges you face when it comes to research as a medical student? (free response)

(Contd...)

Appendix 1: *(Continued).*

Can you please indicate when you completed most of the work for the research project you presented today? (Please choose the single most representative answer)

- Before medical school
- During a dedicated research time built into your medical school curriculum (i.e., research elective time)
- During a medical school gap year (i.e., fellowship and research year)
- During a summer break during medical school
- During the clinical school years (while on rotations)
- During the pre-clinical school years

How did you find/acquire a research mentor? (free response)
Did you complete your research project as part of an organized fellowship or research program? (Yes or No)
What are your main reasons for participating in your research work? (free response)