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BRAINterns 2.0: Durability of Webinar-Based Education and Social Media Beyond the Coronavirus Disease 2019 Pandemic

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BACKGROUND: Webinars offer novel educational opportunities beyond those of traditional, in-person experiences. BRAINterns is an open-access webinar-based education platform created to replace opportunities lost during the coronavirus disease 2019 pandemic. This program previously showed the efficacy of webinars to expand access to careers in medicine, and in particular, neurosurgery. BRAINterns 2.0 was established to assess the durability of Web-based learning.

METHODS: A modified 4-week webinar series was held during July 2021. A retrospective exit survey was distributed to participants and responses analyzed.

RESULTS: A total of 16,045 people registered for BRAINterns 2.0, representing 103 countries. Survey responses were received from 3765 participants (23% response rate). New, first-time registrants comprised 66% of participants, with the rest being returning participants. A total of 342 students participated in a dedicated module delivered entirely in Spanish. Females represented 81% of respondents. Participants identified that desirable elements of the program were opportunities to hear from women (53%) and people of color (44%) in health care. Participants heard about the series through TikTok (n = 1251; 33%), Instagram (n = 1109; 29%), Facebook (n = 637; 17%), and word of mouth (n = 708; 19%) with assistance from an ambassador program.

CONCLUSIONS: Webinar-based education programs continue to be of interest to students in an increasingly digital world. Social media, and specifically the use of educational ambassadors, are effective to improve visibility of educational programs across a diverse population of students. Understanding the desires of participants is critical to building a successful online education platform.

INTRODUCTION

The coronavirus disease 2019 (COVID-19) pandemic served as a catalyst for the expansion of alternative educational modalities, particularly within medical education. Medical education has traditionally relied on in-person shadowing and mentorship as an integral component of career development. In response to the disruption of traditional in-person educational methods created by the pandemic, several Web-based educational initiatives were created, particularly within neurosurgery.¹⁻³ These Web-based programs offered a unique opportunity for programs to expand access and recruitment to historically underrepresented populations in medicine and neurosurgery.

The Lenox Hill Hospital Department of Neurosurgery created the BRAINterns webinar series in 2020, capitalizing on the accelerated improvements in Web-based multimedia platforms. The initial program was met with widespread enthusiasm and garnered the attention of 16,484 registrants from 87 countries.⁴ Analyses of survey participants showed that Web-based education expanded access to medical education to a traditionally
underrepresented cohort of students, including women and underrepresented minorities.

Given the success of the first online series, a second series of webinars was created and dubbed BRAInterns 2.0. BRAInterns 2.0 sought to streamline the open-access webinar platform in an environment that had largely returned to in-person learning through an expanded set of lecture topics focusing on the importance of women and diversity in medicine, an updated centralized Web site, and a week of curated content delivered entirely in Spanish in response to participant requests. BRAInterns also experimented with novel promotional techniques and appointed a cohort of 433 student ambassadors worldwide and promoted widely on common social media platforms.

We analyzed survey responses from participants in BRAInterns 2.0 to confirm the durability of virtual education and to better understand its ability to expand access to careers in medicine and specifically, neurosurgery, through high-quality, multimedia webinars that respond to the real-time needs of students entering health care. We evaluated the usefulness of modern tools such as webcasting technology, electronic anonymized exit surveys, and social media promotion to maximize reach and deliver educational content. These data can be extrapolated and serve as a guide to the development of future Web-based educational programs in an increasingly digital world.

METHODS
This project was granted human subjects research exemption by the Feinstein Institute of Medical Research institutional review board.

| A | Monday | Tuesday | Wednesday | Thursday | Friday |
|---|--------|---------|-----------|----------|--------|
| 9-10AM EST | Special Summer Seminar | Women in Medicine | ACP Corner | Administration Station | Medical Student Journeys |
| 10-11AM EST | Neurology Case Study | Virtual Cerebrovascular OR | Virtual Spine OR | Neuro-oncology Virtual OR | Chairman’s Corner |
| 11-12PM EST | Medical School Preparation | Diversity in Medicine | ‘Introduction to Diagnostic Neuroimaging | Neurosurgical Innovation/Research |

| B | lunes | martes | miércoles | jueves | viernes |
|---|------|-------|----------|-------|--------|
| 9-10AM EST | Introducción a la Cirugía Neuro-Endovascular | Experiencia y conocimiento del asistente del médico en una sala de operación | Cirugía pediátrica | De la hematología y oncología pediátrica a administrar un hospital | Administración de un departamento de neurocirugía |
| 10-11AM EST | La magia de la Neurología y Neuro-anatomía | Anestesia y la conciencia | Cuidado intensivo pediátrico | Introducción a la neuroradiología | De las granjas a la cima de la neurocirugía |
| 11-12PM EST | La determinación y la excelencia entre medicina y el deporte | Consejos de una neurocirujana cerebrovascular y neuro-endovascular | Neuroradiología intervencional, La creación de un campo nuevo en la medicina | Cómo se llega a ser un cirujano neuro-endovascular |

Figure 1. Sample schedule for BRAInterns 2.0 in (A) English and (B) Spanish.
Webinar
BRAINterns 2.0 was delivered as a series of webinars over Zoom’s videoconferencing platform (Zoom Video Communications Inc., San Jose, California, USA). Each week, 15 hours of content were delivered including lectures, pre-recorded live surgical shadowing, and career advising. All content was interactive through the Zoom platform. The program spanned 4 weeks in total. The last week (July 26–30, 2021) was delivered entirely in Spanish and mirrored the English. Sample schedules for a week of lecture series content in both English and Spanish are shown in Figure 1. The webinar series was also recorded and posted to the BRAINterns YouTube channel, where it was available for free asynchronous viewing.

Ambassadors Program
The creators of BRAINterns formed an ambassadors program comprising international participants committed to the goal of marketing and communicating the benefits of this program to students worldwide via multiple media platforms. The opportunity to join the ambassadors program was publicized on all forms of social media and interested BRAINterns participants who wanted an expanded role within the program were invited to contribute. Ambassadors were instructed to produce at least 3 forms of outreach content including e-mails, clubs, and/or flyers. In addition, ambassadors created and managed social accounts under Instagram (@lhhbrainterns) and TikTok (@lhhbrainterns) to further publicize the program. Ambassadors were volunteers and there was no compensation. Ambassadors could resign at any time and continue to participate in the BRAINterns program as they desired.

Survey
Data were obtained through an anonymous retrospective exit survey distributed to participants at the conclusion of the webinar series. A list of the survey questions is provided in Supplementary Table 1. Although survey completion was voluntary, students who submitted the survey were awarded a certificate of completion for the webinar series. The online questionnaire was distributed through SurveyMonkey Inc. (San Mateo, California, USA), which served as the platform for data acquisition. The survey was created to assess 1) demographics of participants, 2) continued interest in another webinar series among those who previously participated, 3) interest among first-time participants, 4) the impact of webinar-based health care education on participants’ career choices (including interest in neurosurgery), 5) the effectiveness of course materials, and 6) goals of students who enrolled.

Data Analysis
Anonymously collected data were exported from the SurveyMonkey platform to Microsoft Excel (Microsoft Corp., Redmond, Washington, USA). SPSS version 26 (IBM Corp., Armonk, New York, USA) was used for all statistical analyses. Mean values for numeric variables were recorded with standard deviations. Two-sided t tests were performed on the self-reported confidence data and career interest data to ascertain whether the increases were statistically significant. Because of a nonnormal distribution of values, a Kruskal-Wallis test was conducted to evaluate if there was a statistically significant relationship between age and methods by which participants first heard about the webinar series. To analyze the statistical significance in retention rate, $\chi^2$ analysis was conducted. A P value <0.05 was considered statistically significant. Qualitative data and open-ended responses were hand-coded and analyzed manually.

RESULTS
Demographic Data
BRAINterns 2.0 had 16,045 registrants and 3795 survey responders (23.5% response rate). Table 1 compares demographics from survey responders who participated in BRAINterns 1.0 and 2.0. There was an increase in international participation and the number of countries represented increased from 87 to 102. In addition, 66% of survey responders were new to the BRAINterns program and had not attended the original webinar series. A total of 342 students attended BRAINterns 2.0 in Spanish. The median age of participation in BRAINterns 2.0 did not differ significantly from BRAINterns 1.0 and was 21 years (range, 12-74 years). Female students continued to represent most participants, at 81.1% of all participants. Asian participants were the most well represented, at 39.71%. Hispanic and Latino students made up 16.63% of participants. Black and African American students made up 7.04% of participants. Participants of all socioeconomic backgrounds participated in the webinar series, with self-reported household income levels ranging from less than U.S. $25,000/year to more than U.S. $150,000/year (Table 2).

Self-Rated Competency and Career Interest Scores Increase After the Webinar Series
Participant interest in pursuing various health care tracks before and after the webinar series was evaluated. Overall, average self-reported likelihood of pursuing physician training increased among participants after the webinar series ($P < 0.0001$). Table 3 summarizes the participants’ average self-reported likelihood scores of pursuing careers as a physician (M.D./D.O.), nurse practitioner, or physician assistant, and within neurosurgery. These values are stratified by sex, race and ethnicity, household income, and if participants have a family member in health care. High-school and college students specifically reported a significant increase in the likelihood of applying to medical school after the webinar series ($P < 0.0001$). Further stratification by household income showed that participants from all 4 income groups included reported a significant increase in likelihood of applying to medical school (Table 4). Participants from all demographic backgrounds reported statistically significant increases in self-rated knowledge of operating room (OR) procedures ($P < 0.0001$) and technology ($P < 0.0001$) (Supplementary Table 2).
Medical student participants reported an overall increase in likelihood of pursuing a career in neurosurgery (*P* < 0.001) (Table 5). When stratified by sex, both female (*n* = 279) and male (*n* = 102) medical students reported a significantly higher likelihood of pursuing a career in neurosurgery after the webinar (*P* < 0.0001). Asian (*n* = 139; *P* < 0.0001), Hispanic/Latino (*n* = 61; *P* < 0.01), Middle Eastern or North African (*n* = 25; Table 1. Demographic Data from Original Webinar (1.0) and Second Webinar (2.0)

| Characteristics                              | Values                      |
|----------------------------------------------|-----------------------------|
| BRAINterns 1.0 participant demographics      |                             |
| Number of registrants                        | 16,484                      |
| Number of participants                       | 6675                        |
| Age (years)                                  |                             |
| Median                                       | 21                          |
| Range                                        | 8–68                        |
| Sex                                          |                             |
| Male                                         | 1094 (16.39)                |
| Female                                       | 5521 (82.71)                |
| Not specified                                | 60 (0.89)                   |
| Race (%)                                     |                             |
| Asian                                        | 2798 (41.92)                |
| Black or African American                    | 516 (7.73)                  |
| Hispanic or Latino                           | 1080 (16.18)                |
| Middle East or North African                 | 335 (5.02)                  |
| Multiracial/multiethnic                      | 236 (3.54)                  |
| Native American or Alaska Native             | 9 (0.13)                    |
| Native Hawaiian or Pacific Islander          | 22 (0.33)                   |
| White                                        | 1514 (22.68)                |
| Level of education                           |                             |
| Middle and high school                       | 945 (14.16)                 |
| College                                      | 4180 (62.62)                |
| Graduate school                              | 280 (4.19)                  |
| Nursing school                               | 55 (0.82)                   |
| Medical school                               | 408 (6.11)                  |
| Medical fellowship and residency             | 29 (0.42)                   |
| Physician assistant school                   | 34 (0.51)                   |
| Not currently enrolled                       | 575 (8.81)                  |
| None of the above                            | 170 (2.55)                  |
| BRAINterns 2.0                               |                             |
| Number of registrants                        | 16,045                      |
| Number of participants                       | 3765                        |
| Age (years)                                  |                             |
| Median                                       | 21                          |
| Range                                        | 12–74                       |
| Sex (%)                                      |                             |
| Male                                         | 685 (18.19)                 |
| Female                                       | 3054 (81.12)                |
| Not specified above                          | 26 (0.69)                   |

Medical student participants reported an overall increase in likelihood of pursuing a career in neurosurgery (*P* < 0.001) (Table 5). When stratified by sex, both female (*n* = 279) and male (*n* = 102) medical students reported a significantly higher likelihood of pursuing a career in neurosurgery after the webinar (*P* < 0.0001). Asian (*n* = 139; *P* < 0.0001), Hispanic/Latino (*n* = 61; *P* < 0.01), Middle Eastern or North African (*n* = 25; Table 2. Yearly Household Income of U.S. Participants (N = 2759)

| Income                | Number (%) |
|-----------------------|------------|
| <USD15,000            | 181 (6.56) |
| USD15,000–29,999      | 262 (9.50) |
| USD30,000–49,999      | 273 (9.89) |
| USD50,000–74,999      | 276 (10.00)|
| USD75,000–99,999      | 234 (8.48) |
| USD100,000–150,000    | 371 (13.45)|
| >USD150,000           | 363 (13.16)|
| Do not know           | 405 (14.68)|
| Prefer not to answer  | 394 (14.28)|

Values are number (%) except where indicated otherwise.
|                             | Likelihood of Pursuing a Career in Neurosurgery | Likelihood of Pursuing the Physician (M.D./D.O.) Track | Likelihood of Pursuing the Nurse Practitioner Track | Likelihood of Pursuing the Physician Assistant Track |
|-----------------------------|-----------------------------------------------|------------------------------------------------------|-----------------------------------------------------|-----------------------------------------------------|
|                             | Before | After | Before | After | Before | After | Before | After |
| *P* value                   |        |        |        |        |        |        |        |        |
| Overall sex                 |        |        |        |        |        |        |        |        |
| Male (n = 675)              | 5.557  | 7.201  | 7.834  | 8.545  | 2.637  | 3.262  | 3.018  | 3.801  |
| <0.0001                     |        |        | <0.0001|        | <0.0001|        | <0.0001|        |
| Female (n = 2973)           | 5.025  | 6.817  | 7.622  | 8.337  | 2.709  | 3.368  | 3.261  | 4.166  |
| <0.0001                     |        |        | <0.0001|        | <0.0001|        | <0.0001|        |
| Annual household income     |        |        |        |        |        |        |        |        |
| <USD15,000 (n=338)          | 5.538  | 7.559  | 7.515  | 8.467  | 2.923  | 3.950  | 3.296  | 4.299  |
| <0.0001                     |        |        | <0.0001|        | <0.0001|        | <0.0001|        |
| USD15,000—29,999 (n = 345)  | 5.299  | 7.330  | 7.501  | 8.354  | 2.716  | 3.528  | 3.458  | 4.504  |
| <0.0001                     |        |        | <0.0001|        | <0.0001|        | <0.0001|        |
| USD30,000—49,999 (n = 327)  | 5.104  | 7.000  | 7.884  | 8.353  | 3.046  | 3.560  | 3.517  | 4.358  |
| <0.0001                     |        |        | 0.0014 |        | 0.0122 |        | 0.0002 |        |
| USD50,000—74,999 (n = 344)  | 4.875  | 6.820  | 7.666  | 8.462  | 2.669  | 3.445  | 3.151  | 4.052  |
| <0.0001                     |        |        | <0.0001|        | <0.0001|        | <0.0001|        |
| USD75,000—99,999 (n = 277)  | 5.166  | 6.791  | 7.989  | 8.588  | 2.585  | 3.173  | 3.325  | 4.375  |
| <0.0001                     |        |        | 0.0042 |        | 0.0014 |        | <0.0001|        |
| USD100,000—150,000 (n = 417)| 4.664  | 6.302  | 7.758  | 8.427  | 2.329  | 2.892  | 3.065  | 3.899  |
| <0.0001                     |        |        | <0.0001|        | <0.0001|        | <0.0001|        |
| >USD150,000 (n = 401)       | 5.080  | 6.708  | 7.920  | 8.531  | 2.262  | 2.576  | 2.751  | 3.421  |
| <0.0001                     |        |        | 0.0004 |        | 0.0198 |        | <0.0001|        |
| Race                        |        |        |        |        |        |        |        |        |
| White (n = 874)             | 4.944  | 6.568  | 7.514  | 8.135  | 2.456  | 2.891  | 3.168  | 3.999  |
| <0.0001                     |        |        | <0.0001|        | <0.0001|        | <0.0001|        |
| Asian (n = 1464)            | 5.051  | 6.879  | 7.557  | 8.292  | 2.855  | 3.567  | 3.268  | 4.128  |
| <0.0001                     |        |        | <0.0001|        | <0.0001|        | <0.0001|        |
| Black/African American (n = 256) | 5.254  | 6.949  | 7.836  | 8.746  | 2.712  | 3.523  | 3.215  | 4.309  |
| <0.0001                     |        |        | <0.0001|        | <0.0001|        | <0.0001|        |
| Hispanic/Latino (n=611)     | 5.363  | 7.241  | 7.948  | 8.632  | 2.804  | 3.609  | 3.321  | 4.391  |
| <0.0001                     |        |        | <0.0001|        | <0.0001|        | <0.0001|        |
| Another race or ethnicity (n=109) | 5.440  | 7.376  | 7.422  | 8.220  | 2.413  | 3.147  | 3.101  | 3.982  |
| <0.0001                     |        |        | 0.0367 |        | 0.0172 |        | 0.0207 |        |
| Middle Eastern or North African (n=203) | 5.246  | 7.241  | 7.948  | 8.632  | 2.804  | 3.609  | 3.321  | 4.391  |
| <0.0001                     |        |        | 0.0022 |        | 0.0009 |        | <0.0001|        |
P < 0.05), and white (n = 104; P < 0.0001) participants were also significantly more likely to pursue a career in neurosurgery after the webinar. In particular, medical students who identified as Asian and female (n = 100; P < 0.0001) or male (n = 39; P < 0.0001); Hispanic/Latina and female (n = 49; P < 0.01); and white and female (n = 71; P < 0.0001) or male (n = 33; P < 0.01) reported that they were more likely to pursue a career in neurosurgery after the webinar.

### The Importance of Social Media

Social media continued to be a driver of participation in the webinar series. The Instagram account (@lhhbrainterns) had 57 posts, 2130 followers, and 6241 likes as of April 11, 2022. The TikTok account (@lhhbrainterns) had 26 posts, 6997 followers, 881,752 views, and 156,700 likes as of April 11, 2022. The Facebook group “Lenox Hill Hospital BRAINterns” has 15,800 members and the YouTube channel, “BRAINterns Webinar Series” has 167 videos and 6150 subscribers. The BRAINterns social media presence is summarized in Table 6. Participants most commonly heard about the series through TikTok (n = 1251; 33%), Instagram (n = 1109; 29%), Facebook (n = 637; 17%), word of mouth (n = 708; 19%), and Twitter (n = 88; 2%). The distribution of participants’ ages and the methods by which participants heard about the webinar are summarized in Figure 2. The median age of participants who found the series through TikTok (20), Instagram (21), Facebook (22), word of mouth (23), and Twitter (21.5) are significantly different ($\chi^2 = 284.701; P < 0.00001$).

### DISCUSSION

#### Continued Interest in Web-Based Education

BRAINterns 1.0 was met with enthusiasm, shown by both the number of participants and their global distribution.4 As educational systems returned to in-person instruction, the durability of Web-based educational endeavors became uncertain. BRAINterns 2.0 was evaluated for potential insights into the durability of Web-based medical education.

BRAINterns 2.0 had 16,045 registrants and 3795 survey respondents (23.5% response rate), compared with BRAINterns 1.0, which had 16,484 registrants and 6675 survey respondents (40.5% response rate). There was only a 2.7% decrease in the number of registrants (16,484 to 16,045), despite the widespread shift back to in-person education. BRAINterns 2.0 continued to have representation from all 50 states, with more widespread international representation (102 countries this year vs. 87 countries previously). Interestingly, the majority of participants were new (66%) and did not participate in the initial series. These data likely reflect an intrinsic automatic annual renewal of students interested in pursuing careers in medicine but also confirm a persistent interest in web-based educational series that provide immediate and convenient access to a broad range of interested students. Although survey engagement decreased between BRAINterns 1.0 and 2.0, it is possible that students who had completed the course the previous year and received a certificate were less incentivized to complete the second survey. However, this finding may also reflect the intrinsic anonymity of Web-based education delivered freely, in which individuals can decide their own degree of engagement. Despite a lower survey response rate in the second rendition compared with the first, the racial and ethnic breakdowns as well as sex breakdowns were similar between both years, supporting the validity of survey responses across both years.

#### Webinar-Based Education Works to Enhance the Student Diversity Pipeline

The use of an open-access, free, Web-based platform for education allows for engagement and recruitment of students who may
Table 4. Self-rated Likelihood (1–10) of Pursuing a Career in Neurosurgery or the Physician Track by Sex, Yearly Household Income (U.S. $), Race or Ethnicity, and of Having a Family Member in Health Care Before and After the Webinar Series in a Cohort of High-School and College Students

|                                   | Likelihood of Pursuing a Career in Neurosurgery | Likelihood of Pursuing the Physician (M.D./D.O.) Track |
|-----------------------------------|-----------------------------------------------|-------------------------------------------------------|
|                                   | Before | After | Before | After | Before | After | Before | After | P value | Before | After | P value |
| Overall sex                       |        |       |        |       |        |       |        |       |         |        |       |         |
| Male (n = 491)                    | 5.243  | 6.866 | 7.751  | 8.546 |        |       |        |       | <0.0001 |        |       | <0.0001 |
| Female (n = 2332)                 | 4.949  | 6.711 | 7.562  | 8.332 |        |       |        |       | <0.0001 |        |       | <0.0001 |
| Annual household income           |        |       |        |       |        |       |        |       |         |        |       |         |
| USD15,000 (n = 211)               | 5.217  | 7.130 | 7.232  | 8.309 |        |       |        |       | <0.0001 |        |       | <0.0001 |
| USD15,000–29,999 (n = 245)        | 5.055  | 7.106 | 7.496  | 8.500 |        |       |        |       | <0.0001 |        |       | <0.0001 |
| USD30,000–49,999 (n = 237)        | 4.934  | 6.843 | 7.934  | 8.638 |        |       |        |       | <0.0001 |        | 0.0014 |
| USD50,000–74,999 (n = 251)        | 4.874  | 6.879 | 7.628  | 8.530 |        |       |        |       | <0.0001 |        | <0.0001 |
| USD75,000–99,999 (n = 230)        | 5.272  | 6.790 | 7.906  | 8.558 |        |       |        |       | <0.0001 |        | 0.0034 |
| USD100,000–150,000 (n = 351)      | 4.767  | 6.324 | 7.749  | 8.486 |        |       |        |       | <0.0001 |        | <0.0001 |
| USD>150,000 (n = 355)             | 5.084  | 6.688 | 7.902  | 8.542 |        |       |        |       | <0.0001 |        | 0.0004 |
| Race                              |        |       |        |       |        |       |        |       |         |        |       |         |
| White (n = 633)                   | 4.809  | 6.439 | 7.469  | 8.172 |        |       |        |       | <0.0001 |        | <0.0001 |
| Asian (n = 1200)                  | 4.978  | 6.710 | 7.543  | 8.297 |        |       |        |       | <0.0001 |        | <0.0001 |
| Black/African American (n = 196)  | 5.063  | 6.794 | 7.667  | 8.672 |        |       |        |       | <0.0001 |        | <0.0001 |
| Hispanic/Latino (n = 463)         | 5.164  | 7.100 | 7.783  | 8.351 | 0.0001 |       |        |       |        | 0.0001 |       |
| Another race or ethnicity (n = 72) | 5.478  | 7.435 | 7.029  | 8.072 |        |       |        |       | <0.0001 |        | 0.0294 |
| Middle Eastern or North African (n = 163) | 5.039 | 6.311 | 7.651  | 8.321 | <0.0001 |       |        |       | 0.0051 |       |
| Native Hawaiian or other Pacific Islander (n = 7) | 5.429 | 7.143 | 8.857  | 9.714 | 0.3031 |       |        |       | 0.2818 |       |
otherwise have limited opportunities for exposure into medical fields. A novel element of BRAINterns 2.0 was the week of specialized medical lectures produced in Spanish. There was a greater retention rate among white (35.1%; $P = 0.002$) and Hispanic/Latino students (38.1%; $P = 0.013$) between BRAINterns 1.0 and 2.0 compared with other racial/ethnic groups, as shown in Figure 3. This finding suggests that having content delivered in Spanish may have been a driving factor in retention among the Hispanic/Latino population. Observing demographic trends and responding with more specialized course content tailored to targeted populations may contribute to long-term program retention.

Our demographic data showed that women continue to be well represented (81.12% of all participants identified as female in BRAINterns 2.0, compared with 82.87% in BRAINterns 1.0). A second year of data with robust female participation underscores both webinar education and social media marketing as particularly effective tools in recruiting women into medical fields. These tools should be readily used when organizing recruitment efforts into fields in which women are underrepresented.

Because the medical school application process often begins several months to years before college graduation, the appropriate educational demographic to target would be high-school and college students.7 Our data show that webinar-based programming is an effective way to reach this particular educational demographic, because high-school and college students comprised most participants ($n = 958$ [25.44%] and $n = 1886$ [59.09%], respectively). Not only were these students well represented in our program but they further reported that their likelihood of pursuing the physician track significantly increased after program participation.

### Webinar-Based Education Facilitates Access to Medical Knowledge for Students Lacking Resources

Among high-school and college students with an interest in health care who reported no family members in health care, individuals identifying as Asian, black or African, Hispanic or Latino, Middle Eastern or North African, and white all reported a significantly higher average knowledge of both OR procedures and technology used in the OR after their participation in BRAINterns (Supplementary Table 2). This finding supports the ability of webinar education to mitigate inequities associated with lack of readily available connections to health care. Furthermore, increased self-reported competency scores showed improved confidence among students who completed the webinar series (Supplementary Table 3). Thus, BRAINterns 2.0 served as a method to close the confidence gap among women and minorities, which may encourage more diverse applications into medicine and surgical subspecialties such as neurosurgery.

Economic status can also pose a significant barrier to entry into medical fields.27 Many educational programs charge tuition fees, and courses with in-person instruction may be impractical to attend for those with summer jobs and household obligations. The option to participate in either the synchronous or asynchronous free course live on Zoom or on YouTube, respectively, mitigates both barriers. When analyzing trends among various self-reported household income levels, the likelihood of applying to medical school significantly increased across all income levels ($P < 0.01$). Although webinar-based educational courses are relatively inexpensive compared with an in-person course, these data may also suggest an opportunity for collaboration with industry for funding to continue the free distribution of information paramount to continuing to expand access to participants of limited financial resources.

### Social Media Are an Essential Tool for Webinar Participant Recruitment

Social media have transformed educational environments, with the COVID-19 pandemic and move to online platforms further accelerating this change. Use of social media is ubiquitous with sites such as TikTok and Instagram boasting more than 800 million and 1 billion monthly users, respectively.6 Our survey results showed that most participants heard of our program through some form of social media. The most frequently cited social media that facilitated BRAINterns publicity was TikTok (33.23%; $n = 1251$). This platform was followed by Instagram (29.46%; $n = 1109$), word of mouth (18.80%;

### Table 4. Continued

| Family member in health care | Likelihood of Pursuing a Career in Neurosurgery | Likelihood of Pursuing the Physician (M.D./D.O.) Track |
|-----------------------------|-----------------------------------------------|-----------------------------------------------------|
|                             | Before                                      | After                                      | Before                                      | After                                      |
|                             | $P$ value                                   | $P$ value                                   | $P$ value                                   | $P$ value                                   |
| Yes ($n = 1231$)             | 5.022                                       | 6.762                                       | 7.451                                       | 8.274                                       |
|                             | <0.0001                                     | <0.0001                                     | <0.0001                                     | <0.0001                                     |
| No ($n = 1613$)              | 4.969                                       | 6.704                                       | 7.769                                       | 8.485                                       |
|                             | <0.0001                                     | <0.0001                                     | <0.0001                                     | <0.0001                                     |
n = 708), and Facebook (16.95%; n = 638). Twitter was the least frequently cited source of social media publicity at 2.34% (n = 88). When choosing which social media platforms to consider using when publicizing programs, it is prudent to consider the age-group of the target audience. Studies conducted by Pew Research Center show that of these social media platforms, younger adults aged 18–29 years old more frequently use Instagram and TikTok. Data from Pew also highlight that social media use can vary by racial and ethnic demographic. Instagram is used by 52% of Hispanic and 49% of black Americans polled in their study, compared with 35% of white Americans. These trends can guide strategic use of social media in driving student recruitment into educational programs.

### Limitations

This study was conducted through the distribution of an optional exit survey. The demographic data that we gathered and analyzed are from survey responders, not from all participants in the webinar series, and, thus, may not be representative of the entire group because of potential survey response bias. Given the high number of survey responses, this effect is likely minimal. This study also relied on self-rated proficiency scores, which are subjective assessments susceptible to response bias. Respondents were told that the results would be anonymized before analysis, but concerns over anonymity may have limited negative responses. In addition, although participants were instructed to complete the exit survey only once, it is possible that they may have completed duplicate entries. To reduce confounding variables among survey respondents, a single survey that was written in English was distributed to all participants. It is possible that this strategy created a barrier for completion in Spanish-only-speaking participants who attended the week in Spanish.
CONCLUSIONS

Webinar-based education continues to play a role in education beyond the COVID-19 pandemic despite a significant return to in-person learning. Data from BRAINterns 2.0 suggest the durability of Web-based learning as a viable component of future medical education. Social media and the use of educational ambassadors are effective recruitment tools to improve visibility of educational programs across a diverse population of students. Medical educators should continue to use and modify these tools in a post-pandemic world to take advantage of the large impact and low-cost of Web-based modalities that can maintain long-term influence on the career decisions of a highly motivated population of diverse students.

CRediT AUTHORSHIP CONTRIBUTION STATEMENT

Amanda V. Immidissetti: Conceptualization, Investigation, Data curation, Formal analysis, Methodology, Writing — original draft. Ashley E. Rosenberg: Conceptualization, Investigation, Data curation, Formal analysis, Methodology, Writing — original draft. Joshua Katz: Conceptualization, Investigation, Data curation, Formal analysis, Methodology, Writing — original draft. Artur Shlifer: Conceptualization, Project administration, Resources, Writing — review & editing. Jason Ellis: Conceptualization, Investigation, Supervision, Methodology, Writing — review & editing. Rafael A. Ortiz: Conceptualization, Investigation, Supervision, Methodology, Writing — review & editing. John A. Boockvar: Conceptualization, Investigation, Supervision, Methodology, Writing — review & editing. Randy S. D’Amico: Conceptualization, Investigation, Supervision, Methodology, Writing — review & editing. David J. Langer: Conceptualization, Investigation, Supervision, Methodology, Writing — review & editing.

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Table 6. BRAINterns Social Media Presence During the First (2020) and Second Iterations (2021) of the Series

| Media Platform | Media Title | Primary Media Manager | Total Number of Subscribers/ Members | Total Number of Posts/ Messages Sent | Total Number of Reactions |
|---------------|-------------|-----------------------|-------------------------------------|-------------------------------------|--------------------------|
| Instagram (1) | lhhbrainterns |课代表 | 2130 followers | 57 posts | 6241 likes |
| TikTok (1) | lhhbrainterns | 课代表 | 6997 followers | 26 posts | 156,700 likes |
| Facebook (1) | Lenox Hill Hospital BRAINterns | 课代表 | 15,800 members | 50 posts | 6306 reactions |
| YouTube (1) | BRAINterns Webinar Series | 课代表 | 6150 subscribers | 167 posts | 118,760 views |
| Slack (2) | Lenox Hill Neurosurgery BRAINterns | 课代表 | 3491 members | 6127 messages | 1563 reactions |
| | BRAINterns Ambassadors | 课代表 | 433 members | 2453 messages | 1725 reactions |
| Web site (1) | www.brainterns.com | 课代表 | N/A | N/A | N/A |

Figure 2. Methods by which participants heard about BRAINterns 2.0 by age (****indicates significance P < 0.00001).

Figure 3. Percent of participants retained from the first iteration of BRAINterns or new to the program by race (*indicates significance P < 0.01, **indicates significance P < 0.001).
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**Supplementary Table 1. List of Survey Questions**

### Demographic Questions
1. Which country do you live in?
2. Which state do you reside in? Select “I do not live in the United States” if applicable.
3. In what year were you born?
4. What is your sex?
   - Male
   - Female
   - Prefer not to say
5. What is your gender identity?
   - Woman
   - Man
   - Genderqueer or non-binary
   - Agender
   - Trans male/trans man
   - Trans female/trans woman
   - Prefer not to say
   - Not specified above, please specify
6. What is your race or ethnicity?
   - Asian
   - Black or African American
   - Hispanic or Latino
   - Middle Eastern or North African
   - Multiracial or multiethnic
   - Native American or Alaska Native
   - Native Hawaiian or other Pacific Islander
   - White
   - Another race or ethnicity
7. What is your household’s yearly income in US dollars?
   - Under $15,000
   - Between $15,000 and $29,999
   - Between $30,000 and $49,999
   - Between $50,000 and $74,999
   - Between $75,000 and $99,999
   - Between $100,000 and $150,000
   - Over $150,000
   - Do not know
   - Prefer not to answer
8. What is the highest level of education that you completed?
   - Elementary school
   - Middle school
   - High school
   - College
   - Graduate school
   - Professional school
   - Doctorate
9. What phase of education/training are you currently in (for the 2020-2021 school year)?
   - Middle school
   - High school
   - College
   - Graduate school (Master’s/PhD)
   - Medical school (MD/DO/MD PhD)
   - Medical residency
   - Medical fellowship (completed medical school and medical residency)
   - Nursing school
   - PA school
   - Not currently enrolled in an academic program (working/non-traditional student)
   - None of the above
10. How did you hear about this course?
   - Instagram
   - Facebook
   - Word of mouth
   - Twitter
   - TikTok
   - University/college
   - Do not recall
   - Other
11. Did you watch any part of the Netflix special, “Lenox Hill”?
   - Yes
   - No
12. Did watching the Netflix special “Lenox Hill” influence you to enroll in the course?
   - Yes
   - No
   - Unsure
   - N/A, did not watch
13. Were you aware of this course prior to watching “Lenox Hill”?
   - Yes
   - No

Continues
| Supplementary Table 1. Continued |
|----------------------------------|
| c. Unsure                        |
| d. N/A, did not watch            |
| 14. Did watching “Lenox Hill” increase your interest in pursuing a healthcare profession? |
| a. Yes                           |
| b. No                            |
| c. Unsure                        |
| d. N/A, did not watch            |
| e. I do not intend on pursuing a healthcare profession |
| 15. Do you have a family member(s) who works in a healthcare profession? |
| a. Yes                           |
| b. No                            |
| 16. If yes, which best describes this role(s)? Please select all that apply |
| a. Physician (MD/DO)             |
| b. Advanced care practitioner (NP, PA) |
| c. Nurse                         |
| d. Hospital administration       |
| e. N/A, I do not have a family member in healthcare |
| f. Other (please specify)        |
| 17. What do you hope to gain from this course? Please select all that apply |
| a. Explore all healthcare fields (physician, nursing, physician assistant, hospital administration, etc.) |
| b. Explore the physician track in particular (MD/DO) |
| c. Explore neurosurgery in particular |
| d. Virtual OR shadowing          |
| e. Insight into how COVID-19 was managed in hospitals |
| f. Lectures from physicians      |
| g. Lectures from other healthcare workers (such as NPs, PAs, administrators, etc.) |
| h. Lectures from medical students |
| i. Opportunity to ask questions live |
| j. Lectures from women in the healthcare system |
| k. Lectures from people of color (POC) in the healthcare system |
| 18. How has COVID-19 impacted your education? Please select all that apply |
| a. Canceled or modified classes |
| b. Canceled or postponed standardized exams (SAT, GRE, MCAT, USMLE, etc.) |
| c. Canceled scientific meetings/conferences |
| d. Canceled shadowing            |
| e. Canceled volunteering opportunities |
| f. Canceled job/internship       |
| g. Canceled research opportunities |

For those who marked “currently enrolled in medical school” on item 9—please answer items 21-31, then proceed to item 32. For all others, please proceed directly to item 32.

Demographic questions specific to medical students:

| Supplementary Table 1. Continued |
|----------------------------------|
| h. Canceled study abroad         |
| i. Delayed graduation date       |
| j. Delayed application to college or professional school |
| k. Postponed or modified rotations in medical school |
| l. Canceled away rotations in medical school |
| m. Difficulty obtaining letters of recommendation |
| n. Canceled or modified residency interviews |
| o. Canceled in-school enrichment activities (lunch lectures, student club meetings, etc.) |
| p. Less face to face time with faculty |
| q. N/A, I am not enrolled in an academic program |
| 19. Which educational enrichments activities were you able to participate in during the COVID-19 pandemic? Please select all that apply |
| a. In-person lectures/classes    |
| b. Online lectures/webinars      |
| c. Independent study             |
| d. Remote research (chart review, meta analysis, systemic reviews, etc.) |
| e. COVID-related volunteering (such as equipment collection efforts) |
| f. Telemedicine initiatives      |
| g. Summer/gap year job or internship |
| h. In-person Clinical Experiences (Shadowing, volunteering, scribing) |
| i. Other                        |
| 20. Which platforms have you used while learning from home? Please select all that apply |
| a. Video conference (Zoom, WebEx, Skype, Facetime, etc.) |
| b. Pre-recorded lectures provided by your school |
| c. YouTube                      |
| d. Instagram                    |
| e. Facebook                     |
| f. Twitter                      |
| g. Microsoft Teams              |
| h. Other                        |

For those who marked “currently enrolled in medical school” on item 9—please answer items 21-31, then proceed to item 32. For all others, please proceed directly to item 32.

PA, physician assistant; NP, nurse practitioner; N/A, not available; MS, medical school; OR, operating room; ACP, advanced care practitioner.

Continues
### Supplementary Table 1. Continued

|   |   |   |   |   |   |   |   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **23.** Do you plan to take a research year? |   |   |   |   |   |   |   |   |   |   |   |   |   |
| a. Yes |   |   |   |   |   |   |   |   |   |   |   |   |   |
| b. No  |   |   |   |   |   |   |   |   |   |   |   |   |   |
| c. Unsure  |   |   |   |   |   |   |   |   |   |   |   |   |   |
| d. In progress  |   |   |   |   |   |   |   |   |   |   |   |   |   |
| **24.** Have you completed an internal medicine clerkship? |   |   |   |   |   |   |   |   |   |   |   |   |   |
| a. Yes |   |   |   |   |   |   |   |   |   |   |   |   |   |
| b. No  |   |   |   |   |   |   |   |   |   |   |   |   |   |
| c. In progress  |   |   |   |   |   |   |   |   |   |   |   |   |   |
| **25.** Have you completed a general surgery clerkship? |   |   |   |   |   |   |   |   |   |   |   |   |   |
| a. Yes |   |   |   |   |   |   |   |   |   |   |   |   |   |
| b. No  |   |   |   |   |   |   |   |   |   |   |   |   |   |
| c. In progress  |   |   |   |   |   |   |   |   |   |   |   |   |   |
| **26.** Have you completed a neurology clerkship? |   |   |   |   |   |   |   |   |   |   |   |   |   |
| a. Yes |   |   |   |   |   |   |   |   |   |   |   |   |   |
| b. No  |   |   |   |   |   |   |   |   |   |   |   |   |   |
| c. In progress  |   |   |   |   |   |   |   |   |   |   |   |   |   |
| **27.** Have you completed a neurosurgery elective? |   |   |   |   |   |   |   |   |   |   |   |   |   |
| a. Yes |   |   |   |   |   |   |   |   |   |   |   |   |   |
| b. No  |   |   |   |   |   |   |   |   |   |   |   |   |   |
| c. In progress  |   |   |   |   |   |   |   |   |   |   |   |   |   |
| **28.** Do you plan to complete a neurosurgery sub-internship? |   |   |   |   |   |   |   |   |   |   |   |   |   |
| a. Yes |   |   |   |   |   |   |   |   |   |   |   |   |   |
| b. No  |   |   |   |   |   |   |   |   |   |   |   |   |   |
| c. In progress  |   |   |   |   |   |   |   |   |   |   |   |   |   |
| **29.** Have you completed a scrub training session? |   |   |   |   |   |   |   |   |   |   |   |   |   |
| a. Yes |   |   |   |   |   |   |   |   |   |   |   |   |   |
| b. No  |   |   |   |   |   |   |   |   |   |   |   |   |   |
| c. In progress  |   |   |   |   |   |   |   |   |   |   |   |   |   |
| **30.** To what extent have you identified your field(s) of interest for residency applications? |   |   |   |   |   |   |   |   |   |   |   |   |   |
| a. Only considering 1 field |   |   |   |   |   |   |   |   |   |   |   |   |   |
| b. Considering 2-5 fields |   |   |   |   |   |   |   |   |   |   |   |   |   |
| c. Considering 6 or more fields |   |   |   |   |   |   |   |   |   |   |   |   |   |
| **31.** What areas do you seek improvement in? Please mark your top five (5) choices |   |   |   |   |   |   |   |   |   |   |   |   |   |
| a. General background on internal medicine concepts |   |   |   |   |   |   |   |   |   |   |   |   |   |
| b. Subspecialty knowledge not covered in core curricula |   |   |   |   |   |   |   |   |   |   |   |   |   |
| c. General surgical etiquette |   |   |   |   |   |   |   |   |   |   |   |   |   |
| d. Suturing skills |   |   |   |   |   |   |   |   |   |   |   |   |   |
| **32.** Do you have concerns that COVID-19 negatively impacted your medical education? |   |   |   |   |   |   |   |   |   |   |   |   |   |
| a. Extremely concerned |   |   |   |   |   |   |   |   |   |   |   |   |   |
| b. Very concerned |   |   |   |   |   |   |   |   |   |   |   |   |   |
| c. Somewhat concerned |   |   |   |   |   |   |   |   |   |   |   |   |   |
| d. Very slightly concerned |   |   |   |   |   |   |   |   |   |   |   |   |   |
| e. Not at all concerned |   |   |   |   |   |   |   |   |   |   |   |   |   |
| **33.** I am concerned that COVID-19 negatively impacted my medical education |   |   |   |   |   |   |   |   |   |   |   |   |   |
| a. Strongly agree |   |   |   |   |   |   |   |   |   |   |   |   |   |
| b. Agree |   |   |   |   |   |   |   |   |   |   |   |   |   |
| c. Neutral |   |   |   |   |   |   |   |   |   |   |   |   |   |
| d. Disagree |   |   |   |   |   |   |   |   |   |   |   |   |   |
| e. Strongly disagree |   |   |   |   |   |   |   |   |   |   |   |   |   |

Items 34-45 will have answer choices presented on a 10-point Likert-type scale with an "N/A" option.

|   |   |   |   |   |   |   |   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **34.** Likelihood of pursuing a track in healthcare before webinar? |   |   |   |   |   |   |   |   |   |   |   |   |   |
| **35.** Likelihood of pursuing a track in healthcare after webinar? |   |   |   |   |   |   |   |   |   |   |   |   |   |
| **36.** Likelihood of pursuing a career in neurosurgery before webinar? |   |   |   |   |   |   |   |   |   |   |   |   |   |
| **37.** Likelihood of pursuing a career in neurosurgery after webinar? |   |   |   |   |   |   |   |   |   |   |   |   |   |
| **38.** Likelihood of pursuing the physician track (MD/DO) before webinar? |   |   |   |   |   |   |   |   |   |   |   |   |   |
| **39.** Likelihood of pursuing the physician track (MD/DO) after webinar? |   |   |   |   |   |   |   |   |   |   |   |   |   |
| **40.** Likelihood of pursuing the NP track before webinar? |   |   |   |   |   |   |   |   |   |   |   |   |   |
| **41.** Likelihood of pursuing the NP track after webinar? |   |   |   |   |   |   |   |   |   |   |   |   |   |
| **42.** Likelihood of pursuing the PA track before webinar? |   |   |   |   |   |   |   |   |   |   |   |   |   |
| **43.** Likelihood of pursuing the PA track after webinar? |   |   |   |   |   |   |   |   |   |   |   |   |   |
| **44.** Likelihood of working in hospital administration before webinar? |   |   |   |   |   |   |   |   |   |   |   |   |   |
| **45.** Likelihood of working in hospital administration after webinar? |   |   |   |   |   |   |   |   |   |   |   |   |   |

Items 46-83 will have answer choices presented on a 10-point Likert-type scale.

|   |   |   |   |   |   |   |   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **46.** Knowledge of cranial anatomy before webinar? |   |   |   |   |   |   |   |   |   |   |   |   |   |
| **47.** Knowledge of cranial anatomy after webinar? |   |   |   |   |   |   |   |   |   |   |   |   |   |

Continues...
### Supplementary Table 1. Continued

| Number | Description                                                                                   |
|--------|-----------------------------------------------------------------------------------------------|
| 48.    | Knowledge of spine anatomy before webinar?                                                    |
| 49.    | Knowledge of spine anatomy after webinar?                                                     |
| 50.    | Knowledge of intracranial trauma before webinar?                                               |
| 51.    | Knowledge of intracranial trauma after webinar?                                                |
| 52.    | Knowledge of intracranial congenital defects before webinar?                                  |
| 53.    | Knowledge of intracranial congenital defects after webinar?                                   |
| 54.    | Knowledge of brain tumors before webinar?                                                     |
| 55.    | Knowledge of brain tumors after webinar?                                                      |
| 56.    | Knowledge of epilepsy before webinar?                                                         |
| 57.    | Knowledge of epilepsy after webinar?                                                          |
| 58.    | Knowledge of cerebrovascular events/stroke before webinar?                                    |
| 59.    | Knowledge of cerebrovascular events/stroke after webinar?                                     |
| 60.    | Knowledge of spine trauma before webinar?                                                     |
| 61.    | Knowledge of spine trauma after webinar?                                                      |
| 62.    | Knowledge of congenital spine defects before webinar?                                         |
| 63.    | Knowledge of congenital spine defects after webinar?                                          |
| 64.    | Knowledge of spine malignancy before webinar?                                                 |
| 65.    | Knowledge of spine malignancy after webinar?                                                   |
| 66.    | Knowledge of degenerative disease of the spine before webinar?                                |
| 67.    | Knowledge of degenerative disease of the spine after webinar?                                 |
| 68.    | Knowledge of technology used in the OR before webinar?                                        |
| 69.    | Knowledge of technology used in the OR after webinar?                                         |
| 70.    | Knowledge of OR procedures before the webinar?                                                |
| 71.    | Knowledge of OR procedures after the webinar?                                                 |
| 72.    | Overall knowledge of neurosurgery before the webinar?                                        |
| 73.    | Overall knowledge of neurosurgery after the webinar?                                          |
| 74.    | Overall knowledge of neurology before the webinar?                                           |
| 75.    | Overall knowledge of neurology after the webinar?                                            |
| 76.    | Overall knowledge of cardiology before the webinar?                                          |
| 77.    | Overall knowledge of cardiology after the webinar?                                           |
| 78.    | Ability to interpret diagnostic imaging of the brain before the webinar?                     |
| 79.    | Ability to interpret diagnostic imaging of the brain after the webinar?                       |
| 80.    | Understanding of the postgraduate medical education (residency & fellowship) before the webinar? |
| 81.    | Understanding of the postgraduate medical education (residency & fellowship) after the webinar?|
| 82.    | If pursuing the physician track, how likely were you to apply to neurosurgical residency before the webinar? (If not applicable leave question blank) |
| 83.    | If pursuing the physician track, how likely were you to apply to neurosurgical residency after the webinar? (If not applicable leave question blank) |

### Supplementary Table 1. Continued

84. What do you see as challenges to pursuing neurosurgery? Please select all that apply

- a. Board exam scores
- b. Length of training
- c. Possibility of taking a research year
- d. Publication volume
- e. Lifestyle
- f. Obtaining mentorship
- g. Fewer available spots
- h. Technical difficulty of neurosurgery
- i. Incorporation of new technology into the field
- j. None of the above

Items 45-94 will have answer choices presented on a 5-point Likert-type scale

1) Agree, 2) Somewhat agree, 3) Neither agree nor disagree, 4) Somewhat disagree, 5) Disagree

85. The course provided me with a comprehensive background on healthcare fields

86. The course provided me with a comprehensive background on the role of physicians in the healthcare system

87. This course provided me with a better understanding of the role of ACPs (PAs/NPs) in the healthcare system

88. This course provided me with a better understanding of neurosurgery

89. This course provided me with a better understanding of cardiology

90. This course provided me with a better understanding of neurology

91. This course helped me review science concepts that were already covered in school

92. This course introduced me to new science concepts that were not yet covered in school

93. This course was a good use of my time in a remote learning environment

94. This course helped me replace some of the learning opportunities that were made unavailable due to COVID-19

95. The components of this course that best prepared me for a career in healthcare were: (check all that apply)

- a. Neurosurgery subspecialty lectures (neuroradiology, neuromonitoring/neurophysiology)
- b. Neurology lectures
- c. Medical school prep
- d. Virtual neuro-oncology OR
- e. Cardiology lectures
- f. ACP Corner presented by NPs/PAs
- g. Virtual spine OR
- h. Administration station presented by hospital administrators
- i. Virtual cerebrovascular OR

PA, physician assistant; NP, nurse practitioner; N/A, not available; MS, medical school; OR, operating room; ACP, advanced care practitioner.
96. The components of this course that did not directly prepare me for a career in healthcare were: (check all that apply)

- a. Neurosurgery subspecialty lectures (neuroradiology, neuromonitoring/neurophysiology)
- b. Neurology lectures
- c. Medical school prep
- d. Virtual neuro-oncology OR
- e. Cardiology lectures
- f. ACP Corner presented by NPs/PAs
- g. Virtual spine OR
- h. Administration station presented by hospital administrators
- i. Virtual cerebrovascular OR
- j. Innovation, research, and entrepreneurship discussions
- k. Chairman’s Corner presented by Dr. Langer
- l. Special summer series
- m. Women in medicine lectures
- n. Diversity in medicine lectures
- o. Neurosurgery research lectures
- p. N/A, do not plan to pursue healthcare

97. How likely are you to recommend the webinar series to a friend?
- a. Very likely
- b. Likely
- c. Neither likely nor unlikely
- d. Unlikely
- e. Very unlikely

98. Please let us know if you have any suggestions for materials to include in future sessions (type answers into the box below)

99. Approximately what percentage of classes did you attend in total (live on Zoom or on YouTube)?

100. What percentage of the classes that you attended were live on Zoom?

101. What percentage of the classes that you attended were on YouTube?
### Supplementary Table 2. Prewebinar and Postwebinar Series Average Self-Rated Competency Scores for Overall Knowledge of Neurosurgery, Technology Used in the Operating Room and Operating Room Procedures Stratified by Sex, Household Income (U.S. $/year), Current Phase of Education, Race, and of Having Family Member in Health Care

|                          | Overall Knowledge of Neurosurgery | Knowledge of Technology Used in the OR | Knowledge of OR Procedures |
|--------------------------|----------------------------------|---------------------------------------|---------------------------|
|                          | Before n=3483                   | Before n=3483                          | Before n=3483              |
|                          | 3.795               | 7.047                          | 3.567                   | 6.735                |
| **P**                   | <0.0001             | <0.0001                        | <0.0001                   | <0.0001              |
| Sex                     | Male n=640            | Male n=640                        | Male n=640                |
|                          | 3.909               | 6.914                          | 3.795                   | 6.769                |
| **P**                   | <0.0001             | <0.0001                        | <0.0001                   | <0.0001              |
|                          | Female n=2843         | Female n=2843                     | Female n=2843             |
|                          | 3.769               | 7.077                          | 3.515                   | 6.727                |
| **P**                   | <0.0001             | <0.0001                        | <0.0001                   | <0.0001              |
| Household income (U.S. $/year) |                          |                                       |                          |
| 15,000—29,999 n=329     | 4.015               | 7.480                          | 3.714                   | 7.046                |
| **P**                   | <0.0001             | <0.0001                        | <0.0001                   | <0.0001              |
| 30,000—49,999 n=314     | 4.070               | 7.366                          | 3.809                   | 7.035                |
| **P**                   | <0.0001             | <0.0001                        | <0.0001                   | <0.0001              |
| 50,000—74,999 n=333     | 3.859               | 7.045                          | 3.592                   | 6.709                |
| **P**                   | <0.0001             | <0.0001                        | <0.0001                   | <0.0001              |
| 75,000—99,999 n=263     | 3.692               | 7.004                          | 3.551                   | 6.665                |
| **P**                   | <0.0001             | <0.0001                        | <0.0001                   | <0.0001              |
| 100,000—150,000 n=403   | 3.538               | 6.670                          | 3.407                   | 6.479                |
| **P**                   | <0.0001             | <0.0001                        | <0.0001                   | <0.0001              |
| >150,000 n=372          | 3.468               | 6.640                          | 3.202                   | 6.355                |
| **P**                   | <0.0001             | <0.0001                        | <0.0001                   | <0.0001              |
| Race                    | White n=827         | White n=827                      | White n=827              |
|                          | 3.924               | 6.989                          | 3.610                   | 6.607                |
| **P**                   | <0.0001             | <0.0001                        | <0.0001                   | <0.0001              |
|                          | Asian n=1390         | Asian n=1390                     | Asian n=1390             |
|                          | 3.560               | 6.815                          | 3.474                   | 6.592                |
| **P**                   | <0.0001             | <0.0001                        | <0.0001                   | <0.0001              |
|                          | Black/African American n=239 | Black/African American n=239  | Black/African American n=239  |
|                          | 4.004               | 7.438                          | 3.713                   | 7.025                |
| **P**                   | <0.0001             | <0.0001                        | <0.0001                   | <0.0001              |
|                          | Hispanic/Latino n=578 | Hispanic/Latino n=578          | Hispanic/Latino n=578    |
|                          | 4.122               | 7.468                          | 3.736                   | 7.190                |
| **P**                   | <0.0001             | <0.0001                        | <0.0001                   | <0.0001              |
|                          | Other race or ethnicity n=100 | Other race or ethnicity n=100 | Other race or ethnicity n=100 |
|                          | 4.060               | 7.620                          | 3.660                   | 7.010                |
| **P**                   | <0.0001             | <0.0001                        | <0.0001                   | <0.0001              |

OR, operating room.
### Supplementary Table 2. Continued

|                                             | Overall Knowledge of Neurosurgery | Knowledge of Technology Used in the OR | Knowledge of OR Procedures |
|---------------------------------------------|-----------------------------------|----------------------------------------|-----------------------------|
|                                             | Before  | After | Before  | After | Before  | After |
|                                             |       |       |       |       |       |       |
| Middle Eastern or North African (n = 197)   | 3.747  | 7.086 | 3.828  | 6.929 | 3.601  | 6.727 |
|                                             | <0.0001 |       | <0.0001 |       | <0.0001 |       |
| Native American or Alaska Native (n = 3)   | 6.333  | 10    | 6.333  | 9     | 6.333  | 9.333 |
|                                             | 0.1194 | 0.3035 |       |       | 0.2028 |       |
| Native Hawaiian or other Pacific Islander (n = 12) | 4.083  | 4.417 | 4.250  | 7.250 | 4.583  | 7.000 |
|                                             | 0.7355 | 0.0233 |       |       | 0.0239 |       |
| Multiracial or multiethnic (n = 137)       | 3.482  | 6.737 | 3.321  | 6.380 | 3.409  | 6.453 |
|                                             | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 |
| Family member in health care                 |        |       |        |       |        |       |
| Yes (n = 1527)                              | 3.910  | 7.080 | 3.750  | 6.830 | 3.920  | 6.840 |
|                                             | <0.0001 |       | <0.0001 |       | <0.0001 |       |
| No (n = 1979)                               | 3.700  | 7.020 | 3.420  | 6.650 | 3.570  | 6.740 |
|                                             | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 |
| Current phase of education                   |        |       |        |       |        |       |
| Middle school (n = 18)                      | 4.611  | 7.278 | 3.333  | 6.056 | 4.389  | 6.889 |
|                                             | 0.0066 | 0.0035 |       |       | 0.0064 |       |
| High school (n = 894)                       | 3.485  | 6.889 | 3.305  | 6.573 | 3.432  | 6.625 |
|                                             | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 |
| College (n = 1751)                          | 3.646  | 6.933 | 3.467  | 6.649 | 3.589  | 6.702 |
|                                             | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 |
| Graduate school (Master’s/Ph.D.) (n = 108)  | 4.380  | 7.361 | 3.898  | 7.194 | 4.130  | 7.093 |
|                                             | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 |
| Medical school (M.D./D.O./M.D.Ph.D.) (n = 360) | 4.992  | 7.800 | 4.481  | 7.467 | 4.794  | 7.497 |
|                                             | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 |
| Medical residency (n = 14)                   | 6.571  | 8.786 | 5.500  | 8.071 | 6.929  | 8.857 |
|                                             | 0.0014 | 0.013 |         |       | 0.0233 |       |
| Medical fellowship (n = 6)                  | 3.333  | 8.333 | 5.000  | 9.000 | 3.833  | 7.500 |
|                                             | 0.0036 | 0.0052 |         |       | 0.0196 |       |
| Nursing school (n = 27)                     | 3.963  | 7.370 | 3.556  | 7.000 | 3.889  | 7.074 |
|                                             | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 |
| Physician assistant school (n = 8)          | 4.000  | 6.250 | 3.500  | 7.125 | 3.500  | 6.250 |
|                                             | 0.0313 | 0.003 |         |       | 0.0339 |       |
| Not currently enrolled in academic program (n = 245) | 3.718  | 6.988 | 3.482  | 6.506 | 3.620  | 6.600 |
|                                             | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 |

OR, operating room.
### Supplementary Table 3. Prewebinar and Postwebinar Series Average Self-Rated Competency Scores for Ability to Interpret Diagnostic Imaging, Knowledge of Cranial and Spinal Anatomy, Cerebrovascular Events/Stroke, Spine Trauma, and Brain Tumors Stratified by Sex, Household Income (U.S. $/year), Current Phase of Education, Race, and of Having Family Member in Health Care

|                                | Average ability to interpret diagnostic imaging | Average knowledge of cranial anatomy | Average knowledge of spine anatomy | Average knowledge of cerebrovascular events/stroke | Average knowledge of spine trauma | Average knowledge of brain tumors |
|--------------------------------|------------------------------------------------|-------------------------------------|-----------------------------------|---------------------------------------------------|---------------------------------|---------------------------------|
|                                | Before After | Before After | Before After | Before After | Before After | Before After | Before After | Before After | Before After | Before After | Before After |
| **Overall (n = 3483)**         | 3.113  5.848 | 3.989  6.618 | 3.862  6.461 | 3.931  6.436 | 3.393  6.032 | 3.920  6.763 |
| **P value**                    | <0.0001   | <0.0001   | <0.0001   | <0.0001   | <0.0001   | <0.0001   |

#### Sex

| **Male (n = 640)**             | 3.481  6.047 | 4.217  6.066 | 4.186  6.569 | 4.114  6.467 | 3.597  6.073 | 3.936  6.633 |
| **P value**                    | <0.0001   | <0.0001   | <0.0001   | <0.0001   | <0.0001   | <0.0001   |

| **Female (n = 2843)**          | 3.031  5.803 | 3.937  6.620 | 3.789  6.437 | 3.890  6.429 | 3.348  6.023 | 3.917  6.792 |
| **P value**                    | <0.0001   | <0.0001   | <0.0001   | <0.0001   | <0.0001   | <0.0001   |

#### Annual household income

| **<$USD15,000 (n = 325)**     | 3.609  6.631 | 4.563  7.314 | 4.502  7.126 | 4.548  7.182 | 4.040  6.877 | 4.502  7.471 |
| **P value**                    | <0.0001   | <0.0001   | <0.0001   | <0.0001   | <0.0001   | <0.0001   |

| **USD15,000—29,999 (n = 329)** | 3.337  6.109 | 4.322  7.091 | 4.140  6.909 | 4.304  6.909 | 3.693  6.495 | 4.167  7.512 |
| **P value**                    | <0.0001   | <0.0001   | <0.0001   | <0.0001   | <0.0001   | <0.0001   |

| **USD30,000—49,999 (n = 314)** | 3.609  6.631 | 4.338  6.946 | 4.137  6.850 | 4.162  6.931 | 3.611  6.366 | 4.156  7.038 |
| **P value**                    | <0.0001   | <0.0001   | <0.0001   | <0.0001   | <0.0001   | <0.0001   |

| **USD50,000—74,999 (n = 333)** | 3.093  5.868 | 3.976  6.673 | 3.805  6.538 | 3.898  6.486 | 3.375  6.033 | 3.820  6.736 |
| **P value**                    | <0.0001   | <0.0001   | <0.0001   | <0.0001   | <0.0001   | <0.0001   |

| **USD75,000—99,999 (n = 263)** | 3.019  5.764 | 3.822  6.426 | 3.821  6.243 | 3.833  6.354 | 3.255  5.894 | 3.753  6.544 |
| **P value**                    | <0.0001   | <0.0001   | <0.0001   | <0.0001   | <0.0001   | <0.0001   |

| **USD100,000—150,000 (n = 403)** | 2.814  5.444 | 3.747  6.280 | 3.618  6.092 | 3.615  6.052 | 3.074  5.648 | 3.630  6.385 |
| **P value**                    | <0.0001   | <0.0001   | <0.0001   | <0.0001   | <0.0001   | <0.0001   |

| **>$USD150,000 (n = 372)**     | 2.763  5.314 | 3.462  6.051 | 3.247  5.817 | 3.457  5.809 | 2.933  5.392 | 3.530  6.360 |
| **P value**                    | <0.0001   | <0.0001   | <0.0001   | <0.0001   | <0.0001   | <0.0001   |

#### Current phase of education

| **Middle school (n = 18)**    | 3.278  4.833 | 3.333  5.333 | 3.333  5.167 | 3.500  6.111 | 3.000  4.833 | 5.111  6.667 |
| **P value**                   | 0.1256    | 0.0337    | 0.0514    | 0.0051    | 0.0631    | 0.1042   |

Continues
## Supplementary Table 3. Continued

|                     | Average ability to interpret diagnostic imaging | Average knowledge of cranial anatomy | Average knowledge of spine anatomy | Average knowledge of cerebrovascular events/stroke | Average knowledge of spine trauma | Average knowledge of brain tumors |
|---------------------|-----------------------------------------------|------------------------------------|-----------------------------------|--------------------------------------------------|---------------------------------|-------------------------------|
|                     | **Before** | **After** | **Before** | **After** | **Before** | **After** | **Before** | **After** | **Before** | **After** | **Before** | **After** | **Before** | **After** |
| High school (n = 894) | 2.522    | 5.379    | 3.060    | 5.984    | 2.911    | 5.903    | 2.774    | 5.531    | 3.852    | 6.651    |
|                     | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  |
| College (n = 1751)  | 3.003    | 5.797    | 3.905    | 6.559    | 3.745    | 6.356    | 3.755    | 6.335    | 3.248    | 5.954    | 3.691    | 6.577    |
|                     | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  |
| Graduate school (Masters/PhD) (n = 108) | 3.759    | 6.463    | 4.704    | 7.333    | 4.667    | 7.185    | 4.583    | 6.981    | 3.907    | 6.463    | 2.522    | 5.379    |
|                     | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  |
| Medical school (MD/DD/MDPhD) (n = 360) | 4.750    | 7.131    | 6.039    | 8.047    | 6.039    | 7.925    | 5.850    | 7.819    | 5.233    | 7.356    | 5.328    | 7.744    |
|                     | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  |
| Medical residency (n = 14) | 6.857    | 8.500    | 7.143    | 8.929    | 7.214    | 8.929    | 6.786    | 8.786    | 6.286    | 8.357    | 6.143    | 8.500    |
|                     | 0.0418   | 0.0116   | 0.0100   | 0.0035   | 0.0084   | 0.0034   |
| Medical fellowship (n = 6) | 4.167    | 7.667    | 5.000    | 8.333    | 3.667    | 8.333    | 4.333    | 7.000    | 5.667    | 8.000    | 3.667    | 8.667    |
|                     | 0.0307   | 0.0788   | 0.0044   | 0.1449   | 0.1612   | 0.0222   |
| Nursing school (n = 27) | 2.778    | 5.593    | 4.074    | 6.704    | 4.037    | 6.593    | 4.222    | 6.778    | 3.111    | 6.037    | 3.963    | 6.852    |
|                     | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  |
| Physician assistant School (n = 8) | 3.000    | 4.875    | 4.250    | 6.500    | 3.625    | 6.750    | 4.375    | 7.000    | 3.500    | 6.250    | 4.125    | 7.125    |
|                     | 0.0596   | 0.0004   | 0.0002   | 0.0037   | 0.0252   | <0.0001  |
| Not currently enrolled in academic program (n = 245) | 2.984    | 5.604    | 4.327    | 6.706    | 4.302    | 6.706    | 4.159    | 6.522    | 3.441    | 5.935    | 3.816    | 6.547    |
|                     | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  |
| Race                |                      |                      |                      |                      |                      |                      |                      |                      |                      |                      |
| White (n = 827)     | 3.232    | 5.746    | 4.261    | 6.571    | 4.112    | 6.355    | 4.141    | 6.355    | 3.511    | 5.777    | 4.007    | 6.583    |
|                     | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  |
| Asian (n = 1390)    | 2.984    | 5.685    | 3.716    | 6.425    | 3.648    | 6.287    | 3.670    | 6.212    | 3.224    | 5.880    | 3.709    | 6.608    |
|                     | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  |
| Black/African American (n = 239) | 3.271    | 6.121    | 3.942    | 6.821    | 3.788    | 6.667    | 4.138    | 6.966    | 3.467    | 6.350    | 4.113    | 7.179    |
|                     | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  | <0.0001  |
| Category                                      | n  | Mean | Median | 25th | 50th | 75th | Mean | Median | 25th | 50th | 75th | Mean | Median | 25th | 50th | 75th |
|----------------------------------------------|----|------|--------|------|------|------|------|--------|------|------|------|------|--------|------|------|------|------|
| Hispanic/Latino (n = 578)                    |    | 3.250| 6.307  | 4.279| 7.088| 4.109| 4.210| 6.914  | 4.260| 6.910| 3.630| 6.616| 4.188  | 7.176|
|                                              |    | <0.0001| <0.0001| <0.0001| <0.0001| <0.0001| <0.0001| <0.0001| <0.0001|
| Another race or ethnicity (n = 100)          |    | 3.590| 6.380  | 4.230| 6.850| 4.990| 6.900| 4.260  | 6.910| 3.630| 6.320| 4.510| 7.470  |
|                                              |    | <0.0001| <0.0001| <0.0001| <0.0001| <0.0001| <0.0001| <0.0001| <0.0001|
| Middle Eastern or North African (n = 197)    |    | 3.040| 5.904  | 3.970| 6.561| 3.692| 6.389| 3.687  | 6.288| 3.409| 6.131| 3.788| 6.758  |
|                                              |    | <0.0001| <0.0001| <0.0001| <0.0001| <0.0001| <0.0001| <0.0001| <0.0001|
| Native American or Alaska Native (n = 3)     |    | 5.333| 9.000  | 6.333| 9.333| 5.333| 9.333| 7.333  | 8.333| 6.667| 8.000| 6.333| 10.000 |
|                                              |    | 0.2318| 0.2595 | 0.0058| 0.6745| 0.5615| 0.1194|
| Native Hawaiian or other Pacific Islander (n = 12) |    | 4.250| 6.250  | 5.500| 7.250| 4.867| 7.417| 5.500  | 7.583| 3.667| 6.667| 6.000| 8.000  |
|                                              |    | 0.0637| 0.0932 | 0.0133| 0.0383| 0.0072| 0.0511|
| Family Member in Healthcare                  |    |      |        |      |      |      |      |        |      |      |      |      |        |      |      |      |
| Yes (n = 1527)                               |    | 3.220| 5.910  | 4.080| 6.660| 3.970| 6.520| 4.050  | 6.540| 3.500| 6.080| 4.000| 6.820  |
|                                              |    | <0.0001| <0.0001| <0.0001| <0.0001| <0.0001| <0.0001| <0.0001| <0.0001|
| No (n = 1979)                                |    | 3.040| 5.800  | 3.910| 6.580| 3.770| 6.410| 3.840  | 6.360| 3.310| 5.990| 3.850| 6.720  |
|                                              |    | <0.0001| <0.0001| <0.0001| <0.0001| <0.0001| <0.0001| <0.0001| <0.0001|