COVID-19 Exposure During Neurology Practice

Results of American Academy of Neurology Survey

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Background: To determine the exposure risk for coronavirus 2019 (COVID-19) during neurology practice. Neurological manifestations of COVID-19 are increasingly being recognized mandating high level of participation by neurologists.

Methods: An American Academy of Neurology survey inquiring about various aspects of COVID-19 exposure was sent to a random sample of 800 active American Academy of Neurology members who work in the United States. Use of second tier protection (1 or more including sterile gloves, surgical gown, protective goggles/face shield but not N95 mask) or maximum protection (N95 mask in addition to second tier protection) during clinical encounter with suspected/confirmed COVID-19 patients was inquired.

Results: Of the 81 respondents, 38% indicated exposure to COVID-19 at work, 1% at home, and none outside of work/home. Of the 28 respondents who experienced at least 1 symptom of COVID-19, 32% or diarrhea (8%) were reported. One respondent tested positive out of 12 (17%) of respondents who were tested for COVID-19 within the last 2 weeks. One respondent received health care at an emergency department/urgent care or was hospitalized related to COVID-19. When seeing patients, maximum protection personal protective equipment was used either always or most of the times by 16% of respondents in outpatient setting and 56% of respondents in inpatient settings, respectively.

Conclusions: The data could enhance our knowledge of the factors that contribute to COVID-19 exposure during neurology practice in United States, and inform education and advocacy efforts to neurology providers, trainees, and patients in this unprecedented pandemic.

Key Words: survey, neurology, coronavirus 2019, exposure, neurologists, questionnaire

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Background: COVID-19 has had a significant impact on healthcare environments, particularly in neurology settings. The American Academy of Neurology (AAN) conducted a survey to assess exposure to COVID-19 during neurology practice. The survey was sent to a random sample of 800 active AAN members who work in the United States.

Methods: The survey inquired about various aspects of COVID-19 exposure, including the use of personal protective equipment (PPE) such as second-tier protection (including sterile gloves, surgical gown, protective goggles/face shield but not N95 mask) or maximum protection (N95 mask in addition to second-tier protection) during clinical encounters with suspected or confirmed COVID-19 patients.

Results: Of the 81 respondents, 38% indicated exposure to COVID-19 at work, and 1% at home, with none outside of work/home. Of the 28 respondents who experienced at least one symptom of COVID-19, 32% reported fever or fatigue, while 8% reported diarrhea. One respondent tested positive for COVID-19 within the last 2 weeks. When seeing patients, maximum protection PPE was used either always or most of the time by 16% of respondents in outpatient settings and 56% in inpatient settings.

Conclusions: The survey data can enhance our understanding of the factors contributing to COVID-19 exposure during neurology practice in the United States. This information can inform education, advocacy, and preventive strategies for neurology providers, trainees, and patients during the pandemic.
received an AAN survey in between February and July, were on
the AAN or AAN Institute Board of Directors, the QC or the
MRS Board of Directors and MRS, the QC, and those who
received a survey in last 6 months, a random sample of 800
members was generated. The sample size of 800 has been used
by AAN survey team as a standard sample and no member
receives more than 1 survey every 6 months to avoid excessive
querying of membership. A comparison between demographics
of AAN membership and study sample is provided in Table 1.
Advanced practice providers, and neurologists with neuro-
critical care and neuro-ophthalmology were overrepresented
and medical students and neurologists missing a primary sub-
specialty were underrepresented. On July 16, an invitation to
participate in the survey was sent by email, signed by Adnan I.
Qureshi, MD and Lytell K. Jones, MD, FAAN with 2 reminder
emails sent to nonrespondents on July 21 and July 28. Five
participants had undeliverable email addresses and were
removed from the sample, leaving 795.

Survey Instrument

The demographic data regarding age, sex, race, primary and
secondary subspecialty, practice setting, and years since residency
and/or fellowship were acquired from the AAN database (Sup-
plemental material, Supplemental Digital Content 1, http://links.
lww.com/NRL/A58). The survey asked respondents to answer
most of the survey questions based on their experiences in the
previous 2 weeks. For this survey, the 2-week timeframe occurred
in July of 2020 and will be referred to as “July.” Also, patients
with suspected/confirmed COVID-19 or those not suspected/
confirmed COVID-19 will be referred to as COVID-19 patients
and non-COVID-19 patients, respectively.

Respondents were inquired regarding new and follow-up
patient visits in-person, or by telemedicine and categorized into:
1 to 9, 10 to 29, 30 or more visits. Furthermore, the respondents
were inquired regarding how much time, on average, did they
spend with the patients during new and follow-up visits. Similar
questions were inquired regarding inpatient visits. Respondents
were inquired regarding many new and follow-up visits were
with patients with suspected/confirmed COVID-19 patients in
outpatient and inpatient settings.

Respondents were asked regarding using second tier pro-
tection (had 1 or more including sterile gloves, surgical gown,
protective goggles/face shield but not N95 mask) or maximum
protection (had N95 mask, sterile gloves, surgical gown, protective
goggles/face shield) during clinical interaction with suspected/con-
firmed COVID-19 patients and those who were not suspected/
confirmed COVID-19 patients. The use was categorized as always,
most of the time, about half of time, some of the time, and never.
The respondents were asked regarding performance of invasive
procedures categorized as: (1) Aerosol-generating procedures
(aerosol-generating procedures include endotracheal intubation,
bronchoscopy, open suctioning, administration of nebulized treat-
ment, manual ventilation before intubation, physical proning of the
patient, disconnecting the patient from the ventilator, noninvasive
positive pressure ventilation, tracheostomy, and cardiopulmonary
resuscitation); (2) Needle insertion procedures (needle insertion
procedures include electromyography, Botox injection, pain-related
injections, epidural injections); (3) Lumbar puncture procedures;
(4) Catheter-based procedures in intensive unit (central venous catheter,
arterial catheter, pulmonary artery catheter); and (5) Catheter-based
procedures in interventional suites (cerebral angiography, endovas-
cular procedures including but not limited to thromboectomy, or
carotid stent placement).

Respondents were asked whether they had any of the
symptoms of COVID-19 in last 2 weeks including cough, fever,
tiredness, difficulty breathing, or diarrhea. Respondents were
asked if they were screened for COVID-19 in last 2 weeks and
if screened whether the results were positive, negative, or
indeterminate. Respondents were asked if they personally
received health care at an emergency department/urgent care/
clinic health care or as inpatient and whether the health care was
related to COVID-19.

The respondents were asked regarding personal risk status to
understand vulnerability to COVID-19. They were asked regard-
ing cigarette smoking status categorized as: none; 1 to 3 per day; 4
to 9 per day; 10+ per day; or unknown, and body mass index (kg/
m²) was categorized as: under 18.5; 18.5 to 24.9; 25 to 29.9; 30 to
34.9; 35 to 39.9; and 40 and over. Respondents were asked
regarding history of chronic lung disease (asthma, chronic
obstructive pulmonary disease, pulmonary fibrosis), heart disease
(coronary artery disease, congestive heart failure, heart rhythm
problems), stroke, cancer, diabetes mellitus, or hypertension and if
they were using medication for the above-mentioned conditions.
The respondents were asked how much stress they had in the last 2
weeks, specifically how much stress have you felt with your work/
job, categorized as: a great deal, a lot, a moderate amount, a little,
or none at all.

Analysis

All analyses were descriptive in nature. Quantitative data was
analyzed using IBM SPSS Statistics (version 26; IBM Corp.,
Armonk, NY). The respondents were further classified according
to their residence area based on regional incidence rate per
100,000 population in the region as defined by CDC as: low
(<1500), medium (1500 or more and <3000), high (3000 or
more) incidence areas. The Johns Hopkins’ data10 from July 16
provided the incidence rate per 100,000 persons per region, and
then the Johns Hopkins’ data were merged with a cross-walk file
from HUD USPS11 to link COVID-19 occurrence rates with zip
code data. These data were then merged with the survey data to
determine COVID-19 risk using CDC guidelines.

RESULTS

Eighty-one AAN members responded to the survey, for a
response rate of 10%. Of the 81 respondents, 63% were neu-
rologists, 17% were residents, fellows or interns, 12% were
advanced practice providers, 6% were medical students, and
1% were categorized as others. Compared with nonrespondents,
advanced practice providers along with those who specialize in
neurocritical care and vascular neurology and stroke are over-
represented, whereas medical students and those who did not
mark a subspecialty were underrepresented.

In July, 38% of respondents indicated exposure to
COVID-19 at work, 1% at home, and none outside of work/ home (Fig. 1).

COVID-19 Exposure at Work: Outpatient Health Care Settings

When asked if they had seen any patients in an outpatient
setting, there was no difference in proportion of respondents
who had seen patients in January (76%) and in July (73%). Of
the 58 respondents who had seen patients in an outpatient
setting in July, 93% had seen at least 1 new patient and 77%
had seen at least 1 follow-up patient. The duration of new visit
was 31 to 60 minutes in 74% of new visits and 30 minutes or
less in 89% of follow visits. Of the 58 respondents who had in-
person visits in an outpatient setting, 11 had a clinical encounter
(4 had 1 encounter, 7 had 2 to 5 encounters, and none had > 5
encounters) with COVID-19 patients within last 2 weeks.
The distribution of PPE use in visits with COVID-19 patients according to maximum or second tier protection and proportion of times used is presented in Figure 2A. Maximum protection PPE were used by 16% of respondents either always or most of the times whereas 75% never used maximum protection. Second tier protection was always used by 55% of respondents always or most of the times. For visits with non-COVID-19 patients, second tier protection always used by 47% of respondents (Fig. 2B).

For procedures performed on non-COVID-19 patients in July in an outpatient setting, 28 respondents (51%) had performed a needle insertion, 5 (10%) had performed a lumbar puncture, and 3 (6%) had performed a catheter-based procedure. For procedures performed on COVID-19 patients in July in an outpatient setting, 1 respondent (2%) had performed a needle insertion and 1 (2%) had performed a lumbar puncture (data not displayed).

COVID-19 Exposure at Work: Inpatient Settings

When asked if they had seen any patients in an inpatient setting, there was no difference in proportion of respondents who had seen patients in January (75%) and in July (70%). Of the 53 respondents who had seen patients in an inpatient setting (in-person or by telemedicine), 50 respondents had seen at least 1 new patient in-person while 3 had done so only by telemedicine.

### TABLE 1. A Comparison of Demographics of AAN Membership and Study Sample

| Items                      | Sample | AAN Membership |
|----------------------------|--------|----------------|
| **Member type**            |        |                |
| Neurologist                | 52 (64)| 13,930 (59)    |
| Junior                     | 12 (15)| 4125 (17)      |
| Student*                   | 5 (6)  | 3897 (16)      |
| Advanced practice provider*| 10 (12)| 1280 (5)       |
| Intern                     | 2 (2)  | 422 (2)        |
| **Total**                  | 81 (100)| 23,654 (100)  |
| **Sex**                    |        |                |
| Men                        | 42 (52)| 12,713 (54)    |
| Women                      | 37 (46)| 10,341 (44)    |
| **Missing**                | 2 (2)  | 614 (3)        |
| **Total**                  | 81 (100)| 23,654 (100)  |
| **Age category (y)**       |        |                |
| < 20                       | 0† (0) | 4 (0)          |
| 20-29                      | 15 (19)| 4830 (20)      |
| 30-39                      | 21 (26)| 7014 (30)      |
| 40-49                      | 18 (22)| 4090 (17)      |
| 50-59                      | 16 (20)| 3318 (14)      |
| 60-69                      | 10 (12)| 2716 (11)      |
| ≥ 70                       | 1 (1)  | 1045 (4)       |
| **Missing**                | 0 (0)  | 637 (3)        |
| **Total**                  | 81 (100)| 23,654 (100)  |
| **Practice type**          |        |                |
| Academic                   | 26 (32)| 6753 (29)      |
| Missing                    | 11 (14)| 5770 (24)      |
| Neurology group            | 11 (14)| 3544 (15)      |
| Hospital                   | 15 (19)| 2753 (12)      |
| Multispecialty group       | 7 (9)  | 1730 (7)       |
| Solo practice              | 8 (10) | 1589 (7)       |
| Other                      | 1 (1)  | 826 (3)        |
| Government                 | 1 (1)  | 475 (2)        |
| Industry                   | 1 (1)  | 180 (1)        |
| No clinical practice       | 0† (0) | 34 (0)         |
| **Total**                  | 81 (100)| 23,654 (100)  |
| **Primary subspecialty**   |        |                |
| Missing*                   | 9 (11) | 6662 (28)      |
| General neurology          | 26 (32)| 6031 (25)      |
| Epilepsy                   | 5 (6)  | 1627 (7)       |
| Vascular neurology and stroke*| 12 (15)| 1244 (5)      |
| Neuromuscular medicine     | 6 (7)  | 1116 (5)       |
| Movement disorders         | 4 (5)  | 1084 (5)       |
| Other                      | 2 (2)  | 804 (3)        |
| Neuroimmunology and multiple sclerosis | 1 (1) | 803 (3) |
| Clinical neurophysiology   | 2 (2)  | 680 (3)        |
| Sleep medicine             | 2 (2)  | 519 (2)        |
| Neurocritical care*        | 5 (6)  | 514 (2)        |
| Headache medicine          | 0† (0) | 514 (2)        |
| Behavioral neurology and neuropsychiatry | 0† (0) | 456 (2) |
| Neurohospitalist           | 2 (2)  | 377 (2)        |
| Neuro-oncology             | 2 (2)  | 256 (1)        |
| Neuro-ophthalmology*       | 2 (2)  | 140 (1)        |
| Pain medicine              | 0† (0) | 134 (1)        |
| Geriatric neurology        | 0† (0) | 111 (0)        |
| Endovascular and interventional neurology | 0† (0) | 107 (0) |
| Neurogenetics              | 0† (0) | 76 (0)         |
| Traumatic brain injury     | 0† (0) | 65 (0)         |
| Neuroimaging               | 0† (0) | 60 (0)         |
| Neural repair and rehabilitation | 0† (0) | 57 (0)  |
| Infectious diseases and neurovirology | 1 (1) | 51 (0)  |
| Sports neurology           | 0† (0) | 51 (0)         |
| Palliative neurology       | 0† (0) | 33 (0)         |

Tests are adjusted for all pairwise comparisons within a row of each inner-most suitable using the Bonferroni correction.
*χ² statistic is significant at the 0.05 level.
†This category is not used in comparisons because its column proportion is equal to 0 or 1.
AAN indicates American Academy of Neurology.

The distribution of PPE use in visits with COVID-19 patients according to maximum or second tier protection and proportion of times used is presented in Figure 2A. Maximum protection PPE were used by 16% of respondents either always or most of the times whereas 75% never used maximum protection. Second tier protection was always used by 55% of respondents always or most of the times. For visits with non-COVID-19 patients, second tier protection always used by 47% of respondents (Fig. 2B).

For procedures performed on non-COVID-19 patients in July in an outpatient setting, 28 respondents (51%) had performed a needle insertion, 5 (10%) had performed a lumbar puncture, and 3 (6%) had performed a catheter-based procedure. For procedures performed on COVID-19 patients in July in an outpatient setting, 1 respondent (2%) had performed a needle insertion and 1 (2%) had performed a lumbar puncture (data not displayed).

**COVID-19 Exposure at Work: Inpatient Settings**

When asked if they had seen any patients in an inpatient setting, there was no difference in proportion of respondents who had seen patients in January (75%) and in July (70%). Of the 53 respondents who had seen patients in an inpatient setting (in-person or by telemedicine), 50 respondents had seen at least 1 new patient in-person while 3 had done so only by telemedicine. Of the

![Figure 1](https://example.com/figure1.png)
50 respondents who had in-person encounter in an inpatient setting, 33% or 66% of respondents reported at least 1 encounter (7 had 1 encounter, 13 had 2 to 5 encounters, and 13 had >5 encounters) with COVID-19 patients within the last 2 weeks.

The distribution of PPE use in visits with COVID-19 patients according to maximum or second tier protection and proportion of times used is presented in Figure 3A. Maximum PPE were always used by 56% of respondents and second tier protection was always used by 75% of respondents. For visits with non–COVID-19 patients, second tier protection was always used by 43% of respondents (Fig. 3B). Of the 49 respondents who had in-person visits with non-COVID patients in an inpatient setting, 25 (51%) used second tier PPE always or most of the time, whereas 13 (27%) never used it. Of the 32 respondents who had seen COVID-19 patients in an inpatient setting, 27 (84%) used second tier PPE always or most of the time, whereas 4 (13%) never used second tier PPE and 7 (22%) never used maximum PPE.

For procedures performed in July in an inpatient setting: in non-COVID-19 patients, 2 respondents (10%) had performed a lumbar puncture, 2 (10%) had performed a needle insertion, and 1 (5%) had performed a catheter-based procedure in intensive unit, and in COVID-19 patients, 1 respondent (5%) had performed a lumbar puncture (data not displayed).

Personal Risk Factors
All of the respondents were nonsmokers (not displayed). About half of the respondents (49%) had a normal body mass index, 35% were overweight, 11% obese, and 1% underweight.

Sixty-five percent of respondents reported a moderate amount of stress or less in the last 2 weeks, whereas 18% reported a lot of stress, and 17% a great deal of stress. The most frequent health issues respondents had were hypertension (12%), asthma (6%), diabetes mellitus (5%), or cancer (2%). Similarly, the most frequent treatments or medications respondents used that would increase their vulnerability to COVID-19 were medications for hypertension (17%), for diabetes mellitus (7%), or for cancer (2%).

COVID-19–Related Medical Care in Respondents
Almost all respondents (99%) were not taking any medication prophylaxis for COVID-19 (data not displayed). A total of 12 (17%) of respondents were tested for COVID-19 in the last 2 weeks; 1 respondent tested positive for COVID-19. Most respondents (61%) did not experience any symptoms suggestive of COVID-19 symptoms in the last 2 weeks (data not displayed). Of the 28 who did experience at least 1 symptom, they most frequently reported symptoms were tiredness (32%) or diarrhea (8%). Of the 71 respondents, 4 (5%) received health care personally at an emergency department/urgent care or were hospitalized unrelated to COVID-19. One respondent received health care personally at an emergency department/urgent care or was hospitalized related to COVID-19 (data not displayed).

Comparison Between Respondents
Additional analysis was completed comparing neurologist (n = 51) to other neurology providers [advanced practice provider, resident, fellow, intern, medical student (M3/4) (n = 28)].

FIGURE 2. Outpatient use of personal protective equipment (A) for COVID-19 encounters, and (B) for non–COVID-19 encounters.

FIGURE 3. Inpatient use of personal protective equipment (A) for COVID-19 encounters, and (B) for non–COVID-19 encounters.
In both January and July, neurologists saw more patients in outpatient health care settings than other neurology providers.

### Regional Exposure Risk According to Residence

Of the respondents, 46 were residing in low prevalence, 22 in medium prevalence, and 1 was residing in high prevalence region, and 10 resident addresses were not able to be matched to an incidence rate. No differences were seen between respondent according to residence.

### DISCUSSION

Our survey found that ~38% of respondents (neurologist or neurology practitioners) indicated exposure to COVID-19 at work in July. Approximately, 12% of respondents had seen a COVID-19 in-patient in outpatient setting whereas 32% of respondents had seen a COVID-19 in-patient within inpatient setting. In July, more respondents saw COVID-19 patients in an inpatient setting than in an outpatient setting. When seeing COVID-19 patients, respondents within inpatient setting more frequently used both maximum and second tier PPEs. Only 3 respondents during inpatient practice with COVID-19 patients, 2 within inpatient setting and 1 in outpatient setting. Owing to the low number of respondents, results should be used with caution. In the survey, advanced practice providers along with those who specialize in neurocritical care and vascular neurology and stroke are overrepresented in respondents, whereas medical students and those who did not mark a subspecialty are underrepresented. Given the multiple differences, results should be used with caution. The results are reflective of early period of the pandemic and additional changes may have been occurred based on regional increase in cases, increase in access to PPE, and availability of additional medical data. Our survey does not provide data on redeployment of neurologists from outpatient practice to inpatient units to provide care of COVID-19 patients in the hospital.

The frequency of testing and confirmed COVID-19 in AAN members appeared higher than seen in general population. One of 5 respondents (17%) required testing for COVID-19 within the last 2 weeks (170 per 1000 population). The prevalence of testing among neurologists appeared to be much higher than the CDC reported national average of 1.6 tests per 1000 population (CDC Covid-Response Team)\(^1\) with the maximum test administered in state of New York (excluding New York City) with 4.9 tests per 1000 population.\(^1\) Of those tested, 1 (1%) respondent tested positive for COVID-19. The estimated incidence of COVID-19 was 1245 per 100,000 persons. One respondent received health care personally at an emergency department/urgent care or was hospitalized related to COVID-19. The overall cumulative COVID-19 hospitalization rate in United States was 120.9 per 100,000 in July.\(^1\)

The risk of exposure to COVID-19 during neurology practice occurs from 3 groups of patients; patients with known infection, patients with suspected infection, and patients with undiagnosed infection. Patients who develop neurological disorders in advanced stages of COVID-19 are already identified by the institutional screening protocols. The biggest exposure risk is during evaluation of patients with undiagnosed COVID-19. Certain neurological symptoms such as headache, dizziness, impaired consciousness, acute cerebrovascular disease, ataxia, and seizure may precede the classic symptoms of COVID-19 such as cough, dyspnea, and fever.\(^14,15\) Approximately 20% of patients with COVID-19 do not develop clinical symptoms.\(^16,17\) Therefore, neurologists may see patients in clinics or hospitals who may have not classic symptoms of COVID-19 and thus not identified by screening protocols. Additional challenges in identifying COVID-19 in patients with neurological disorders is inability to get an accurate history of clinical symptoms due to underlying aphasia, dysarthria, and confusion. The delay in confirming COVID-19 is an additional impediment as using real-time reverse-transcription polymerase chain reaction from nasopharyngeal and oropharyngeal swab can take up to 8 h and 3 days for serological enzyme-linked immuno-sorbent assays. Further delay may be incurred if the specimen has to be sent to a laboratory outside the hospital also delay screening in clinics and hospitals.\(^18\) Repeat testing may be necessary due to poor quality of the specimen, limited patient specimens, or the inappropriate timing of specimen collection (too early or too late) during the infection process.\(^19\) It was surprising that maximum PPE was always used by only 84% of respondents during in patient clinical encounters with COVID-19 patients. The lack of use by other 16% may be due to lack of PPEs in medical facilities\(^20\) or lack of definitive evidence that N95 masks provide additional protection compared with standard masks.\(^21\)

It is likely that the risk of contracting COVID-19 is lower among neurologists than other medical specialties who are involved in evaluation of respiratory or infectious diseases and those who perform aerosol-generating procedures. A survey of 91 programs, which represented 24 specialties and 2306 residents residency program directors, was conducted inquiring about how many of their residents contracted COVID-19 from March 2 to April 12.\(^22\) At least 1 resident tested positive for COVID-19 in 45.1% of programs. There were 101 confirmed positive cases among resident physicians, and an additional 163 residents were presumed to be positive for COVID-19. Emergency medicine, anesthesiology, and ophthalmology residents were at highest risk. The survey was performed when neurology services had already taken steps to prevent exposure to COVID-19.\(^2\) Most elective admissions for nonurgent purposes were canceled in early March, and epilepsy monitoring units were closed in both pediatrics and adult services. All urgent admissions and possible transfers were screened by phone for possible COVID-19 symptoms. Ambulatory staff were trained to screen all patients and those accompanying the patient for possible COVID-19 symptoms. Transition to teleneurology visits began for outpatient practices in early March for all new and established patients.

The data generated from this survey could enhance our knowledge of the factors that contribute to COVID-19 exposure during neurology practice and inform education and advocacy efforts to neurology providers, trainees, and patients in this unprecedented pandemic. As COVID-19 continues to spread across the United States and the world, more patients with COVID-19 may be seen by neurology providers, increasing exposure and risk of transmission. As the COVID-19 exposure risk is likely to change over time, the AAN could consider doing the survey again, and possibly at regular intervals. The manuscript does not constitute an official position of the AAN.

### REFERENCES

1. TRT World. US reports 58,858 more Covid-19 infections—latest updates; 2020. Available at: https://www.trtworld.com/life/us-reports-58-858-more-covid-19-infections-latest-updates-38100. Accessed November 19, 2020.
2. CDC Covid-Response Team. Characteristics of health care personnel with COVID-19—United States. MMWR Morb Mortal Wkly Rep. 2020;69:477–481.
3. The Lancet. COVID-19: protecting health-care workers. Lancet. 2020;395:922.
4. Wu Z, McGoogan JM. Characteristics of and important lessons from the coronavirus disease 2019 (COVID-19) outbreak in China: summary of a report of 72314 cases from the Chinese center for disease control and prevention. JAMA. 2020;323:1239–1242.

5. Livingston E, Bucher K. Coronavirus disease 2019 (COVID-19) in Italy. JAMA. 2020;323:1335.

6. Nguyen LH, Drew DA, Graham MS, et al. Risk of COVID-19 among front-line health-care workers and the general community: a prospective cohort study. Lancet Public Health. 2020;5:e475–e483.

7. Asadi-Pooya AA, Simani L. Central nervous system manifestations of COVID-19: a systematic review. J Neurol Sci. 2020;413:116832.

8. Qureshi AI, Abd-Allah F, Al-Senani F, et al. Management of acute ischemic stroke in patients with COVID-19 infection: report of an international panel. Int J Stroke. 2020;15:540–554.

9. Ellul MA, Benjamin L, Singh B, et al. Neurological associations of COVID-19. Lancet Neurol. 2020;19:767–783.

10. Dong E, Du H, Gardner L. An interactive web-based dashboard to track COVID-19 in real time. Lancet Infect Dis. 2020;20:533–534.

11. HUD USPS. HUD USPS ZIP code crosswalk files; 2020. Available at: https://www.huduser.gov/portal/datasets/usps_crosswalk.html#data. Accessed December 28, 2020.

12. CDC Covid-Response Team. Geographic differences in COVID-19 cases, deaths, and incidence—United States. MMWR Morb Mortal Wkly Rep. 2020;69:465–471.

13. CDC. COVIDView summary ending on July 18, 2020; 2020. Available at: https://www.cdc.gov/coronavirus/2019-ncov/covid-data/covidview/past-reports/07242020.html. Accessed November 19, 2020.

14. Mao L, Jin H, Wang M, et al. Neurologic manifestations of hospitalized patients with coronavirus disease 2019 in Wuhan, China. JAMA Neurol. 2020;77:683–690.

15. Qureshi AI, Liaqat J, Agunbiade S, et al. Characteristics of headache and dizziness in COVID-19 patients. Health Care Res J. 2020;1:32–37.

16. Grant MC, Geoghegan L, Arbyn M, et al. The prevalence of symptoms in 24,410 adults infected by the novel coronavirus (SARS-CoV-2; COVID-19): a systematic review and meta-analysis of 148 studies from 9 countries. PLoS One. 2020;15:e0234765.

17. Buitrago-Garcia D, Egli-Gany D, Counotte MJ, et al. Occurrence and transmission potential of asymptomatic and presymptomatic SARS-CoV-2 infections: a living systematic review and meta-analysis. PLoS Med. 2020;17:e1003346.

18. Carter LJ, Garner LV, Smoot JW, et al. Assay techniques and test development for COVID-19 diagnosis. ACS Cent Sci. 2020;6:591–605.

19. Agarwal R. Quality-improvement measures as effective ways of preventing laboratory errors. Lab Med. 2014;45:e80–e88.

20. Rose J. Why can’t America make enough N95 masks? 6 months into pandemic, shortages persist; 2020. Available at: https://www.npr.org/2020/09/17/913093387/why-cant-america-make-enough-n95-masks-6-months-into-pandemic-shortages-persist. Accessed January 6, 2021.

21. Bartoszko JJ, Farooqi MAM, Allhazzani W, et al. Medical masks vs N95 respirators for preventing COVID-19 in healthcare workers: a systematic review and meta-analysis of randomized trials. Influenza Other Respir Viruses. 2020;14:365–373.

22. Stewart A. Preprint finds 3 specialties at higher risk of contracting COVID-19—4 takeaways; 2020. Available at: https://www.beckersas.com/anesthesia/preprint-finds-3-specialties-at-higher-risk-of-contracting-covid-19-4-takeaways.html. Accessed November 19, 2020.