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Impacts and challenges of the COVID-19 pandemic on emergency medicine physicians in the United States

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Abstract

Background: Emergency medicine (EM) physicians have been on the front line of the COVID-19 pandemic. This study aims to determine the impact of COVID-19 pandemic and other related factors such as resource availability and institutional support on well-being, burnout and job-satisfaction of EM physicians in the United States.

Methods: A cross-sectional survey study of EM physicians was conducted through the Emergency Medicine Practice Research Network of the ACEP. The survey focused on resource adequacy, institutional support, well-being, and burnout. A total of 890 EM physicians were invited to participate. Both descriptive and risk adjusted, and multivariate regressions were performed with a statistical significance defined as p < 0.05.

Results: EM physicians’ response rate was 18.7% (166) from 39 states. Burnout was reported by 74.7% (124) since the start of the pandemic. Factors contributing included work-related emotional strain and anxiety, isolation from family and friends, and increased workload. Those reporting inadequate resources felt ignored by their institutions (p < 0.0001). Physicians who felt there was inadequate institutional support, were also dissatisfied with patient care resources (p = 0.001). Physicians expressing job dissatisfaction were more likely to report feelings of burnout (p = 0.001).

Conclusion: EM physicians face greater burnout in the COVID-19 pandemic. This may be compounded by resource scarcity, psychological stress, isolation, and job dissatisfaction. Many of the survey respondents reported inadequate mental health services and resources. The findings of this study may help identify solutions to mitigate these issues.

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1. Introduction

The novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which causes coronavirus disease 2019 (COVID-19), has rapidly spread worldwide. The clinical course ranges from asymptomatic to severe [1–3]. The task of management and infection containment has largely fallen on emergency medicine (EM) physicians, who have become first-line of defense in the pandemic. They must isolate, diagnose, and treat patients with a highly infectious disease, while still managing other emergent cases.

Resources and staffing have become a growing concern nationwide [4–6]. The shortage of vital resources has resulted in greater risk of infection and increased work-related strain among EM physicians [7,8,5,9,10]. High-stakes rapid decision-making is routine in EM. However, this can come with a significant psychological burden and increased mental, emotional, and physical exhaustion caused by job stress, resulting in burnout and affecting both health and well-being [11]. EM physicians consistently rank among the specialties with the highest burnout rates [12]. The higher risk of litigation, chronic fatigue from circadian rhythm disruption, and workload intensity have been identified as key reasons [13]. Although, 42% of physicians reported feelings of burnout in 2020, only a small portion of these individuals have sought professional help [12].

A longitudinal prospective cohort survey of 213 EM physicians found that feelings of isolation were also prevalent during the initial surge of the pandemic [14]. More than 50% of respondents reported relationship strain and isolation, which remained unchanged over the four-week study period. Furthermore, 66% of EM providers reported negative impacts on basic self-care [14]. Another recent survey study of 1300 EM physicians found that post-traumatic stress disorder (PTSD) was significant and a major source of stress was disinformation about COVID-19, PPE and workload [15]. This is concerning as higher levels of burnout...
have been associated with increased medical errors, lower patient satisfaction, unprofessional behavior, and prolonged ED wait times [16-18]. The COVID-19 pandemic has had a significant impact on EM physicians [19-21]. This study aims to survey EM physicians in the United States to ascertain changes in perspectives of burnout as a result of changes to resource levels, institutional support, well-being, and job satisfaction during the COVID-19 pandemic.

2. Methods

2.1. Study design and setting

In this cross-sectional study, an online 18-item survey was administered to US EM physicians between November 12th, 2020 to December 22nd, 2020 to determine the psychological and emotional impact of the COVID-19 pandemic on EM physicians, and the factors which may influence burnout.

2.2. Selection of participants

The Emergency Medicine Practice Research Network (EMPRN) was utilized to recruit participants. The EMPRN is a practice-based network created by the American College of Emergency Physicians (ACEP) consisting of approximately 890 EM physicians nationwide utilized for research in the advancement of EM [22]. EM physicians currently practicing in the US during the COVID-19 pandemic were eligible for enrollment. International physicians and resident physicians were not eligible.

2.3. Survey content and administration

The 18-item survey consists of original items and a number of modified questions from a previously validated instrument (Supplementary File). Basic demographic information such as gender, age, and geographic location were provided by the EMPRN. Questions regarding institution type and years in practice were included in this survey. Additional questions elicited information regarding opinions on resource levels, institutional support, well-being, and feelings of burnout. The well-being and burnout questions, specifically, were adapted from the Maslach Burnout Inventory–Human Services Survey for Medical Personnel (MBI-HSS (MP)). The MBI-HSS (MP) is a validated tool widely used to evaluate burnout [23,24]. The survey was comprised of multiple-choice, five-point agreement Likert scale, and five-point frequency Likert questions. An “Other” option for free responses was available where applicable.

Prior to dissemination, the survey was internally validated through a small pilot study conducted internally within our institution. The internal pilot study was utilized to refine language, test for face validity and assess survey questions clarity, and improve content and quality. Revisions were completed to ensure ease of understanding and consistency of the questions. The survey was then submitted to the ACEP Practice Management Manager and Research Surveys Committee for review and approval before distribution to the ACEP members through the EMPRN. Revisions were made to standardize survey questions based on the recommendations provided by the ACEP Practice Management Manager and Research Surveys Committee, and the ACEP survey guidelines [22]. Once approved by the ACEP Practice Management and Research Surveys Committee, the survey was directly distributed through ACEP to its members via the EMPRN webmail system.

The survey remained open for six weeks. Two reminder emails were sent on November 24th and December 17th. No identifying information was recorded. No incentives were offered to complete the survey. The human subjects review board at Nova Southeastern University deemed this study to be exempt. This study was performed in compliance with the standards outlined by the board.

2.4. Data analysis

All data were analyzed using SAS version 9.4 (SAS Institute Inc., Cary, NC, USA). Nonparametric data were evaluated by Fisher’s exact test for proportions and the Wilcoxon Rank-Sum test for continuous data. Multivariable logistic regression was used for calculating the adjusted odds ratio for binary outcomes. Confounders were identified if there was either literature or a logical reason to support a variable having an independent effect on the exposure or outcome. The final regression model included age, gender, institution type, number of years in practice, resource availability, institutional support, and job satisfaction. P-values <0.05 were considered significant.

2.5. Study outcomes

The primary outcome was burnout. Burnout was defined by answering either “sometimes,” “often,” or “always” to question 14 of the survey. Not being burned out was defined by answering either “never” or “rarely.” Question 14 reads: I feel more burned out because of the COVID-19 pandemic as compared to before it. Secondary outcomes examined were resource availability, institutional support, and job satisfaction. Resource availability was defined by answering either “strongly agree” or “somewhat agree” to question one. Lack of resource availability was defined by either answering “neither agree nor disagree,” “somewhat disagree,” or “strongly disagree.” Question one reads: Since the start of the COVID-19 pandemic (Jan 20th) to currently, I have felt supported by my institution through implementation of extra precautionary techniques and/or maintenance of adequate resource level (PPE, sanitation items, etc.). Institutional support was defined by answering question four as either “strongly agree” or somewhat agree”. Lack of institutional support was defined as either answering “neither agree nor disagree,” “somewhat disagree,” or “strongly disagree.” Question four reads: I feel that my institution was prepared for the COVID-19 pandemic and has the proper guidelines/protocols in place needed for the identification, treatment, and isolation of COVID-19 patients. Job satisfaction was defined as answering question 15 as either “strongly agree” or somewhat agree”. Lack of job satisfaction was defined as either answering “neither agree nor disagree”, “somewhat disagree”, or “strongly disagree”. Question 15 reads: I feel satisfied with my work since the start of the COVID-19 pandemic.

2.6. Cohort groups and risk factors

To identify variables associated with each outcome, a stratified analysis was carried out by the presence or lack of certain risk factors. For the primary outcome burnout, it was stratified by either having resource availability, institutional support, job satisfaction, having mental health support, satisfaction with level of resources, attitudes towards patients and staff, and risk factors leading to being burned out. For the secondary outcome resource availability, it was further stratified by whether the physician felt that there was adequate level of SARS-CoV-2 testing for patients, whether they felt that the turnaround time for testing was adequate, whether they felt that their institution listened to their concerns, having mental health support, and whether or not they felt that they had adequate level of resources. For the secondary outcome institutional support, it was further stratified by whether or not they felt that their institution listened to their concerns, if their institution had furloughed or laid off staff, if their institution offered their concerns, whether or not they felt that their institution listened to their concerns, having mental health support, and whether or not they had access to mental health counseling, whether or not there was appropriate precautions to prevent colleague to colleague spread of COVID-19, and specific risk factors related to burnout. For the secondary outcome of job satisfaction, stratified analysis was carried out by whether or not the physicians felt that the institutions listened to their concerns, whether or not they had access to mental health counseling, whether or not there was appropriate precautions to prevent colleague to colleague spread...
of COVID-19, whether or not they felt more callous towards patient and staff, whether or not they felt that their academic obligations were compromised, and if they felt more burned out.

3. Results

3.1. Characteristics of study subjects

A total of 166 participants completed the survey; the response rate was 18.7% (166/890). There were respondents from 39 different states. One hundred twenty-one respondents (72.9%) were male. The largest age demographic represented respondents between 41 and 50 years (33.1%). The largest institution demographic represented respondents practicing at community teaching hospitals (31.3%). The largest regional demographic represented respondents located in the Southern US (34.9%). The majority of respondents have practiced for >20 years (34.7%) were employed at a community teaching hospital, 46.8% have been in practice for >20 years, and 37.1% are located in the Southern US. Respondents reporting burnout also reported higher proportions of feeling callous towards patients and other staff compared to those determined using Fisher’s exact test.

3.2. Well-being and burnout

A majority of participating EM physicians disclosed increased feelings of burnout since the start of the pandemic. There were three times as many physicians reporting burnout than those that did not (74.7% vs 25.3%) (Table 2). There was a statistically significant association between reported feelings of burnout and age (p = 0.04) as well as gender (p = 0.01). The age group with the highest proportion of reported burnout were those between 41 and 50 years; those in the oldest age group, 71–75, reported burnout in the lowest proportions. Of the physicians reporting burnout, 70.2% were white, 67.7% were male, 34.7% were employed at a community teaching hospital, 46.8% have been in practice for >20 years, and 37.1% are located in the Southern US.

Respondents reporting burnout also reported higher proportions of feeling callous towards patients and other staff compared to those determined using Fisher’s exact test.

Table 1

Characteristics of survey respondents.

| Demographics (Total = 166) | n | % |
|---------------------------|---|---|
| Age                       |   |   |
| 32–40                     | 22| 13.3% |
| 41–50                     | 55| 33.1% |
| 51–60                     | 42| 25.3% |
| 61–70                     | 37| 22.3% |
| 71–75                     | 10| 6.0% |
| Gender                    |   |   |
| Male                      | 121| 72.9% |
| Female                    | 45 | 27.1% |
| Race                      |   |   |
| White                     | 121| 72.0% |
| Black                     | 1 | 0.6% |
| Hispanic                  | 2 | 1.2% |
| Asian                     | 7 | 4.2% |
| Other                     | 35| 21.1% |
| Institution Type          |   |   |
| University Teaching Hospital | 42| 25.3% |
| Community non-teaching hospital | 45| 27.1% |
| Community teaching hospital | 52| 31.3% |
| Combined                  | 16| 9.6% |
| Other                     | 11| 6.6% |
| Practicing Years ≤5       | 4 | 2.4% |
| 6–10                      | 25| 15.1% |
| 11–20                     | 51| 30.7% |
| >20                       | 85| 51.2% |
| Region                    |   |   |
| Midwest                   | 34| 20.5% |
| Northeast                 | 28| 16.9% |
| South                     | 58| 34.9% |
| West                      | 37| 22.3% |
| Unknown                   | 9 | 5.4% |

Table 2

Reported feelings of burnout, resource availability, institutional support, and job satisfaction by surveyed emergency medicine physicians stratified by demographics. P-values were determined using Fisher’s exact test.

| Burnout | Yes: Sometimes/often/always feel burned out (n = 124) | No: Never/rarely feel burned out (n = 42) | p-value |
|---------|----------------------------------------------------|------------------------------------------|---------|
| Age     |                                                    |                                          |         |
| 32–40   | 13.7% (17)                                         | 11.9% (5)                                | 0.04    |
| 41–50   | 37.9% (47)                                         | 19.1% (8)                                |         |
| 51–60   | 23.4% (29)                                         | 31.0% (13)                               |         |
| 61–70   | 21.8% (27)                                         | 23.8% (10)                               |         |
| 71–75   | 3.2% (4)                                           | 14.3% (6)                                |         |
| Gender  |                                                    |                                          |         |
| Male    | 67.7% (84)                                         | 88.1% (37)                               | 0.01    |
| Female  | 32.3% (40)                                         | 11.9% (5)                                |         |
| Race    |                                                    |                                          | 0.66    |
| White   | 70.2% (87)                                         | 81.0% (34)                               |         |
| Black   | 0.8% (1)                                           | 0.0% (0)                                 |         |
| Hispanic| 1.6% (2)                                           | 0.0% (0)                                 |         |
| Asian   | 4.0% (5)                                           | 4.8% (2)                                 |         |
| Other   | 23.4% (29)                                         | 14.3% (6)                                |         |
| Institution Type |                                  |                                          | 0.17    |
| University Teaching Hospital | 25.0% (31) | 26.2% (11)                                |         |
| Community non-teaching hospital | 23.4% (29) | 38.1% (16)                                |         |
| Community teaching hospital | 34.7% (43) | 21.4% (9)                                 |         |
| Combined | 11.3% (14)                                         | 4.8% (2)                                 |         |
| Others  | 5.7% (7)                                           | 9.5% (4)                                 |         |
| Practicing Years ≤5 |                          |                                          | 0.14    |
| 6–10    | 14.6% (18)                                         | 16.7% (7)                                |         |
| 11–20   | 35.0% (43)                                         | 19.1% (8)                                |         |
| >20     | 47.2% (58)                                         | 64.3% (27)                               |         |
| Region  |                                                    |                                          | 0.32    |
| Midwest | 22.6% (28)                                         | 14.3% (6)                                |         |
| Northeast | 16.1% (20)                                        | 19.1% (8)                                |         |
| South   | 37.1% (46)                                         | 28.6% (12)                               |         |
| West    | 20.2% (25)                                         | 28.6% (12)                               |         |
| Unknown | 4.0% (5)                                           | 9.5% (4)                                 |         |

| Resource availability | Yes: Strongly agree/somewhat agree (n = 121) | No: Neither agree or disagree/Somewhat disagree (n = 45) | p-value |
|-----------------------|-----------------------------------------------|----------------------------------------------------------|---------|
| Age                   |                                               |                                                          |         |
| 32–40                 | 17.4% (21)                                    | 2.2% (1)                                                 | 0.05    |
| 41–50                 | 30.6% (37)                                    | 40.0% (18)                                               |         |
| 51–60                 | 26.5% (32)                                    | 22.2% (10)                                               |         |
| 61–70                 | 19.8% (24)                                    | 28.9% (13)                                               |         |
| 71–75                 | 5.8% (7)                                      | 6.7% (3)                                                 |         |
| Gender                |                                               |                                                          |         |
| Male                  | 73.6% (89)                                    | 71.1% (32)                                               | 0.84    |
| Female                | 26.4% (32)                                    | 28.9% (13)                                               |         |
| Race                  |                                               |                                                          | 0.73    |
| White                 | 70.3% (85)                                    | 80.0% (36)                                               |         |
| Black                 | 0.8% (1)                                      | 0.0% (0)                                                 |         |
| Hispanic              | 1.7% (2)                                      | 0.0% (0)                                                 |         |
| Asian                 | 4.1% (5)                                      | 4.4% (2)                                                 |         |
| Other                 | 23.1% (28)                                    | 15.6% (7)                                                |         |
| Institution Type      |                                               |                                                          | 0.77    |
| University Teaching Hospital | 24.0% (29) | 28.9% (13) |         |
| Community non-teaching hospital | 26.5% (32) | 28.9% (13) |         |
| Community teaching hospital | 33.1% (40) | 26.7% (12) |         |
| Combined              | 10.7% (13)                                    | 6.7% (3)                                                 |         |
| Others                | 5.8% (7)                                      | 8.9% (4)                                                 |         |
Table 2 (continued)

| Burnout | Yes: Sometimes/often/always feel burned out (n = 124) | No: Never/rarely feel burned out (n = 42) | p-value |
|----------|--------------------------------------------------|------------------------------------------|---------|
| Practicing Years | | | |
| ≤5 | 1.7% (2) | 4.4% (2) | 0.60 |
| 6–10 | 15.8% (19) | 13.3% (6) | |
| 11–20 | 32.5% (39) | 26.7% (12) | |
| >20 | 50.0% (60) | 55.6% (25) | |
| Region | | | 0.66 |
| Midwest | 18.2% (22) | 26.7% (12) | |
| Northeast | 19.0% (23) | 11.1% (5) | |
| South | 34.7% (42) | 35.6% (16) | |
| West | 22.3% (27) | 22.2% (10) | |
| Unknown | 5.8% (7) | 4.4% (2) | |
| Institutional support | Yes: Strongly agree/somewhat agree (n = 84) | No: Neither agree or disagree/somewhat disagree (n = 82) | p-value |
| Age | | | 0.67 |
| 32–40 | 13.1% (11) | 13.4% (11) | |
| 41–50 | 34.5% (29) | 31.7% (26) | |
| 51–60 | 25.0% (21) | 25.6% (21) | |
| 61–70 | 19.1% (16) | 25.6% (21) | |
| 71–75 | 8.3% (7) | 3.7% (3) | |
| Gender | Male | 75.0% (63) | 70.7% (58) | 0.60 |
| | Female | 25.0% (21) | 29.3% (24) | |
| Race | White | 70.2% (59) | 75.6% (62) | 0.67 |
| | Black | 1.2% (1) | 0.0% (0) | |
| | Hispanic | 2.4% (2) | 0.0% (0) | |
| | Asian | 4.8% (4) | 3.7% (3) | |
| | Other | 21.4% (18) | 20.7% (17) | |
| Institution Type | University teaching hospital | 22.6% (19) | 28.1% (23) | 0.94 |
| | Community non-teaching hospital | 27.4% (23) | 26.8% (22) | |
| | Community teaching hospital | 33.3% (28) | 29.3% (24) | |
| | Combined | 9.5% (8) | 9.8% (8) | |
| | Others | 7.1% (6) | 6.1% (5) | 0.93 |
| Practicing Years | | | |
| ≤5 | 2.4% (2) | 2.5% (2) | |
| 6–10 | 14.3% (12) | 16.1% (13) | |
| 11–20 | 33.3% (28) | 28.4% (23) | |
| >20 | 50.0% (42) | 53.1% (43) | |
| Region | Midwest | 21.4% (18) | 19.5% (16) | 0.61 |
| | Northeast | 19.1% (16) | 14.6% (12) | |
| | South | 28.8% (25) | 40.2% (33) | |
| | West | 22.6% (19) | 22.0% (18) | |
| | Unknown | 7.1% (6) | 3.7% (3) | |
| Job satisfaction | Yes: Strongly agree/somewhat agree (n = 94) | No: Neither agree or disagree/somewhat disagree (n = 72) | p-value |
| Age | | | 0.84 |
| 32–40 | 14.9% (14) | 11.1% (8) | |
| 41–50 | 31.9% (30) | 34.7% (25) | |
| 51–60 | 23.4% (22) | 27.8% (20) | |
| 61–70 | 22.3% (21) | 22.2% (16) | |
| 71–75 | 7.5% (7) | 4.2% (3) | |
| Gender | Male | 79.8% (75) | 63.9% (46) | 0.03 |
| | Female | 20.2% (19) | 36.1% (26) | |
| Race | White | 71.3% (67) | 75.0% (54) | 0.85 |
| | Black | 1.1% (1) | 0.0% (0) | |
| | Hispanic | 2.1% (2) | 0.0% (0) | |

Table 2 (continued)

| Burnout | Yes: Sometimes/often/always feel burned out (n = 124) | No: Never/rarely feel burned out (n = 42) | p-value |
|----------|--------------------------------------------------|------------------------------------------|---------|
| Asian | 4.3% (4) | 4.2% (3) | 0.75 |
| Other | 21.3% (20) | 20.8% (15) | |
| Institution Type | University | 28.7% (27) | 20.8% (15) | |
| | Teaching hospital | 25.4% (23) | 30.6% (22) | |
| | Community non-teaching hospital | 31.9% (30) | 30.6% (22) | |
| | Community teaching hospital | Combined | 8.5% (8) | 11.1% (8) | |
| | Others | 6.4% (6) | 6.9% (5) | 0.74 |
| Practicing Years | | | |
| ≤5 | 2.1% (2) | 2.8% (2) | |
| 6–10 | 12.7% (12) | 18.3% (13) | |
| 11–20 | 30.9% (29) | 31.0% (22) | |
| >20 | 54.3% (51) | 47.9% (34) | |
| Region | Midwest | 21.3% (20) | 19.4% (14) | 0.71 |
| | Northeast | 17.0% (16) | 16.7% (12) | |
| | South | 30.9% (29) | 40.3% (29) | |
| | West | 25.5% (24) | 18.1% (13) | |
| | Unknown | 5.3% (5) | 5.6% (4) | |

who reported no burnout (36.1% vs 4.8%, p = 0.0001). The most common feelings contributing to burnout were increased work-related emotional strain and anxiety, followed by isolation from family and friends, and then by increased workload (Table 3).

3.3. Resource availability

Most participants (72.9%) reported adequate availability of resources such as PPE and sanitation items since the start of the pandemic (Table 2). There was a statistically significant association between reported feelings of resource adequacy and age (p = 0.05). Physicians age 32–40 reported feelings of resource adequacy in the highest proportions compared to all other age groups. Physicians who practice in the Southern US (34.7%) reported the most resource adequacy. Those employed at community teaching hospitals and those located in the Southern US reported the highest rate of feeling adequately supplied with necessary resources (33.1% and 34.7%, respectively). Participants employed at community non-teaching and those employed at university teaching hospitals each accounted for 28.9% of those who disagreed their institution maintained adequate resource levels. The highest proportion of physicians who did not feel there were adequate resource levels were those who had been practicing for >20 years (55.6%).

Respondents reporting burnout noted resource and supply inadequacy (sanitation items, hospital beds, and ventilators) for treating COVID-19 positive patients at higher proportions compared to those who did not report burnout (21.8% vs 2.4%, p = 0.004) (Table 3). However, after adjusting for confounding factors (age, gender, institution type, number of years in practice, institutional Support, job Satisfaction), the odds of burnout were not significantly increased with feelings of resource inadequacy (Table 4a). Furthermore, a greater proportion of respondents reporting feelings of inadequate resource availability also expressed that SARS-CoV-2 testing for their patients was inadequate compared to those who reported sufficient resources (44.4% vs 26.5%, p = 0.03) (Table 5). None of the respondents reporting feelings of inadequate resources felt there was sufficient testing compared to 11.6% of those who felt adequately supplied (p = 0.02). A greater proportion of those who reported feelings of resource inadequacy also strongly disagreed that there was adequate turnaround time for SARS-CoV-2
them (either disagreed or strongly disagreed that their institutions listened to proper guidelines and protocols (Table 2). Of the physicians who difference in feelings of institutional support; 50.6% of the respondents table 4a

Table 4a
Feelings of burnout as reported by surveyed emergency medicine physicians in relation to resource availability.

| Resource availability | Burnout | Resource availability |
|-----------------------|---------|-----------------------|
|                       | Yes: Sometimes/often/always feel burned out | No: Never/rarely feel burned out |
| Burnout               | 71.1% (86) | 28.9% (35) |
|                      | 95.5% (6) | 0.93 |
|                      | 13.7% (17) | 19.1% (8) |
|                      | 29.8% (37) | 26.2% (11) |
|                      | 29.8% (37) | 31.0% (13) |

Professional counseling and/or mental health support was offered by my institution as a result of the impact on workload and stress from the COVID-19 pandemic. There was no statistically significant association between reported job satisfaction and gender (p = 0.03). Women reported job dissatisfaction in higher proportions than men (57.8% vs. 38.0%). Physicians located in the Southern US reported the highest proportion of job dissatisfaction (40.3%) compared to those in other regions. Job satisfaction was higher among those who felt their institution listened to them, compared to those who did not (44.7% vs. 27.8%, p = 0.03) (Table 7). Those who reported job satisfaction also reported greater availability of professional counseling (p = 0.003). A greater proportion of those who were satisfied with their jobs reported that they rarely saw their clinical responsibilities as hurting their academic obligations, compared to those who were dissatisfied (20.9% vs. 4.4%, p = 0.003).

Physicians reporting burnout were also more likely to report job dissatisfaction (aOR 6.94; 95% CI 2.47, 19.54) (Table 4c). This remained even when adjusting for age, gender, institution, number of years in practice, and sense of resource adequacy. There was also a positive correlation between feelings of burnout and a sense of lack of resources or institutional support. However, these relationships were not statistically significant. Additionally, among respondents reporting burnout, those who also reported job dissatisfaction were more likely to feel burnout due to COVID-19, compared to those who were satisfied with their jobs (p = 0.001) (Table 7).

4. Discussion

The COVID-19 pandemic has placed tremendous strain on the US health care system. As the number of cases increases, there is a related increase in admission rates from the ED. [25] Previous surveys have broadly evaluated the mental health of EM physicians, although none have looked at which specific pandemic-related factors contribute to their burnout.

The findings of our survey are consistent with previous literature that EM physicians face greater psychological burdens since the pandemic onset [26]. A recent nationwide poll conducted by ACEP found...
87% of surveyed EM physicians had experienced more stress due to the pandemic; 72% reported feelings of burnout; 73% felt uncomfortable seeking mental health treatment due to the perceived stigma [27]. Rodriguez et al. found that greater than 90% of surveyed EM physicians during the pandemic reported changes in their behavior which included decreased affection towards friends and family [28]. Our results further support these findings as among surveyed participants, three times the number of EM physicians noted increased feelings of burnout and callousness towards loved ones since the start of the pandemic.

The significant number of EM physicians reporting burnout may be attributable to the immense emotional and mental burden of frontline work during the pandemic. However, our study found no statistically

### Table 4b
Feelings of burnout as reported by surveyed emergency medicine physicians in relation to institutional support.

| Burnout                                      | Institutional support |
|----------------------------------------------|-----------------------|
| Yes: Sometimes/Often/Always Feel Burned Out | 69.1% (58)            |
| No: Never/Rarely Feel Burned Out             | 30.9% (26)            |

| Burnout                                      | No: Neither agree or disagree/somewhat disagree/strongly disagree (N = 82) |
|----------------------------------------------|---------------------------------------------------------------------------|
| Yes: Sometimes/Often/Always Feel Burned Out | 80.5% (66) 1.82 (0.89, 3.73) 1.26 (0.49, 3.20)* |
| No: Never/Rarely Feel Burned Out             | 19.5% (16) 0.55 (0.27, 1.12) 0.80 (0.31, 2.03)* |

* Adjusted Odds Ratio by: Age, Gender, Institution Type, # of Years in Practice, Resource Availability, Job Satisfaction.

### Table 4c
Feelings of burnout as reported by surveyed emergency medicine physicians in relation to job satisfaction.

| Burnout                                      | Job satisfaction |
|----------------------------------------------|------------------|
| Yes: Sometimes/Often/Always Feel Burned Out | 61.7% (58)       |
| No: Never/Rarely Feel Burned Out             | 38.3% (36)       |

| Burnout                                      | No: Neither agree or disagree/somewhat disagree/strongly disagree (N = 72) |
|----------------------------------------------|---------------------------------------------------------------------------|
| Yes: Sometimes/Often/Always Feel Burned Out | 91.7% (66) 6.72 (2.64, 17.11) 6.94 (2.47, 19.54)* |
| No: Never/Rarely Feel Burned Out             | 8.3% (6) 0.15 (0.06, 0.38) 0.14 (0.05, 0.41)* |

* Adjusted Odds Ratio by: Age, Gender, Institution Type, # of Years in Practice, Resource Availability, Institutional Support.

### Table 5
Feelings of resource availability (yes/no) stratified by various survey questions.

| Resource availability                                      | During the COVID-19 pandemic: I felt the needed level of testing for COVID-19 for patients was adequate | I felt the turnaround time for COVID-19 test results was adequate for patients | I feel that my institution listens when I voice concerns related to the COVID-19 pandemic | Professional counseling and/or mental health support was offered by my institution as a result of the impact on workload and stress from the COVID-19 pandemic | I am satisfied with the level of resources (sanitation items, hospital beds capacity, ventilators, medications, administration support etc.) provided by my institution to treat COVID-19 patients |
|------------------------------------------------------------|--------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|---------------------------------------------------------------------------------|---------------------------------------------------------------------------------|
| Yes: Sometimes/often/always (n = 121)                      | No: Neither agree or disagree/somewhat disagree/strongly disagree (n = 45) | p-value                                                                 | p-value                                                                 | p-value                                                                 | p-value                                                                 |
| Strongly disagree 26.5% (32)                               | 44.4% (20)                                                                                     | 0.03                                                                            | <0.0001                                                                          | <0.0001                                                                          | <0.0001                                                                          |
| Disagree 32.2% (39)                                        | 33.3% (15)                                                                                     | 0.89                                                                            | 0.03                                                                            | 1                                                                               | 0.0003                                                                          |
| Neutral 5.0% (6)                                           | 8.9% (4)                                                                                       | 0.35                                                                            | 0.53                                                                            | 0.59                                                                            | 0.0004                                                                          |
| Agree 24.8% (30)                                           | 13.3% (6)                                                                                      | 0.67                                                                            | 0.05                                                                            | 0.0004                                                                          | 0.004                                                                           |
| Strongly agree 11.6% (14)                                  | 0.0% (0)                                                                                       | 0.02                                                                            | 0.21                                                                            | 0.30                                                                            | 0.002                                                                           |
| Strongly disagree 35.5% (43)                               | 55.6% (25)                                                                                     | 0.02                                                                            |                                                                               |                                                                                  |                                                                                  |
| Disagree 36.4% (44)                                        | 31.1% (14)                                                                                     | 0.53                                                                            |                                                                               |                                                                                  |                                                                                  |
| Neutral 5.0% (6)                                           | 6.7% (3)                                                                                       | 0.67                                                                            |                                                                               |                                                                                  |                                                                                  |
| Agree 15.7% (19)                                           | 4.4% (2)                                                                                       | 0.05                                                                            |                                                                               |                                                                                  |                                                                                  |
| Strongly agree 7.4% (9)                                    | 2.2% (1)                                                                                       | 0.21                                                                            |                                                                               |                                                                                  |                                                                                  |
| I feel that my institution listens when I voice concerns related to the COVID-19 pandemic | Strongly disagree 2.5% (3)                                                                          | 28.9% (13)                                                                     | <0.0001                                                                          |                                                                               |                                                                                  |
| Disagree 7.4% (9)                                          | 33.3% (15)                                                                                     | <0.0001                                                                        |                                                                               |                                                                                  |                                                                                  |
| Neutral 24.0% (29)                                         | 20.0% (9)                                                                                      | 0.59                                                                            |                                                                               |                                                                                  |                                                                                  |
| Agree 45.5% (55)                                          | 15.6% (7)                                                                                      | 0.0004                                                                         |                                                                               |                                                                                  |                                                                                  |
| Strongly agree 20.7% (25)                                  | 2.2% (1)                                                                                       | 0.004                                                                          |                                                                               |                                                                                  |                                                                                  |
| Professional counseling and/or mental health support was offered by my institution as a result of the impact on workload and stress from the COVID-19 pandemic | Strongly disagree 11.6% (14)                                                                          | 17.8% (8)                                                                     | 0.30                                                                            |                                                                               |                                                                                  |
| Disagree 9.9% (12)                                         | 24.4% (11)                                                                                     | 0.02                                                                            |                                                                               |                                                                                  |                                                                                  |
| Neutral 11.6% (14)                                         | 20.0% (9)                                                                                      | 0.16                                                                            |                                                                               |                                                                                  |                                                                                  |
| Agree 28.9% (35)                                          | 28.9% (13)                                                                                     | 1                                                                               |                                                                               |                                                                                  |                                                                                  |
| Strongly agree 38.0% (46)                                  | 8.9% (4)                                                                                       | 0.0003                                                                         |                                                                               |                                                                                  |                                                                                  |
| I am satisfied with the level of resources (sanitation items, hospital beds capacity, ventilators, medications, administration support etc.) provided by my institution to treat COVID-19 patients | Strongly disagree 6.6% (8)                                                                          | 44.4% (20)                                                                     | <0.0001                                                                          |                                                                               |                                                                                  |
| Disagree 17.4% (21)                                        | 28.9% (13)                                                                                     | 0.10                                                                            |                                                                               |                                                                                  |                                                                                  |
| Neutral 10.7% (13)                                         | 20.0% (9)                                                                                      | 0.12                                                                            |                                                                               |                                                                                  |                                                                                  |
| Agree 42.2% (51)                                          | 4.4% (2)                                                                                       | <0.0001                                                                        |                                                                               |                                                                                  |                                                                                  |
| Strongly agree 23.1% (28)                                  | 2.2% (1)                                                                                       | 0.002                                                                           |                                                                               |                                                                                  |                                                                                  |
**Table 6**

Feelings of institutional support (yes/no) stratified by various survey question.

| Institutional support | Yes: Strongly agree/somewhat agree (n = 84) | No: Neither agree or disagree/somewhat disagree/strongly disagree (n = 82) | p-value |
|-----------------------|--------------------------------------------|---------------------------------------------------------------|---------|
| I feel that my institution listens when I voice concerns related to the COVID-19 pandemic | 18.3% (15) | 22.0% (18) | 0.0002 |
| Strongly disagree | 1.2% (1) | 7.1% (6) | 0.01 |
| Disagree | 25.0% (21) | 20.7% (17) | 0.51 |
| Neutral | 45.2% (38) | 29.3% (24) | 0.03 |
| Agree | 21.4% (18) | 9.8% (8) | 0.04 |
| My institution has furloughed/laid off significant numbers of healthcare workers during the COVID-19 pandemic | 19.5% (16) | 13.4% (11) | 0.56 |
| Strongly disagree | 32.1% (27) | 11.0% (10) | 0.12 |
| Disagree | 23.8% (20) | 28.1% (23) | 0.53 |
| Neutral | 15.0% (13) | 18.3% (15) | 0.63 |
| Strongly agree | 9.5% (8) | 17.1% (14) | 0.15 |
| Professional counseling and/or mental health support was offered by my institution as a result of the impact on workload and stress from the COVID-19 pandemic | 26.8% (22) | 26.8% (22) | 0.05 |
| Strongly disagree | 7.1% (6) | 14.6% (12) | 0.77 |
| Disagree | 14.3% (12) | 18.3% (15) | 0.10 |
| Neutral | 7.1% (6) | 19.5% (16) | 0.02 |
| Agree | 46.4% (39) | 24.4% (20) | 0.21 |
| Strongly agree | 34.5% (29) | 25.6% (21) | 0.21 |
| I am satisfied with the level of resources (sanitation items, hospital beds capacity, ventilators, medications, administration support etc.) provided by my institution to treat COVID-19 patients | 26.8% (22) | 26.8% (22) | <0.0001 |
| Strongly disagree | 7.1% (6) | 14.6% (12) | 0.16 |
| Disagree | 14.3% (12) | 16.0% (13) | 0.57 |
| Neutral | 7.1% (6) | 19.5% (16) | 0.81 |
| Strongly agree | 46.4% (39) | 17.1% (14) | 0.01 |
| If you were infected with COVID-19, who is/are the most likely source(s) of the infection? | 26.8% (22) | 26.8% (22) | 0.05 |
| Colleagues | 3.7% (3) | 3.7% (3) | 0.30 |
| Family | 7.3% (6) | 7.3% (6) | 0.72 |
| Friends | 4.9% (4) | 4.9% (4) | 0.17 |
| Neighbors | 0.0% (0) | 0.0% (0) | 0.16 |
| Patient | 16.0% (13) | 14.6% (12) | 0.57 |
| Unknown | 7.3% (6) | 7.3% (6) | 0.81 |
| Not applicable | 62.2% (51) | 62.2% (51) | 0.90 |
| If you were infected with COVID-19 do you suspect or worry you may have infected others including but not limited to family, friends, patients, or colleagues? Select one | 30.0% (24) | 30.0% (24) | 0.69 |
| Yes | 32.1% (27) | 30.0% (24) | 0.69 |
| No | 48.4% (4) | 7.5% (6) | 0.49 |
| Not applicable | 63.1% (53) | 62.5% (50) | 0.78 |
| What, if anything, is/are contributing your feeling of burnout? Select all that apply | 26.2% (56) | 26.2% (56) | 0.03 |
| Increased emotional strain/anxiety from work | 35.0% (63) | 25.2% (56) | 0.03 |
| Increased workload | 18.0% (34) | 18.0% (34) | 1.0 |
| Isolation from family/friends | 29.4% (53) | 23.0% (51) | 0.14 |
| Lack of institutional support | 7.8% (14) | 16.7% (37) | 0.01 |
| Need for a safe place to go after work | 5.0% (9) | 8.6% (19) | 0.17 |
| Other (please specify) | 7.7% (7) | 7.7% (7) | 0.11 |

A significant difference in the number of respondents endorsing versus denying burnout. A previous study investigating the mental health effects of the COVID-19 pandemic on healthcare workers found that healthcare workers felt that they and their loved ones were more susceptible to infection due to the shortage of supplies and resources [29]. Increased patient volume and work intensity were also named as contributing factors to this group’s decline in overall mental health [29]. Additionally, the highly infectious nature of the virus and lack of definitive management guidelines or viable treatment options were found to be at least partly responsible for the mental health decline as well [30]. Lai et al. noted a significant proportion of surveyed healthcare workers reported insomnia, anxiety, depression, and distress symptoms due to treating patients with COVID-19 [31]. Our survey also found the most cited factors contributing to EM physician burnout to be increased work-related emotional strain and anxiety, isolation from family and friends, and increased workload. However, no significant difference was found for citing these contributors between respondents reporting feelings of burnout and those who did not.

Not only did our survey demonstrate EM physicians face greater burnout from the pandemic, but it also shows that a greater proportion of EM physicians reported inadequate professional counseling and support as a component of inadequate resource availability. We also found that physicians reporting job satisfaction noted greater availability of such services. These findings highlight the importance of mental health services [26]. Physicians with access to readily available psychological support services have shown reduced burnout rates [32]. Moreover, distressed physicians were found to benefit from confidential, secure mental health services as well exhibiting again decreased burnout rates and increased professional fulfillment [33]. Unfortunately, the limited access to mental health support and services during pandemic closures has further worsened issues of anxiety, psychological distress, and depression [29]. This is especially concerning as a few ED physicians have died by suicide as a result of the strain of the COVID-19 pandemic [34,35].

The results of this survey also indicate a relationship between job dissatisfaction and burnout; EM physicians reporting feelings of burnout were more likely to express job dissatisfaction. This finding is consistent with existing literature on physicians in other specialties [36,37]. Interestingly, our survey found that physicians age 41–60 reported the highest proportion of job dissatisfaction and burnout. This seems to suggest that those most at risk of burnout are mid-career physicians. The Medscape National Physician Burnout & Suicide Report
seen in late-career physicians [41]. The authors found that as by career stage [39]. They found mid-career physicians, de
Dryby et al. evaluated differences in physician satisfaction and burnout and mid-career physicians [39]. Peisah et al. investigated this trend levels of burnout and higher job satisfaction when compared to early [40]. Dryby et also found late-career physicians demonstrate lower physicians, those in their late-career were less vulnerable to burnout report burnout. Del Carmen et al. assessed burnout of physicians in a stages, and were more likely to consider leaving the medical
be attributable to dissatisfaction with career progress, home or personal
field.

Professional counseling and/or mental health support was offered by my institution as a result of the impact on workload and stress from the COVID-19 pandemic

| Job satisfaction | Yes: Strongly agree/somewhat agree (n = 94) | No: Neither agree or disagree/somewhat disagree (n = 72) | p-value |
|------------------|------------------------------------------|------------------------------------------------|---------|
| Strongly agree   | 5.3% (5)                                 | 15.3% (11)                                      | 0.03    |
| Disagree         | 12.8% (12)                               | 16.7% (12)                                      | 0.48    |
| Neutral          | 19.2% (18)                               | 27.8% (20)                                      | 0.19    |
| Strongly agree   | 44.7% (42)                               | 27.8% (20)                                      | 0.03    |
| Agree            | 18.1% (17)                               | 12.5% (9)                                       | 0.33    |

If you were infected with COVID-19 do you suspect or worry you may have infected others including but not limited to family, friends, patients, or colleagues? Select one

| If you were infected with COVID-19 | Yes | No | Don’t know | Not applicable |
|-----------------------------------|-----|----|------------|----------------|
| Always                            | 31.2% (29) | 31.0% (22) | 0.97 |                  |
| Often                             | 10.6% (10) | 18.1% (13) | 0.17 |                  |
| Rarely                            | 9.6% (9) | 19.4% (14) | 0.07 |                  |
| Sometimes                        | 29.8% (28) | 27.8% (20) | 0.78 |                  |
| Sometimes                        | 39.4% (37) | 18.1% (13) | 0.003 |                  |

If you feel more callous towards patients, staff, family, and/or people around me as a result of my work during the COVID-19 pandemic

| If you feel more callous towards patients | Never | Rarely | Sometimes | Often | Always |
|-----------------------------------------|-------|--------|-----------|-------|--------|
| Never                                   | 37.6% (35) | 25.4% (18) | 0.09 |                  |
| Rarely                                  | 36.6% (34) | 26.8% (19) | 0.18 |                  |
| Sometimes                               | 22.6% (21) | 35.2% (25) | 0.08 |                  |
| Often                                   | 3.2% (3) | 9.9% (7) | 0.08 |                  |
| Always                                  | 0.0% (0) | 2.8% (2) | 0.11 |                  |

If my academic obligations (research, teaching, etc.) have been negatively impacted by my clinical responsibilities due to the COVID-19 pandemic

| If my academic obligations | Never | Rarely | Sometimes | Often | Always |
|----------------------------|-------|--------|-----------|-------|--------|
| Never                      | 29.7% (27) | 23.2% (16) | 0.34 |                  |
| Rarely                     | 20.9% (19) | 4.4% (3) | 0.003 |                  |
| Sometimes                  | 23.1% (21) | 33.3% (23) | 0.17 |                  |
| Often                      | 17.6% (16) | 30.4% (21) | 0.06 |                  |
| Always                     | 8.8% (8) | 8.7% (6) | 0.97 |                  |

If I feel more burned out because of the COVID-19 pandemic as compared to before it

| If I feel more burned out | Never | Rarely | Sometimes | Often | Always |
|--------------------------|-------|--------|-----------|-------|--------|
| Never                    | 10.6% (10) | 5.6% (4) | 0.24 |                  |
| Rarely                   | 27.7% (26) | 2.8% (2) | -0.0001 |                  |
| Sometimes                | 42.6% (40) | 38.9% (28) | 0.64 |                  |
| Often                    | 14.9% (14) | 31.9% (23) | 0.01 |                  |
| Always                   | 4.3% (4) | 20.8% (15) | 0.001 |                  |

2020: The Generational Divide reported similar findings [12]. In their evaluation of suicide among surgeons, Elkbuli et al. found that middle aged physicians comprised the majority of completed suicides [38]. Dryby et al. evaluated differences in physician satisfaction and burnout by career stage [39]. They found mid-career physicians, defined as having 11–20 years of work experience, were more likely to have burnout and high emotional exhaustion compared to physicians at other career stages, and were more likely to consider leaving the medical field. These findings persisted even after controlling for factors such as gender, specialty, and institution type. The mid-career peak burnout may be attributable to dissatisfaction with career progress, home or personal conflicts, and long work hours and call days; dissonance between mid-career expectations and reality may impact burnout and warrants further investigation [39].

Conversely, physicians with >20 years of practice were less likely to report burnout. Del Carmen et al. assessed burnout of physicians in a large academic center. They noted that when compared to mid-career physicians, those in their late-career were less vulnerable to burnout [40]. Dryby et also found late-career physicians demonstrate lower levels of burnout and higher job satisfaction when compared to early and mid-career physicians [39]. Peisah et al. investigated this trend and identified two key factors that allow for the lower burnout levels seen in late-career physicians [41]. The authors found that as experienced physicians are more aware of burnout, they have delineated personal boundaries from their professional responsibilities to protect themselves. Furthermore, the accumulated clinical experience of late-career physicians has fostered confidence in their abilities and in so liberated them from the stressors of providing quality healthcare [41].

We also found that EM physicians who were satisfied with their career, more likely to feel listened to by their institutions. They were also more likely to feel that they were able to carry on with obligations outside their clinical duties such as research or education. It is important to recognize this phenomenon. A sense of control over practice environment and autonomy can aid in not only increasing job satisfaction and reducing burnout but also can improve the quality of healthcare provided and physician adherence to guidelines [42].

Our survey found that the highest proportion of physicians reporting burnout were in the South, followed by the Midwest, and the Western US. However, there was no statistically significant difference in the proportion reporting burnout versus no burnout in any region. This may be due to the greater number of survey respondents were from these regions. The geographic distribution of respondents may not be completely representative. The analysis of differences in survey responses between regions may limit the overall generalizability due to the variations in COVID-19 exposure surge, severity of cases and fatalities, and resource utilization. Also, it is possible that regional differences in responses can be linked to dissimilarities in provincial politics however, it is not possible to make definitive conclusions on the effect of politics in survey responses. Of note, the lowest number of respondents were from the Northeast, one of the regions initially most impacted by COVID–19 [43,44].

While our study focused on the effect of COVID-19 on feelings of burnout among EM physicians, it may be appropriate to examine effects in other medical specialties and non-medical fields as well. EM physicians may not be alone in feeling increased burnout due to recent events. Jha et al. evaluated the COVID-19-related burnout among interventional pain specialists and found that 98% of responding practices were negatively affected by the pandemic, and 52% of responding physicians reported burnout. However, they also found that 76% of those surveyed previously felt this way earlier in their careers [45].

The following limitations should be considered when interpreting the results of this study. The response rate of 18.7% was relatively low and may represent some level of nonresponse bias. It is possible that increased workload or burnout itself may present a barrier to survey completion. Because of the low response rate and small sample size, this survey may not reflect the sentiment and attitudes of all EM physicians. Instead, it offers useful insights from EM colleagues who are actively participating in the care of COVID–19 patients and who are members of the ACEP and EMPRN. Their experiences across the country are likely similar to many of their colleagues. Several attempts were made to maximize the response rate; reminder emails were sent two and four weeks after the initial dispersal of the survey through the EMPRN online mail system. Additionally, the cross-sectional nature of this study only allows for momentary insight into the perspective of the respondents. This survey was distributed after a peak in US COVID–19 incidence, which may have some effect on responses regarding institutional resources and support. It may be of value to reexamine the effects of vaccine availability on EM physician responses to burnout. Geographic differences in COVID–19 burden may also account for any regional differences in sentiment; there were notable differences in response rate and peak case incidence between states. The majority of respondents of this survey were male and white; therefore, the generalizability of these findings may be limited; the perspective of female and minority EM physicians may be under-reported. This is interesting to note as the literature has demonstrated high levels of burnout and lower perceived control over work environment among female EM physicians [46–48]. Those who are mid-career are seven-fold more likely to seriously contemplate leaving the field when compared to their male counterparts [47].
Additionally, prior studies have found minority physicians report race-related struggles such as discrimination, microaggressions, and feelings of marginalization contributing to higher levels of career dissatisfaction and contemplation of switching careers [49–51]. Therefore, more investigation of these two under-reported groups is needed.

There are no studies that we are aware of that evaluate burnout as a result of COVID-19 between different medical specialties. In the future, this survey may be distributed to other specialty professional societies to examine potential differences between groups. Interestingly, in the study conducted by Wu and colleagues in Wuhan, China, evaluating burnout among physicians in frontline COVID-19 work areas and non-COVID-19 wards, there was significantly lower burnout in the frontline group [52]. Further investigation on whether burnout is related to frontline work versus COVID-19-related stress, in general, may be needed.

5. Conclusion

EM physicians face many stressors from the inherent high-stakes nature of the field, which may be further heightened in the COVID-19 pandemic. EM physician burnout may be compounded by perceived resource scarcity, psychological stress, isolation, and job dissatisfaction. The importance of mental health support for EM physicians is highlighted by the report of inadequate mental health services and resources by many of the survey respondents. It may be valuable to reexamine shifting attitudes and the evolution of contributing factors through the progression of this pandemic. The findings of this study may help identify solutions to mitigate these issues.

Author contribution

Study design and conception: Adel Elkbuli, Jackie Nguyen. Data collection, interpretation and analysis: Adel Elkbuli, Jackie Nguyen, Amy Liu, Huazhi Liu, Darwin Ang, Mark McKenney. Manuscript preparation: Adel Elkbuli, Jackie Nguyen, Amy Liu, Mark McKenney, Darwin Ang. Critical revision of manuscript: Adel Elkbuli, Jackie Nguyen, Amy Liu, Huazhi Liu, Mark McKenney, Darwin Ang. All authors read and approved the final manuscript.

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Declaration of Competing Interest

Authors disclose no competing interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ajem.2021.03.088.

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