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Differences in Crowding and Stress Experienced by Emergency Medicine Physicians Prior to and During the COVID-19 Pandemic

Caroline Grace Barrows

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Clemson University

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Burnout in Emergency Medicine physicians has become an increasingly apparent problem in the United States. This psychological syndrome is a result of emotional exhaustion, detachment, and an overwhelming sense of ineffectiveness (Maslach & Leiter, 2016). Work demands within the emergency department are likely to produce chronic exposure to stressors. However, the onset of the COVID-19 pandemic likely contributed to amplifying workplace stressors, suggesting that the rate at which burnout developed was elevated. In the present study, data were collected from Emergency Medicine physicians at Greenville Memorial Hospital in Greenville, South Carolina prior to the start of and during the COVID-19 pandemic. Physicians provided saliva samplesfor salivary cortisol analysis and completed a short assessment of fatigue and shift demands. These data were collected at the beginning and end of each shift, for a total of 116 shifts. Analyses will be done to test whether the average number of stressors reported by physicians, National Emergency Department Overcrowding Scores (NEDOC) scores, and salivary cortisol levels increased in data collected after the start of the pandemic, in comparison to before, for the end-of-shift measures.

In order to provide support for these claims, this thesis will begin with an overview of research that has previously been examined on the topic. Firstly, the significance of burnout in healthcare professionals will be described and discussed. The focus will then shift to emergency medicine, highlighting the primary stressors that are faced by healthcare personnel within the emergency department. The consequences of stressors, such as well-being or burnout, on emergency medicine physicians, including the use of salivary cortisol as an objective measure of stress, will be examined. Next, how the COVID-19 pandemic has exacerbated burnout within

these settings will be discussed. The introduction will conclude with a presentation of the overview of the study and reveal the hypotheses that are intended to test.

Burnout in Healthcare Professionals

Burnout of healthcare professionals is very common and is classified by high levels of emotional exhaustion, frustration, and feelings of ineffectiveness. This work-related phenomenon can be caused by continuous exposure to stressors and chronic fatigue and was first identified in the early 1970s by Herbert Freudenberger. Freudenberger argued that burnout results due to excessive demands in the subjects of energy, strength, or resources (Freudenberger, 1975). The impacts of burnout can creep into other aspects of one's life, such as their interactions with coworkers, ability to cope with stress, quality of sleep, and capacity to fight off illness. Burnout also contributes to the overall care received by patients and the quality of work performed within the healthcare setting. In an analysis of 82 studies, Salyers et al. (2016) examined the relationship between healthcare provider burnout and quality of care. The studies analyzed data obtained from 210,699 healthcare providers. In this case, burnout was classified as emotional exhaustion, depersonalization, and reduced personal accomplishment. Results showed that levels of burnout were negatively associated with the quality of care and safety of patients. Study-level moderators of this relationship were tested for both quality and safety. These moderators included year, type of report, provider type, setting, region, and quality of the study. Both burnout and events, the two safety indicator types studied, were found to be significant. "Events" included reported adverse events and near misses. However, burnout had a stronger relationship with the perception of safety (Salyers et al., 2016).

Associations between emotional intelligence development and burnout in healthcare workers may also exist. Năstasă and Fărcaş (2015) examined 120 healthcare professionals, both

nurses and physicians, who completed two psychological tests: the Maslach Burnout Inventory and an Emotional Intelligence Scale. The Maslach Burnout Inventory was designed specifically to examine professional burnout in employees that work with customers. The inventory has 25 items: nine referring to emotional exhaustion, five to depersonalization, eight to personal accomplishment, and three optional items centered on personal accomplishment. High scores on this self-administered test correlate to a high degree of burnout. On the other hand, the Emotional Intelligence Scale measures emotional intelligence from the perspective of its skills. These skills include identifying, using, understanding, and managing emotions. Results from the study showed that there was a statistically significant positive relationship between emotional intelligence and the burnout subscale of the ability to sense personal accomplishment. They also found that nurses experienced a higher sense of accomplishment than physicians. However, emotional intelligence development was higher in physicians than in nurses. Researchers believe that the ability to manage emotions, detach from problems, and be flexible are key practices for healthcare workers to overcome their struggles with burnout.

Burnout is linked to negative outcomes for both physicians and patients. In a study done with 7,095 surgeons, results showed that there was a strong, positive correlation between reporting a perceived error in the past three months and both symptoms of depression and the three domains of burnout used in the study: emotional exhaustion, depersonalization, and personal accomplishment (Shanafelt et al., 2010). Results also show an increased risk of future errors being made by a physician who has made errors in the past, but additional studies are necessary to determine if distress caused by the first error is a contributing factor to the occurrence of the second error.

In a study comparing instances of burnout in US physicians in comparison to workers in other fields, 7,288 physicians were surveyed using the Maslach Burnout Inventory (Shanafelt et al., 2012). Analysis revealed that 45.8% of physicians who completed the survey reported at least one symptom of burnout. Additionally, surveys showed that physicians worked an average of ten hours more per week, had higher levels of dissatisfaction with work-life balance, and were at a higher risk for emotional exhaustion than employees from other occupations. Notably, there was no statistically significant difference found in symptoms of depression or suicidal ideation. Overall results suggested that burnout, and its symptoms, are more commonly found in physicians than workers in other fields in the United States. Furthermore, it was discovered that the specialties of emergency medicine, internal medicine, neurology, and family medicine had the highest rates of burnout. On the other hand, pathology, dermatology, general pediatric, and preventative medicine had lower rates. These findings suggest that burnout is impacted by many different factors, such as patient demographics, age, call schedule, and rigor of training.

Three years later, to further examine the growing issue of burnout, the Maslach Burnout Inventory was used again to compare data to the previous study (Shanafelt et al., 2015). Researchers found that in 2014, compared with 2011, the percentage of physicians reporting at least one symptom of burnout increased to 54.4%. Consequently, satisfaction with work-life balance declined. In 2011, 48.5% of physicians surveyed reported being satisfied with their work-life balance. This percentage decreased to 40.9% in 2014. These findings support the argument that burnout is an increasing issue within the healthcare community.

Burnout in Emergency Medicine Physicians

As discovered by Shanafelt et al. (2012), certain specialties within the healthcare field pose an increased risk of the development of burnout. Emergency medicine was discovered to be

one of these specialties. Burnout is widespread within the emergency medicine field, affecting greater than 60% of physicians and having the highest rate of burnout in comparison to physicians in general. In a study of 1,272 emergency physicians in the United States, a 79-item questionnaire was given to categorize burnout into ranges (Goldberg et al. 1996). 60% of participants experienced moderate to high burnout and using this data, 21 correlated predictors were observed. The most highly correlating predictors were: self-recognition of burnout, lack of job involvement, negative self-assessment of productivity, dissatisfaction with career, sleep disturbances, increased number of shifts per month, dissatisfaction with specialty services, intent to leave the practice within 10 years, higher levels of alcohol consumption, and lower levels of exercise.

The majority of emergency medicine physician studies have been conducted in urban areas. However, one study from Southwestern Ontario aimed to analyze the differences between physician wellness in urban and rural areas (Leigh et al., 2020). 67 urban and 22 rural emergency medicine physicians were recruited. Participants completed the Maslach Burnout Inventory-Human Services Survey (MBI-HSS). Scores equal to or above 27 in the emotional exhaustion section and scores equal to or above 10 in the depersonalization section were considered the threshold for burnout. It was found that 71.4% of urban and 85.7% of rural physicians met this threshold. It was concluded that both urban and rural emergency medicine physicians experienced high levels of burnout. There was no statistically significant difference between the two groups.

In another Canadian study, researchers had the goal of determining levels of life and job satisfaction, burnout, and depression in emergency medicine physicians (Lloyd, Streiner & Shannon, 1994). Several different tools were used to gather these data: the emotional exhaustion,

depersonalization, and personal accomplishment intensity subscales of the Maslach Burnout Inventory (MBI), the Center for Epidemiologic Research Self-Report Depression Scale (CES-D), the Satisfaction With Life Scale (SWLS), and the Emergency Physician Job Satisfaction Measurement Instrument (EPJS). Of the participating physicians, 46% were classified as having medium to high levels of emotional exhaustion, 93% as having medium to high levels of depersonalization, and 79% within the medium to low range of personal accomplishment. Despite these high indicators of burnout, 61% had satisfaction with their lives and 75.5% with their career. Further analysis showed that a positive correlation existed between increased age, being a department head, and increased vacation time in a year all contributed to EPJS scores. However, involvement in medical education and increased clinical hours worked per year negatively correlated with EPJS scores.

Furthermore, in a study comparing different roles within the emergency medicine field in Romania, it was found that emergency medicine physicians experienced the highest rate of emotional exhaustion among the other roles within the department (Popa et al. 2010). While personal accomplishment values were high, higher values were found in emergency medicine nurses. Researchers suggest that this may be due to work hour limits. In Romania, nurses will only work up to 12 consecutive hours, while physicians may work up to 24. Additionally, levels of depersonalization were relatively low for all roles studied; however, higher-than-average values were found in the emergency medicine physician category. To explain these results, several key problems within the field were identified: high patient flow to the emergency department, insufficient staffing, low levels of interaction with other patient care systems, staff supervision, and dealing with management.

Using a mail-in survey with a 43.1% response rate, emergency medicine physician career satisfaction, tolerance for uncertainty, and burnout were analyzed (Kuhn, Goldberg & Compton, 2009). The largest takeaway from this study was that emotional exhaustion was the most widely-experienced symptom of burnout. This emotional exhaustion was rooted in anxieties produced by the fear of bad outcomes. Concerns regarding producing bad outcomes were the greatest indicator of burnout in emergency medicine physicians.

Likely as a result of extreme emotional exhaustion, depersonalization, and a reduced sense of personal accomplishment, more than 400 emergency medicine physicians have taken their own lives annually, while 6,000 have considered suicide (Stehman et al., 2019). Additionally, both emergency medicine physicians and residents experience higher rates of substance abuse than any other specialty. Estimations suggest 4.9-12.5% of emergency medicine residents drink daily and 7-18% seek treatment for substance abuse. Furthermore, emergency medicine physicians are at a greater risk of falling to Second Victim Syndrome. This phenomenon occurs due to trauma, shame, anxiety, or guilt, resulting from a patient with a bad outcome (Stehman et al., 2019). Due to the little time that emergency medicine physicians have to debrief and cope before treating the next patient, they often fall victim to this syndrome, making them more likely to commit errors in the future. Second Victim Syndrome is closely tied to burnout in the emergency medicine field. While burnout is not a direct precursor to suicide, emergency medicine physicians are especially at-risk for the condition. The many factors that lead to the development of burnout are also contributing factors to depression, self-medication, declined quality of care, and suicide.

Research has also been conducted on protecting character traits against burnout. Dam et al. (2009) conducted a study across five large, urban, academically affiliated emergency

departments to analyze the relationships between burnout, well-being, and grit. Grit is defined as a positive character trait based on perseverance and passion for a specific long-term goal. To quantify these, the Short Grit Scale, Maslach Burnout Inventory, and World Health Organization-5 Well-Being Index were used. Ultimately, 222 emergency medicine residents completed the survey, a response rate of 86%. It was found that 173 (77.9%) of these residents met the criteria to be classified as experiencing burnout and 107 (48.2%) for low well-being. However, the residents with high scores on the Short Grit Scale were more likely to experience lower levels of burnout and have greater well-being. Moreover, residents with low scores on the Short Grit Scale were more likely to experience high levels of burnout and have lower well-being. These data suggested a significant relationship between grit, burnout, and well-being.

Stressors Faced by Emergency Medicine Physicians

Many different stressors contribute to the development of burnout in emergency medicine physicians. A study done in Australia and Sweden analyzed the prevalence and severity of 15 stressors, identified by the ED Stressor Scale, in emergency department staff (Greenslade et al., 2020). This was done using a cross-sectional survey where the median stress score for each item and frequency of each event were reported. It was found that the events responsible for the greatest amount of stress were heavy workload, death of a child, sexual abuse of a child, inability to provide optimum care, and workplace violence. In addition, the most commonly occurring stressful events included treating high acuity patients, heavy workload, and crowding of the emergency department. A separate study concluded that despite the frequency of occurrence, the events having the greatest impact on stress include the death of a child and sexual abuse of a child. In this separate study, the heavy workload was identified as the most prevalent stressor in emergency medicine physicians (Elder et al., 2019). This study was conducted in two public

Australian emergency departments using both doctors and nurses. When coping strategies were analyzed, it was found that female medical staff were more likely to cope with the negative strategy of blaming themselves than their male counterparts.

To analyze the environmental stressors within the clinical setting of emergency physicians, twelve surveys were collected for 18 emergency medicine residents, four each from the day, evening, and night shifts (Wrenn et al., 2010). 216 shifts in total were analyzed. The goal of this study was to examine the impact of overcrowding on emergency medicine resident stress, and the prevalence of stress related to hours worked and sleep deprivation. Surveys completed consisted of the Perceived Stress Questionnaire and a visual analog stress scale. Using multivariate mixed-effects regression analysis, it was determined that anticipated overtime and process failures were associated with stress. Process failure refers to a fault in performance, such as an adverse event or outcome. This study did not find emergency department overcrowding to be a significant cause of stress in emergency medicine residents.

However, it is known that overcrowding has become an increasingly significant problem in emergency departments worldwide (Di Somma et al., 2015). Overcrowding can be a result of different factors, including, but not limited to, insufficient access to hospital beds and a shortage of emergency department nurses and physicians. Overcrowding can increase the length of waiting time for receiving care, leading to poor patient outcomes, increased medical errors, adverse events, and increased morbidity and mortality.

In order to systematically quantify overcrowding on a standardized level, the National Emergency Department Overcrowding Study (NEDOCS) score system was created (Weiss et al., 2004). The creation of NEDOCS stemmed from a 23-question site-sampling form that was designed using the input of academic physicians at eight different medical schools (Weiss et al.,

2004). The sample form was reduced to five questions that predicted the full result of the full 23-question model with 88% accuracy, therefore the five-question form was used as the index of crowding. The system assists to allow hospitals to anticipate needs and provide appropriate resources to the emergency department based on total patients, patients using ventilators, number of beds in the emergency department, number of beds in the hospital, waiting time of the longest-waiting waiting room patient, and admitted patient, and number of new admissions to the emergency department. To test the effectiveness of the NEDOCS, scoring was compared to the physicians' perception (Hargreaves et al., 2020). Results showed that NEDOC scores were sufficiently correlated with clinician perception. Before NEDOCS, it was difficult to quantify crowding and determine emergency department cut-off thresholds.

Aside from stressors within the clinical setting, operational stressors also exist. Operational stressors include the measure of workload, patient acuity, and complexity of the case. Pines et al. (2020) assessed clinical shifts to search for a disparity in workload across shifts. Their goal was to identify if certain shifts had more obligations than others in order to determine if operational stressors, such as workload, patient acuity, and case complexity, should be considered for clinician scheduling. Shifts were categorized into three groups; morning, 7 AM to 3 PM, evening, 3 PM to midnight, and night, midnight to 7 am. Shifts less than one hour or more than 24 hours in length were excluded from the study. From evaluating shifts from 2014 to 2018 in 159 general emergency departments, located in 22 different states within the US, 14,085,448 unique emergency department patient visits were analyzed, over the course of 353,126 shift periods. Results showed that the average number of patient discharges per hour was 2.23. Operational stressors, as defined above, had significant but small effects on the number of patient departures per hour and the percentage of admissions. While operations stressors had minimal

impacts, temporal factors, such as time and day of the week, and facility characteristics, such as annual visit volume, teaching status, and location, had more influence on scheduling.

Salivary Cortisol as an Indicator of Stress

Salivary cortisol is often used as a physiological biomarker of stress. It has been used across many studies as a reliable measure of hypothalamic-pituitary-adrenal axis (HPAA) adaptation to stress (Hellhammer et al., 2009). Cortisol is the human body's primary stress hormone. This hormone increases glucose in the bloodstream which provides the body with energy to overcome stressful situations. While effective in short-term scenarios, increased cortisol secretion can be physically and psychologically damaging if secreted at elevated levels over long periods of time (Hannibal & Bishop, 2014). Furthermore, due to the fact that saliva samples can be taken easily, without provoking additional stress, and without the need for a trained medical professional, salivary cortisol measures serve as a reliable mode for the assessment of stress in psychobiological studies (Kirschbaum & Hellhammer, 1989).

In a study done using 77 healthy subjects working at a video display unit, short-term stress was analyzed (Schreinicke et al., 1990). Participants carried out a task on the video display unit for 30 minutes. This task required high speed and accuracy. Saliva samples were collected before and after the task. Heart rate, blood pressure, and respiratory rate were also measured before and after the task as additional indicators of physiological stress. Results showed that participants had increased levels of heart rate, blood pressure, and respiratory rate after completing the task. Salivary cortisol levels, determined by sensitive enzyme immunoassay, were significantly increased after the task. These results indicated that salivary cortisol is an effective means of measuring short-term stress.

Another study was designed to investigate physiological stress responses induced by mental arithmetic (Qi et al., 2016). Fifteen participants were asked to estimate the product of a multiplication problem, involving two-decimal numbers, above or below 10, either with or without a time limit. This estimation was done mentally, without the assistance of a calculator. For this experiment, the group was asked to perform the mental arithmetic with a time limit to serve as the stress condition, while the group not given a time limit served as the control condition. Before the experiment, all participants were instructed to answer the mathematical questions as quickly and accurately as possible. Both saliva and self-reports by the participants of stress were taken before and after each performance episode. Participant anxiety levels and emotional states were also analyzed using the State-Trait Anxiety Inventory and the Positive and Negative Affect Scale. Results revealed that both the level of state anxiety and the level of negative affect were higher for the stress condition than in the control condition. Additionally, when subjective measures were analyzed using ANOVA, it was found that self-reported stress was highest after stress cessation. Similarly, salivary cortisol peaked ten minutes following the stress cessation, explained as an expected time lag.

Salivary cortisol has become a common method of objectively measuring stress. A study performed comparing stress between emergency medical dispatchers and control subjects aimed to analyze stress experienced by workers in a medical dispatch center (Weibel et al., 2003). Eight healthy medical dispatchers, all having worked at the dispatch center for at least a year and having the same work rotation, participated. All data were collected after a period of seven rest days, to avoid confounding variables on the circadian rhythm of cortisol. Saliva was collected every two hours between 9 AM and 7 PM from both the experimental and control groups. Results showed that emergency medical dispatchers had significantly higher levels of salivary

cortisol at all time points, averaging 22.8% higher than the control group. Additionally, results showed that perception of emotional stress positively correlated with total cortisol concentration.

COVID-19's Impact on the Stressors Faced by Healthcare Professionals

This study happened to be collecting data prior to the COVID-19 pandemic to analyze stress and fatigue in emergency medicine physicians. Timing allowed for the comparison of objective and subjective measures of stress in these physicians during the COVID-19 pandemic, compared to before its beginning. Burnout in physicians has been a known and growing issue for decades. However, the COVID-19 pandemic has both worsened existing and created additional stressors within the healthcare field. Some of these newfound stressors include the risk of infection, social isolation, and economic consequences (Bradley & Chahar, 2020). A study of 9,120 ICU clinicians revealed special measures critical care workers were taking during the outbreak of COVID-19, such as changing clothes (72%), showering and/or washing clothes away from family members (64%), using hand sanitizer before entering home (51%), self-isolation with the home (16%), and alternative housing away from family members (12%) (Kleinpell et al., 2020). This same study also revealed many potentially limited resources in the intensive care unit: personnel (41%), isolation room capacity (31%), ICU bed capacity related to surge potential (36%), medications (36%), necessary communication from the institution about care strategies (23%), and ventilators (25%). Kleinpell et al. (2020) suggest prioritizing COVID-19 testing for healthcare workers may alleviate levels of personal anxiety and stress and that lowering these levels should be a primary objective.

A Romanian study of 523 healthcare workers from two hospitals aimed to identify predictors of burnout during the COVID-19 pandemic (Cotel et al., 2021). Participants completed a series of questionnaires that identified burnout, job demands, job resources, and

personal resources. Burnout was measured using the Maslach Burnout Inventory, job demands using the Job Demands in Nursing Scale, job resources using the Job Resources in Nursing Scale, and personal resources using the Job Demands–Resources Questionnaire. The results revealed three job demands (work/family conflict, lack of preparedness/scope of practice, and emotional demands), three job resources (training, professional development, and continuing education), and one personal resource (self-efficacy) as significant predictors of burnout during the pandemic.

In mid-March of 2020, a study was conducted with the goal of assessing factors that affect the psychological health of emergency medicine physicians in the United States (Rodriguez et al., 2020). Researchers identified this time period as the "acceleration" phase, explaining that they hoped to collect data from each of the three phases of the pandemic, acceleration, plateau/deceleration, and resolution. A survey was designed that addressed the following subjects: provider estimates of numbers of patients treated with suspected COVID-19 infection, availability of COVID-19 diagnostic testing, home and workplace anxiety, work burnout, identification of work-related stressors, changes in behavior at home arising from their work during the pandemic, and perceptions as to what measures might decrease provider anxiety. The survey was sent out to 751 emergency medicine physicians, including residents and fellows, and received 426 responses (57% response rate). Of these responses, 98.4% indicated that they had come in contact with a patient who had contracted the virus between February 15th, 2020, and their survey date. The median number for both work stress levels and home stress levels, caused by the pandemic, was a five on a scale of one to seven. On the other hand, physicians reported a median number of 4 when asked about emotional exhaustion and burnout since the start of the pandemic, compared to a 3 for pre-pandemic conditions, on the same one to seven

scale. Additionally, it was found that women, on average, reported a higher effect of the pandemic on both work and home anxiety levels than men.

Furthermore, a second survey was sent out (Baumann et al., 2021). Of the 426 initial respondents, 262 completed the follow-up survey. 97.3% of the respondents reported treating a patient with suspected COVID-19 infection between April 1st and May 7-14th of 2020. Interestingly, the majority of physicians (61.8%) had not yet received any COVID-19 testing at the time of taking the second survey. Of the 209 respondents that had not received testing, 167 (80%) were interested in receiving serological testing for antibodies. PC-PTSD-5 was used to screen participating emergency medicine physicians for PTSD. It was found that 33% of participants met risk level requirements for PTSD in the initial survey, while 26% met requirements in the second, follow-up survey. Additionally, a greater proportion of women met these requirements than men.

Overview of Proposed Study and Hypotheses

I was interested in examining the stressors experienced by emergency medicine physicians, salivary cortisol as an indicator of stress, and how both of these factors are impacted by the crowding of the emergency department before the start of the pandemic and during the pandemic. The present study will examine whether there is a difference between the number of stressors reported by emergency medicine physicians, per shift, and the average crowding score of shifts, before and after the start of the COVID-19 pandemic. These data were collected in the emergency department of Greenville Memorial Hospital in Greenville, South Carolina. Additionally, end-of-shift measures of cortisol taken prior to the start of the pandemic will be compared to those taken during the pandemic. There are several hypotheses that I will be examining in the present study.

Hypothesis 1: The average crowding score, determined by NEDOCS, will be significantly higher during the COVID-19 pandemic than before the pandemic.

Hypothesis 2: The average number of stressors, reported in an end-of-shift questionnaire at the end of every shift, will be higher during the COVID-19 pandemic than before the pandemic.

Hypothesis 3: End-of-shift cortisol levels, a physiological indicator of stress, will be higher during the COVID-19 pandemic than before the pandemic

Hypothesis 4: The difference in cortisol levels before and during the pandemic will be a function of the elevated crowding scores and reported number of stressors, as a function of either increased crowding scores or increased stressor reporting.

Method

Context

Data for this study were collected between November 2019 and July 2021. More specifically, data were collected between November 19th, 2019, and March 8th, 2020, then again between February 18th, 2021, and July 1st, 2021. In the first window of data collection, there were zero reported cases of COVID-19 in Greenville County, South Carolina. The first reported case occurred on March 10th, 2020. However, in the second window of data collection, there were 13,998 reported cases in Greenville County. By the end of the second window of data collection, a total of 75,688 cases had been reported from the start of the pandemic to July 1st, 2021. Moreover, there were 101,977 new COVID-19 cases reported in the state of South Carolina during the second window of data collection. By the end of this window, July 1st, 2021, 597,021 cases had been reported in total since the beginning of the pandemic (The New York Times, 2021).

Participants

Data were collected from 16 Emergency Medicine physicians over the course of 116 shifts. 60 of these shifts occurred prior to the COVID-19 pandemic, while 56 occurred during the pandemic. Nine females and seven males participated in the study and each completed no more than eight shifts. All participants were physicians, residents, or attendings at Greenville Memorial Hospital in Greenville, South Carolina. Data were collected from November 19th, 2019 to March 8th, 2020 before the pandemic, and from February 18th, 2021 to July 1st, 2021 during the pandemic. Shifts assessed during the initial time period were identified as pre-pandemic and shifts assessed during the second time period were identified as during the pandemic.

Measures

NEDOC Score. National Emergency Department Overcrowding Scores (NEDOCs) were used to estimate the severity of overcrowding within Greenville Memorial Hospital every 15 minutes. Evaluated on a scale of 1 to 200, a NEDOC score of 120 indicated a crowded ED, while a score of 160 indicated severe overcrowding, and dangerously overcrowdedness was indicated for a score of 200 (Weiss et al., 2004). Using site sampling techniques, Weiss et al. (2004) created the NEDOC scoring system. This system takes into account the number of beds in the emergency department, the total number of beds in the hospital, the total number of patients in the emergency department, the number of patients being treated with a mechanical ventilator, the time in hours of the patient with the longest stay in the emergency department, and the time in hours since the last patient was admitted. For each shift, the average NEDOC score system was used to determine crowding in the Greenville Memorial Hospital emergency department. A score was generated every 15 minutes and these scores were averaged together for each 8-hour shift in which data were collected.

Stressors Reported by Physicians. Participants completed a survey at the end of each shift. A portion of this survey was dedicated to identifying demands faced during the shift. A 10 CM line was used and participants dragged a notch to one of the following descriptors: Not at All, A little, Somewhat, A lot, or Very Much. Participants used this answering method to respond to the following question for 10 different stressors: How frequently did you encounter the following. The stressors were as follows: Low acuity patients, High acuity patients, Difficult patient/family encounters, Needed equipment, supplies, or medications not readily available, Unnecessary interruptions, Necessary interruptions, Calls from the referral center, Computer/equipment problems, Negative consultant interactions, Insufficient staff availability. These stressors were identified based on prior research that examined the demands facing emergency physicians, as well as through interviews with local emergency physicians (Greenslade et al., 2020).

Salivary Cortisol. Saliva samples were collected using the passive drool method (with no flow stimulants used). Participants provided samples of at least 1.5 mL of saliva. Samples were immediately stored in a standard refrigerator unit (34-35°F) until they were transferred to a -80°F freezer (typically within 24 hours). Free cortisol was analyzed (in duplicate) using a competitive immunoassay kit for saliva provided by Salimetrics® (Salimetrics LLC, State College, PA).

Procedure

Measures used in the present study were part of a larger study that sought to analyze meaningful work, such as positive encounters with patients, as a buffer against work demands experienced by emergency medicine physicians. In this larger study, participants completed a salivary cortisol assessment, questionnaire, and pupilometer assessment, at the beginning and

end of each shift. Questionnaires were completed on a hand-held tablet. The pupilometer machine measured the magnitude and latency of pupils in response to light stimuli. After each instance of data collection, participants were provided with a $5 gift card for their time.

However, only end-of-shift salivary cortisol and questionnaire data were used for the present study. End-of-shift cortisol was selected to examine the cumulative effects of stressors encountered on the shift. Approximately 60 minutes before the end of each shift, physicians provided a saliva sample for salivary cortisol testing using a competitive immunoassay kit. This same method was used in previous studies which examined salivary cortisol as a physiological indicator of stress (Qi et al., 2016). Physicians also completed a short assessment of demands encountered during the shift on a hand-held tablet.

Planned Analyses

To examine whether there is a difference between the number of stressors reported by emergency medicine physicians, per shift, and the average crowding score of shifts, before and after the start of the COVID-19 pandemic, I plan on using several statistical methods. The first planned method is using descriptive statistics and correlations among the continuous variables. I will then use three linear mixed-effects models with the wave of the pandemic, before the pandemic or during the pandemic, as the predictor and crowding, reported stressors, and cortisol as the outcome variables. Physician ID will be entered as a random effect. Maximum likelihood estimation will be used for all models. Finally, I will use one linear mixed-effects model with wave of the pandemic, crowding, and reported stressors as the predictors, and cortisol as the outcome variable. Physician ID will be entered as a random effect. Maximum likelihood estimation will be used for the model.

Results

Descriptive information on the continuous measures is provided in Table 1, along with the correlations among the measured variables. The average salivary cortisol sample, obtained from a physician at the end of their shift, was $M = 1.01$, with a standard deviation of $SD = 0.389$. The average crowding score, using the NEDOCS system, was $M = 100.182$, with a standard deviation of $SD = 35.205$. For the nine stressors studied, EMPs reported an average of $M = 2.33$, with a standard deviation of $SD = 0.457$. As seen in Table 1, a significant positive correlation was found between Post-Shift Cortisol and Mean Stressor Rating reported by EMPs. Higher levels of stress were associated with higher levels of salivary cortisol. Additionally, a significant positive correlation was found between pre-shift and post-shift cortisol levels.

When analyzing the wave of the pandemic as a predictor of crowding scores and stressors reported, there was not a significant difference in crowding scores as a result of the pandemic, $t(114) = -.54$, $p = .59$. Crowding scores before the pandemic ($M = 98.56$, $SE = 4.45$) were similar to those during the pandemic ($M = 102.11$, $SE = 4.85$). A score of 80 would indicate an extremely busy, but not overcrowded emergency department, while a score of 120 would indicate an overcrowded emergency department (Weiss et al., 2004). Furthermore, mean stressors reported before the pandemic ($M = 2.31$, $SE = 0.46$) were not significantly lower than those during the pandemic ($M = 2.34$, $SE = 0.45$), $t(108) = -0.36$, $p = 0.72$.

In Table 2, the means and standard deviations of each of the individual stressors were calculated and compared between the two waves of data collection, before and during the COVID-19 pandemic. There were 59 shifts analyzed during the first wave of data collection and 51 shifts in the second wave. The following individual stressor experienced a significant increase in mean rating from before to during the pandemic: Difficult Patient/Family Encounter. Notably,

this was the only significant change in the mean, positive or negative, between the data collection periods.

Linear mixed models were used in order to examine how the predictor variables were related to the outcome variable of post-shift cortisol after controlling for the physician, pre-shift cortisol, and shift start time. Table 3 provides the results of the linear mixed model for the Wave of Pandemic, Pre-Shift Cortisol, Average NEDOC Score, Shift Start-Time, and Mean Stressor Rating as predictors of post-shift cortisol. The Wave of Pandemic, Pre-Shift Cortisol, and Mean Stressor Rating were all significant predictors of post-shift cortisol levels. The B value for Wave of Pandemic was -0.22. The program coded the data collected before the COVID-19 pandemic as "1" and during the pandemic as "0". A B value of -0.22 indicated that post-shift cortisol levels were lower before the pandemic and higher in the data collected during the COVID-19 pandemic. The B value for Mean Stressor Rating was 0.19, suggesting that the mean of stressors studied were predictors of post-shift cortisol levels. On the other hand, the Average NEDOC Score and Shift Start Time were not significant predictors.

Each individual stressor was analyzed as a predictor of post-shift cortisol after controlling for wave, shift start time, and pre-shift cortisol. The results are presented in Table 4. Calls from Referral Center, Computer/Equipment problems, Negative Consultant Interactions, and Insufficient Staff Availability were all significant predictors of post-shift cortisol levels. Negative Consultant Interactions had the largest B value, indicating that this stressor was the strongest predictor of post-shift cortisol.

Discussion

As outlined previously, this study was conducted in the emergency department of Greenville Memorial Hospital in Greenville, South Carolina, and focused on the stressors

experienced by emergency medicine physicians, salivary cortisol levels of EMPs, and crowding levels of the ED before and during the COVID-19 pandemic. Analyses were done to test whether or not significant changes were seen in the data collected during the two timeframes. Hypotheses were formulated that the average crowding score, determined by NEDOCS, would be significantly higher during the COVID-19 pandemic than before the pandemic and the average number of stressors, reported in an end-of-shift questionnaire at the end of every shift, would be higher during the COVID-19 pandemic than before the pandemic. Additionally, hypotheses predicted that end-of-shift cortisol levels, a physiological indicator of stress, would be higher during the COVID-19 pandemic than before the pandemic and that the difference in cortisol levels before and during the pandemic would be a function of the elevated crowding scores and reported number of stressors, as a function of either increased crowding scores or increased stressor reporting.

After analyses were done, it was found that the average crowding score was not significantly higher during the pandemic, in comparison to before the pandemic. Furthermore, the average score of the nine stressors examined across the shifts analyzed during the COVID-19 pandemic was not significantly higher than the average score from shifts analyzed prior to the start of the pandemic. The only individual stressor to experience a significant and positive increase across the two waves of data collection was Difficult Patient/Family Encounter.

Furthermore, data showed that there was a significant, positive increase in post-shift cortisol, collected by saliva samples, in the data collected during the pandemic. Analyses indicated that the post-shift cortisol was significantly lower in the data collected prior to the pandemic. While the average of the nine stressors analyzed was not significantly different between the two waves of data collection, the average number of stressors was a significant,

positive predictor of post-shift cortisol. As the average reported score for stressors increased, so did the concentration of salivary cortisol levels in post-shift collection. However, the average NEDOC score was not a significant predictor of post-shift cortisol level. After each individual stressor was analyzed, controlling for wave of data collection, shift start time, and pre-shift cortisol, it was found the following stressors significantly predicted post-shift cortisol: Calls from Referral Center, Computer/Equipment problems, Negative Consult Interactions, and Insufficient Staff Availability. The strongest predictor of these significant predictors was Negative Consult Interactions.

Contrary to the results found in the present study, Kleinpell et al. found that isolating room capacity and ICU bed capacity were both limited resources due to an abundance of patients during the COVID-19 pandemic. This crowding resulted from a surge in patient quantity within the ICU (Kleinpell et al., 2020). The emergency department in the present study did not see the same significant increase in patients. Furthermore, contrary to the results found in this study, Rodriguez et al. (2020) examined emergency physicians before and during the pandemic and found that physicians reported a median number of 4 when asked about emotional exhaustion and burnout since the start of the pandemic, compared to a 3 for pre-pandemic conditions, on a one to seven scale (Rodriguez et al., 2020). It has been shown that prolonged exposure to stressors can lead to burnout (Shanafelt et al., 2012). Therefore, it would be expected that if results from Rodriguez et al. showed a significant, positive increase in reported emotional exhaustion and burnout from pre-pandemic conditions, the present study would show an increase in the average reported score of stressors from pre-pandemic conditions.

On the other hand, a positive, significant increase was seen in the report of EMPs experiencing difficult patient and family encounters. Cotel et al. found that difficult encounters

with family or conflict within a family were significant predictors for the development of burnout during the COVID-19 pandemic (Cotel et al., 2021). Furthermore, Kuhn et al. (2009) found that concern for bad outcomes, which can result in difficult patient or family encounters, is the strongest predictor of career burnout within EMPs. Similarly, Wrenn et al. (2010) found that adverse events, which often can lead to difficult patient or family encounters, were positively correlated with stress. Although Greenslade et al. (2020) found high acuity patients to be the most commonly reported stressor of emergency department staff, this stressor by itself was not a significant predictor of post-shift salivary cortisol levels in the present study.

The results also showed that the average NEDOC score was not a significant predictor of post-shift cortisol. These results are consistent with those of Wrenn et al. (2010). They found that, among residents working in the emergency department, there was considerable variability in stressors reported. However, overcrowding was not found as a significant cause of stress (Wrenn et al., 2010).

When each individual stressor was analyzed, it was found the following stressors could be used as predictors of post-shift cortisol: Calls from Referral Center, Computer/Equipment problems, Negative Consult Interactions, and Insufficient Staff Availability. Insufficient staffing was also identified as a key problem by emergency medicine nurses as a contributing factor to emotional exhaustion (Popa et al. 2010). In a separate study, Stehman et al. found that a bad patient outcome, similar to negative consult interaction, can cause trauma, shame, anxiety, or guilt and increase the risk for EMPs experiencing Second Victim Syndrome (Stehman et al., 2019).

Applications of the Findings to the Practice of Emergency Physicians

It was found that the following individual stressors were significant predictors of post-shift salivary cortisol: Calls from the Referral Center, Computer/Equipment Problems, Negative Consultant Interactions, and Insufficient Staff Availability. Using this knowledge, hospital administration could take measures to reduce the occurrence of these stressors in the emergency department. Reduction of stressors would lessen the demands that emergency medicine physicians face and could help to reduce the development and prevalence of burnout.

Furthermore, the administration could take a step further and monitor post-shift salivary cortisol levels of staff on their own. These measurements could be used to determine if staff are experiencing high levels of stress. Additionally, salivary cortisol levels could be monitored following the implementation of any measures taken to reduce stress. This would give objective measures of if the action taken had significant effects on the reduction of stress.

Limitations and Directions for Future Research

As noted previously, this study was performed in Greenville, South Carolina in the emergency department of Greenville Memorial Hospital. Therefore, the data is limited to physicians at this hospital and results may not be able to be attributed to a larger population. Additionally, data were collected from November 19th, 2019 to March 8th, 2020 prior to the pandemic, and from February 18th, 2021 to July 1st, 2021 during the pandemic. The first recorded case of COVID-19 in South Carolina was recorded on March 4th and the first death on March 16th of the year 2020. While data collection ceased on March 8th, EMPs could have been affected by fears of the spread of the virus and these factors could have influenced data collection. Furthermore, no data were collected between March 9th, 2020, and February 17th, 2021. These data could have been influential on results and pose as another limitation to the

study. To increase the reliability of data, more EMPs could have been recruited as participants and the dates of data collection could have been expanded.

In regard to future research, there are hopes to expand a similar version of this study to additional hospitals within North and South Carolina. This expansion would include the analysis of stress and fatigue in emergency medicine physicians, with the goal of suggesting changes to hospital administration to limit the stress levels of EMPs. Currently, the research team is looking into wearable devices that monitor heart rate and sleep quality, among other factors, to predict readiness to work. However, due to the unique conditions that occurred during the COVID-19 pandemic, a more similar version of the present study would be impossible to replicate.

As discussed, chronic exposure to stressors and fatigue can lead to the development of burnout. Burnout is becoming an increasingly apparent psychological syndrome, specifically within the career field of medicine. The study at hand hoped to analyze the prevalence of stressors experienced in the emergency department before and during the COVID-19 pandemic. Results showed a significant increase in salivary cortisol, in post-shift measures, between the data collected before the pandemic and the data collected during the pandemic. Furthermore, it was found that although crowding scores were not-related to post-shift cortisol levels, the average number of stressors reported was a significant predictor of post-shift cortisol. When each individual stressor was analyzed, it was found that four of the nine stressors were significant in their ability to predict post-shift cortisol levels. These results can be used to better understand the development of burnout in emergency medicine physicians.

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Table 1: Descriptive information and correlations between the continuous variables examined

	N	M	SD	1	2	3
1. Post-Shift Cortisol	110	1.01	0.39			
2. Pre-Shift Cortisol	113	0.83	0.31	0.546**		
3. Average NEDOC Score	116	100.18	35.20	0.133	0.04	
4. Mean Stressor Rating	110	2.33	0.46	0.262**	0.04	-0.03

** Correlation is significant at the 0.01 level (2-tailed).

Table 2: Comparison of mean and standard deviation for the nine common stressors analyzed in this study before the pandemic and during the pandemic.

	Wave 1 (Before COVID-19 Pandemic)			Wave 2 (During COVID-19 Pandemic)		
Variables	N	M	SD	N	M	SD
1. Low Acuity Patients	59	2.70	0.86	51	2.51	0.84
2. High Acuity Patients	59	3.21	1.02	51	3.19	1.05
3. Difficult Patient/Family Encounter*	59	2.06	0.85	51	2.42	0.98
4. Needed Equipment, Supplies, or Medications Not Readily Available	59	2.14	0.96	51	2.17	0.81
5. Unnecessary Interruptions	59	2.32	0.91	51	2.36	0.85
6. Calls from the Referral Center	59	2.14	0.77	51	2.21	0.82
7. Computer/Equipment Problems	59	2.01	0.70	51	2.14	0.77
8. Negative Consultant Interactions	59	2.10	0.79	51	1.96	0.71
9. Insufficient Staff Availability	59	2.13	0.77	51	2.13	0.72

* $p < 0.05$

Table 3: Generalized Linear Model of Main Study Variables

	B	Std. Error	t-Value	Sig.
Wave of Pandemic	-0.22	0.06	-3.41	0.00
Pre-Shift Cortisol	0.55	0.12	5.21	0.00
Average NEDOC Score	0.00	0.00	1.59	0.12
Shift Start Time	0.00	0.00	-1.47	0.15
Mean Stressor Rating	0.19	0.06	2.95	0.00

Dependent Variable: Post-Shift Cortisol

Table 4: Linear Mixed Model with Each Individual Stressor Instead of Mean Stressor Rating Time.

Variables	B	Std. Error	t-Value	Sig.
1. Low Acuity Patients	0.06	0.00	1.72	0.09
2. High Acuity Patients	-0.03	0.03	-1.11	0.27
3. Difficult Patient/Family Encounter	0.04	0.03	1.26	0.21
4. Needed Equipment, Supplies, or Medications Not Readily Available	0.02	0.03	0.72	0.47
5. Unnecessary Interruptions	0.03	0.03	0.83	0.41
6. Calls from the Referral Center	0.09	0.04	2.41	0.02
7. Computer/Equipment Problems	0.11	0.04	2.81	0.01
8. Negative Consultant Interactions	0.15	0.04	3.94	0.00
9. Insufficient Staff Availability	0.11	0.04	2.83	0.01