Association Between Proportion of Workday Treating COVID-19 and Depression, Anxiety, and PTSD Outcomes in US Physicians

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Objective: The primary objective of this cross-sectional study was to examine the association between time spent treating patients with Coronavirus disease 2019 (COVID-19) and levels of depression, anxiety, and posttraumatic stress disorder (PTSD) in US physicians. **Methods:** The authors conducted an anonymous online survey of US physicians. Linear regression was used to test the association between proportion of day treating COVID-19 and symptoms of depression, anxiety, and PTSD. **Results:** In a sample of 1724 US physicians, proportion of day treating COVID-19 was positively and significantly associated with depression, anxiety, and PTSD scores ($P < 0.001$ for each). **Conclusions:** Mental health resources should be provided to physicians who treat COVID-19 because the proportion of day treating COVID-19 is associated with depression, anxiety, and PTSD outcomes.

Keywords: anxiety, COVID-19, depression, healthcare workers, mental health, physicians, PTSD

Learning Objectives

- Review previous evidence related to stressors and mental health symptoms in healthcare providers during the COVID-19 pandemic.
- Summarize the new findings on the association between time spent treating COVID-19 patients and levels of mental health symptoms in a survey of US physicians.
- Identify differences in the mental health impact of COVID-19 among groups of physicians with differing characteristics and the implications for mental health resources provided for healthcare workers.

Coronavirus disease 2019 (COVID-19), the disease caused by SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2), has impacted the practice of physicians across the United States. The surge in healthcare demand due to COVID-19 has placed hospital physicians under increased stress and pressure[1] while other physicians were forced to rapidly shift workforce practices[2] or begin utilizing telehealth platforms[3] for medical services. Physicians were already at a higher risk of burnout, depression, and suicide prior to COVID-19,[4] and the global pandemic has added to increased levels of stress.[5] Physicians are facing frustration, fear due to a lack of adequate personal protective equipment,[6] exhaustion, and traumatic patient outcomes which are exacerbated by physical distancing measures and social isolation.[7] These experiences may worsen mental health outcomes, including depression, anxiety, and posttraumatic stress disorder (PTSD) symptoms.

Existing literature suggests that past pandemics have resulted in an increase in stress and mental health symptoms among healthcare workers.[8,9] Studies involving the 2003 Severe Acute Respiratory Syndrome (SARS) outbreak showed that healthcare workers experienced mental health effects including high levels of stress, anxiety, depression, and posttraumatic stress.[10] Physicians practicing in various specialties experienced psychological trauma as a result of caring for patients infected with the virus.[10] A 2007 study published in the BMJ Emergency Medicine Journal found that as many as 93% of emergency department physicians who treated victims of the 2003 SARS outbreak reported symptoms associated with PTSD.[10,11] Healthcare workers face many stressors when treating patients with a respiratory virus, including the risk of infection while performing daily tasks, the fear of infecting family and friends, and fear related to being seen as a source of contagion.[11,12]

COVID-19 healthcare workers across the globe are experiencing similar stressors. A cross-sectional study published by Lai et al[1] involving 1257 healthcare workers across multiple regions in China found that healthcare workers involved in the diagnosis, treatment, and direct care of patients with COVID-19 had a greater likelihood of negative mental health symptoms, specifically depression, anxiety, insomnia, and distress. A recent study in India evaluated rates of depression, anxiety, and stress in 152 physicians during the COVID-19 pandemic utilizing the Depression, Anxiety, and Stress Scale-21 and found rates of 34.9%, 39.5%, and 32.9%, respectively.[13] Xu et al[14] conducted a study in China on the surgical staff within a hospital and found that anxiety and depression symptoms of the staff during the COVID-19 outbreak were significantly higher when compared with a non-outbreak time period. Healthcare workers with occupational exposure to COVID-19 have also limited their contact with friends and family or changed their usual methods of coping, to limit exposure to others[15] but potentially exacerbating feelings of distress. Although national organizations have called for wellness initiatives[16] and support interventions[17] have been created for healthcare workers on the frontlines, physicians remain vulnerable to the negative mental health effects of caring for COVID-19 patients while balancing their own physical and emotional needs.[18]

The purpose of this study was to examine the associations between the proportion of workday spent treating patients with active COVID-19 infection or physical sequelae and depression, anxiety, and PTSD outcomes in US physicians. While most physicians have been impacted by the pandemic, we hypothesized that those physicians who spent more time treating COVID-19 would suffer from higher scores on depression, anxiety, and PTSD rating scales.

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Funding/Support: None. The authors do not have funding to support open access publishing.
Ethical approval: This study (#06908) was exempted by the Wright State University Institutional Review Board.
Gainer, Nahhas, Bhatt, Merrill, and McCormack have no relationships/conditions/circumstances that present potential conflict of interest.
The JOEM editorial board and planners have no financial interest related to this research.
Clinical Significance: While many physicians have been impacted by the COVID-19 pandemic, our study shows that physicians who spent more time treating COVID-19 had higher scores on depression, anxiety, and PTSD rating scales. Mental health resources should be provided to healthcare workers who treat COVID-19.
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DOI: 10.1097/JOM.0000000000002086

METHODS

We conducted an anonymous voluntary online survey of 1724 US physicians between April 30 and June 1, 2020. Eligibility was limited to physicians currently practicing in the United States. Recruitment was done through email and social media. Emails containing a link to the survey were sent to 10,022 US physicians from academic medical centers inviting them to participate. We sent 3569 emails to department administrators and training directors of US residency programs and asked them to forward the link to department physicians and resident trainees. Links to the survey were also posted on Twitter with the hashtags #medtwitter and #COVID19 in addition to physician-exclusive COVID-19 Facebook groups. We also utilized snowball sampling by asking participants to share the link with other US physicians. Participation was voluntary and anonymous (no IP addresses were collected). No monetary incentive was provided to participate in the study.

This study was reviewed and exempted by the Wright State University Institutional Review Board. Study data were collected and managed using REDCap (Research Electronic Data Capture) hosted at Wright State Research Institute.[19,20] Individuals who chose to click on the survey link were first provided with an online informed consent document. In addition, at the end of the survey, participants were provided with a list of mental health resources including support groups, suicide hotlines, and links to meditation apps which were made free to healthcare workers during the pandemic. Participants who scored highly on the validated depression, anxiety, or PTSD symptom measures were provided with additional resources.

Study Measures

The survey asked, ''How much of your average workday is spent treating patients with active COVID-19 infection or physical sequelae?'' (with possible answers on a slider ranging from 0% to 100%; hereafter, ''proportion of day treating COVID-19'') and measured the outcomes of depression, anxiety, and PTSD via Patient Health Questionnaire-9 (PHQ-9), Generalized Anxiety Disorder - 7 (GAD-7), and Abbreviated PTSD Checklist (APCL) total scores, respectively. The PHQ-9 is a self-administered, validated, and reliable tool that asks about symptoms of depression occurring over the prior 2 weeks.[21,22] The score can range from 0 to 27. The GAD-7 is a validated, widely used tool to screen for generalized anxiety disorder symptoms in the general population.[23] This is also a self-report measure and consists of seven questions. Scores range from 0 to 21. We chose the abbreviated PTSD checklist (hereafter, APCL), a six-question, self-report instrument to measure PTSD symptoms in participants.[24,25] Scores range from 5 to 30.

PHQ-9 more than or equal to five indicates at least mild depression, GAD-7 more than or equal to five indicates at least mild symptoms of generalized anxiety disorder, and APCL more than or equal to fourteen indicates difficulties with posttraumatic stress. Hereafter, these cutoffs are referred to as the ''clinically meaningful thresholds.''

Additional questions collected information about age group, sex, race, medical specialty, work setting, and trainee status (possible responses shown in Table 1). Respondents were also asked to indicate the state and county in which they work most often. US Census Region (Midwest, Northeast, South, West) was derived from state, and the proportion rural population in each county was obtained from the 2010 US Census. Possible sex responses were male, female, and non-binary; however, only five respondents reported non-binary. Rather than exclude these individuals or group them all with either males or females, we set these sex responses to missing and included these individuals using multiple imputation as described below. Possible race responses were ''American Indian or Alaska Native,'' ''Asian,'' ''Black or African American,'' ''Hispanic or Latino,'' ''Native Hawaiian or Other Pacific Islander,'' ''White,'' or ''I prefer not to answer.''

Statistical Analysis

Descriptive statistics were computed for continuous variables (mean, standard deviation, median, minimum, maximum, number of missing values) and categorical variables (frequency, proportion, number of missing values). Additionally, overall and at each level of each categorical variable we computed the proportion of respondents who reported spending more than or equal to 25% of their workday treating COVID-19 patients, and who scored above the clinically meaningful thresholds for PHQ-9, GAD-7, and APCL. For the purpose of these descriptive statistics only, not for the primary analysis, the continuous variables ''proportion of day treating COVID-19'' and ''% rural population'' were grouped into categories and included in the summary of categorical variables.

Linear regression was used to test the association between proportion of day treating COVID-19 and total score from each outcome (depression, anxiety, or PTSD) measure, adjusted for confounding due to age group, sex, race, specialty, work setting, trainee status, US census region, and % rural population. A number of variables had skewed distributions bounded below at zero. To reduce the influence of the largest observations, proportion of day treating COVID-19, PHQ-9, GAD-7, and % rural population were each natural-log-transformed as $\ln(x + 1)$, and APCL, which by design has no zeros, was transformed as ln(APCL). Collinearity was examined using variance inflation factors and found to be minimal. The linearity assumption for proportion of day treating COVID-19 was relaxed via a restricted cubic spline.[26] All tests were two-sided, and the three tests of association with each outcome were adjusted for multiple testing using a Bonferroni correction to preserve a familywise $\alpha = 0.05$ level of significance.

In secondary, exploratory, analyses, we examined possible interactions between demographic variables and the primary predictor to see if any moderate the association between proportion of day treating COVID-19 and depression, anxiety, and PTSD scores, as well as examined confounder main effects.

Prior to fitting a linear regression model, missing data were imputed using multiple imputation.[27] Regression models were then fit for each imputed dataset and combined using Rubin's rules.[28] Diagnostics were examined on each fit and no meaningful model violations were observed. Descriptive statistics are reported for the observed data, prior to imputation. All data analyses were carried out in R v4.0.0[29] including the R packages Hmisc[30] and rms.[31]

RESULTS

Descriptive Statistics

One thousand nine hundred fifty eight individuals accessed the survey. Of these, 1855 were eligible (US physicians) and consented, however, 131 answered no questions and so were excluded, resulting in a sample size of 1724 US physicians. Of these, 1600 completed the survey (with some item non-response) and 124 exited the survey before completion. However, all analysis variables for all 1724 respondents were included in the analysis via multiple imputation.

Tables 1 and 2 provide descriptive statistics for categorical and continuous variables, respectively, including displaying the relationship between each variable and the (1) proportion reporting at least 25% of their workday spent treating patients with active COVID-19 infection or physical sequelae, (2) proportion with PHQ-9 total score more than or equal to five, (3) proportion with GAD-7 total score more than or equal to five, and (4) proportion with APCL total score more than or equal to 14.

About half reported spending at least 5% of their workday treating COVID-19 patients (Table 2). About one-third reported not currently treating COVID-19 patients (not shown in the table), and 19.3% reported spending at least 25% of their workday treating such patients. Median total scores for PHQ-9, GAD-7, and APCL were 3, 3, and 10, respectively, with 39.5%, 36.5%, and 27.5% of respondents, respectively, scoring at or above the clinically meaningful threshold.

TABLE 1. Descriptive Statistics for Categorical Variables

			% Above Cutoff			
Variable (No. Missing)	**Level**	***N* (%)**	**COVID-19**	**PHQ-9**	**GAD-7**	**APCL**
% of day treating COVID-19 (58) (categorized)	0	554 (33.3)	0.0	35.4	35.8	24.7
	>0 to 5	396 (23.8)	0.0	32.6	29.7	19.8
	>5 to 10	213 (12.8)	0.0	35.2	31.7	27.2
	>10 to 25	243 (14.6)	25.5	47.5	42.1	35.9
	>25 to 50	136 (8.2)	100.0	49.6	45.9	32.0
	>50 to 100	124 (7.4)	100.0	58.0	46.4	37.9
2010% Rural population (187) (categorized)	0	272 (17.7)	34.4	47.7	44.7	33.6
	>0 to 3	363 (23.6)	18.8	36.6	33.3	25.3
	>3 to 5	294 (19.1)	10.5	34.2	33.5	25.5
	>5 to 15	281 (18.3)	17.5	42.2	37.0	28.6
	>15 to 50	304 (19.8)	15.3	39.6	35.3	30.0
	>50 to 100	23 (1.5)	13.0	31.8	47.6	27.3
Age, yr (10)	26–30	217 (12.7)	30.6	41.6	37.4	31.1
	31–40	614 (35.8)	21.7	40.9	38.3	31.6
	41–50	402 (23.5)	19.9	45.8	41.6	28.3
	51–60	260 (15.2)	10.1	38.0	37.0	23.2
	over 60	221 (12.9)	11.4	24.1	20.9	16.3
Gender (15)	Male	750 (43.9)	18.6	29.6	26.3	18.8
	Female	959 (56.1)	19.9	47.5	44.8	34.5
Race (76)	White	1306 (79.2)	16.6	39.4	36.3	26.1
	Minority	342 (20.8)	29.1	37.5	35.1	29.0
Specialty (7)	Pediatrics	270 (15.7)	6.7	37.6	40.2	29.5
	Emergency Medicine	192 (11.2)	53.2	46.9	44.7	29.1
	Internal Medicine	177 (10.3)	40.5	37.4	31.9	27.4
	Family Medicine	163 (9.5)	17.7	43.9	38.1	31.6
	Psychiatry	134 (7.8)	3.0	28.3	32.3	16.8
	IM Specialties*	111 (6.5)	13.0	40.6	40.0	30.8
	ObGyn	82 (4.8)	11.1	53.8	45.5	38.5
	Neurology	79 (4.6)	15.4	31.0	21.7	14.7
	Pulmonary/Critical Care	70 (4.1)	51.5	43.8	32.8	27.3
	Anesthesiology	66 (3.8)	3.1	37.3	33.9	21.0
	Surgery†	60 (3.5)	11.7	34.0	26.9	35.1
	Pathology	54 (3.1)	5.7	36.7	25.5	26.9
	Radiology/Nuclear Medicine	53 (3.1)	17.0	40.5	36.4	25.5
	Infectious Diseases	39 (2.3)	28.9	41.7	30.6	23.7
	Other‡	167 (9.7)	7.9	38.6	38.1	26.8
Work setting (42)	Academic/University	949 (56.4)	16.2	37.8	34.0	25.5
	Hospital	447 (26.6)	32.6	42.4	39.3	30.3
	Outpatient—hospital affiliated	154 (9.2)	10.1	40.7	41.5	29.5
	Outpatient—private practice	47 (2.8)	8.5	38.1	34.9	30.4
	VA	36 (2.1)	8.6	24.2	23.5	14.3
	Other	49 (2.9)	12.2	55.6	53.3	30.4
Trainee (16)	Yes	447 (26.2)	26.0	43.6	37.0	30.7
	No	1261 (73.8)	16.8	38.3	36.3	26.4
US Census Region (8)	Midwest	342 (19.9)	12.3	40.0	36.0	26.0
	Northeast	343 (20.0)	36.1	43.7	40.1	31.9
	South	633 (36.9)	16.9	37.5	35.4	25.6
	West	398 (23.2)	15.1	38.9	35.8	28.0

$N = 1724$, % above cutoff: COVID-19 = proportion treating COVID-19 $\geq$25% of their workday; PHQ-9 = proportion with total $\geq$5; GAD-7 = proportion with total $\geq$5; APCL = proportion with total $\geq$14; APCL, Abbreviated PTSD Checklist; GAD-7, Generalized Anxiety Disorder - 7; PHQ-9, Patient Health Questionnaire-9.

*Cardiology, Gastroenterology, Nephrology, Oncology, Rheumatology.

†Colon & Rectal Surgery, Thoracic Surgery, Orthopedics, General Surgery, Plastic Surgery.

‡Allergy & Immunology, Dermatology, Physical Medicine & Rehabilitation, Medical Genetics and Genomics, Preventive Medicine/Public Health, Ophthalmology, Otolaryngology, Urology, other.

Respondents were age 26 to 60+ years, from all 50 states and Washington, D.C. 21% were minorities, 56% were women, 26% were trainees, and over half (56%) worked in an academic/university setting. The 342 Minority participants were Asian (226), Hispanic or Latinx (55), Black or African American (54), Native Hawaiian or Other Pacific Islander (4), and American Indian, or Alaska Native (3). An additional 71 marked "Prefer not to answer" and 5 skipped the question (these 76 were set to missing and imputed via multiple imputation).

The demographic characteristics with the highest proportion of physicians spending more than 25% of their day treating COVID-19 patients were age 26 to 30 years, female, Minority, Emergency Medicine specialty, hospital work setting, trainee, Northeast region, and urban county (0% rural) (see Table 1).

Primary Analysis—Associations Between COVID-19 Caseload and Mental Health

Table 3 displays the multivariable model results, adjusted for missing data via multiple imputation. After adjusting for multiple tests, proportion of day treating COVID-19 was positively and

TABLE 2. Descriptive Statistics for Continuous Variables

Variable (No. Missing)	Median (IQR)	% Above Cutoff COVID-19	PHQ-9	GAD-7	APCL
% of day treating COVID-19 (58)	5 (15.8)	19.3	–	–	–
PHQ-9 total (153)	3 (6.0)	–	39.5	–	–
GAD-7 total (150)	3 (5.0)	–	–	36.5	–
Abbreviated PCL-C total (82)	10 (6.0)	–	–	–	27.5
2010% Rural population (187)	3.2 (11.6)	–	–	–	–

$N = 1724$, % above cutoff: COVID-19 = proportion treating COVID-19 ≥25% of their workday; PHQ-9 = proportion with total ≥5; GAD-7 = proportion with total ≥5; APCL = proportion with total ≥14. APCL, Abbreviated PTSD Checklist; GAD-7, Generalized Anxiety Disorder - 7; PHQ-9, Patient Health Questionnaire-9.

TABLE 3. Multiple Linear Regression Results After Multiple Imputation

Term	Level	ln(PHQ-9 total + 1) B (95% CI)	P	ln(GAD-7 total + 1) B (95% CI)	P	ln(APCL total) B (95% CI)	P
Intercept		0.96 (0.73, 1.19)	<0.001	0.97 (0.74, 1.19)	<0.001	2.23 (2.14, 2.33)	<0.001
ln (% of day treating	RCS term 1	0.00 (−0.12, 0.11)	<0.001	−0.06 (−0.18, 0.06)	<0.001	−0.02 (−0.07, 0.03)	<0.001
COVID-19 + 1)	RCS term 2	0.19 (−0.17, 0.55)		0.32 (−0.04, 0.69)		0.16 (0.02, 0.31)	
(restricted cubic spline)	RCS term 3	−0.47 (−2.27, 1.34)		−1.15 (−2.96, 0.66)		−0.63 (−1.37, 0.11)	
Age (years) *(ref = 26–30)*	31–40	−0.01 (−0.17, 0.16)	0.001	−0.09 (−0.25, 0.07)	<0.001	−0.01 (−0.07, 0.06)	0.015
	41–50	0.08 (−0.11, 0.28)		−0.07 (−0.26, 0.12)		−0.02 (−0.10, 0.06)	
	51–60	−0.01 (−0.22, 0.19)		−0.17 (−0.37, 0.04)		−0.05 (−0.13, 0.03)	
	Over 60	−0.25 (−0.47, −0.03)		−0.46 (−0.68, −0.25)		−0.11 (−0.20, −0.02)	
Gender *(ref = Male)*	Female	0.37 (0.29, 0.46)	<0.001	0.39 (0.30, 0.48)	<0.001	0.16 (0.13, 0.20)	<0.001
Race *(ref = White)*	Minority	−0.10 (−0.21, 0.01)	0.072	−0.15 (−0.26, −0.04)	0.006	−0.03 (−.07, 0.02)	0.215
Specialty *(ref = Pediatrics)*	Emergency Medicine	−0.01 (−0.19, 0.18)	0.125	0.00 (−0.19, 0.18)	0.379	−0.04 (−0.11, 0.04)	0.014
	Internal Medicine	−0.11 (−0.29, 0.08)		−0.14 (−0.32, 0.04)		−0.09 (−0.16, −0.01)	
	Family Medicine	0.03 (−0.15, 0.22)		0.03 (−0.15, 0.21)		−0.02 (−0.09, 0.06)	
	Psychiatry	−0.07 (−0.26, 0.12)		−0.04 (−0.22, 0.15)		−0.09 (−0.16, −0.01)	
	IM Specialties	0.07 (−0.14, 0.27)		0.06 (−0.14, 0.26)		0.04 (−0.04, 0.12)	
	Obstetrics & Gynecology	0.19 (−0.03, 0.41)		0.17 (−0.05, 0.38)		0.07 (−0.02, 0.16)	
	Neurology	−0.22 (−0.45, 0.01)		−0.12 (−0.34, 0.11)		−0.10 (−0.19, −0.01)	
	Pulmonary/ Critical Care	0.00 (−0.24, 0.24)		0.03 (−0.21, 0.27)		−0.04 (−0.14, 0.06)	
	Anesthesiology	0.23 (−0.01, 0.48)		0.14 (−0.10, 0.38)		0.03 (−0.07, 0.12)	
	Surgery	0.15 (−0.10, 0.41)		0.03 (−0.22, 0.28)		0.03 (−0.07, 0.13)	
	Pathology	0.16 (−0.10, 0.42)		0.03 (−0.22, 0.29)		0.04 (−.06, 0.15)	
	Radiology/ Nuclear Medicine	0.03 (−0.25, 0.32)		−0.07 (−0.34, 0.21)		−0.04 (−0.15, 0.07)	
	Infectious Diseases	−0.04 (−0.35, 0.27)		−0.22 (−0.52, 0.09)		−0.06 (−0.18, 0.07)	
	Other	0.02 (−0.16, 0.21)		0.07 (−0.11, 0.25)		0.00 (−0.07, 0.08)	
Work setting *(ref = Academic/ University)*	Hospital	0.05 (−0.06, 0.15)	0.139	0.11 (0.01, 0.21)	0.096	0.01 (−0.03, 0.05)	0.329
	Outpatient hospital	0.08 (−0.07, 0.24)		0.11 (−0.04, 0.27)		0.05 (−0.01, 0.11)	
	Outpatient private	0.07 (−0.19, 0.34)		0.10 (−0.15, 0.36)		0.07 (−0.04, 0.17)	
	VA	0.01 (−0.29, 0.31)		0.04 (−0.25, 0.33)		−0.03 (−0.15, 0.09)	
	Other	0.36 (0.10, 0.61)		0.29 (0.04, 0.55)		0.08 (−0.02, 0.19)	
Trainee *(ref = Yes)*	No	−0.01 (−0.15, 0.14)	0.942	0.05 (−0.09, 0.19)	0.479	−0.01 (−0.07, 0.04)	0.674
Region *(ref = Midwest)*	Northeast	0.07 (−0.07, 0.21)	0.570	0.14 (0.00, 0.28)	0.225	0.05 (−0.01, 0.10)	0.138
	South	−0.02 (−0.14, 0.10)		0.04 (−0.08, 0.16)		−0.01 (−0.05, 0.04)	
	West	0.04 (−0.10, 0.18)		0.10 (−0.04, 0.23)		0.04 (−0.02, 0.09)	
ln(% rural county pop. + 1)		0.02 (−0.02, 0.06)	0.349	0.02 (−0.02, 0.06)	0.431	0.01 (0.00, 0.03)	0.079

All terms in the model; primary predictor = proportion of day treating COVID-19 (all others terms are included to control for confounding); outcomes = PHQ-9, GAD-7, and APCL total scores ($N = 1724$). APCL, Abbreviated PTSD Checklist; GAD-7, Generalized Anxiety Disorder - 7; PHQ-9, Patient Health Questionnaire-9.

significantly associated with each of depression, anxiety, and PTSD scores ($P < 0.001$ for each three df test; regression coefficients and 95% confidence intervals in Table 3). The relationships between proportion of day treating COVID-19 and each outcome, after transforming back to the original scale, are visualized in Fig. 1.

Secondary Analyses

Overall, there was no significant association between trainee status and any of the mental health outcomes (Table 3). However, our secondary analysis of potential interactions (not shown in Table 3) revealed that the association between proportion of day treating COVID-19 and each mental health outcome differed

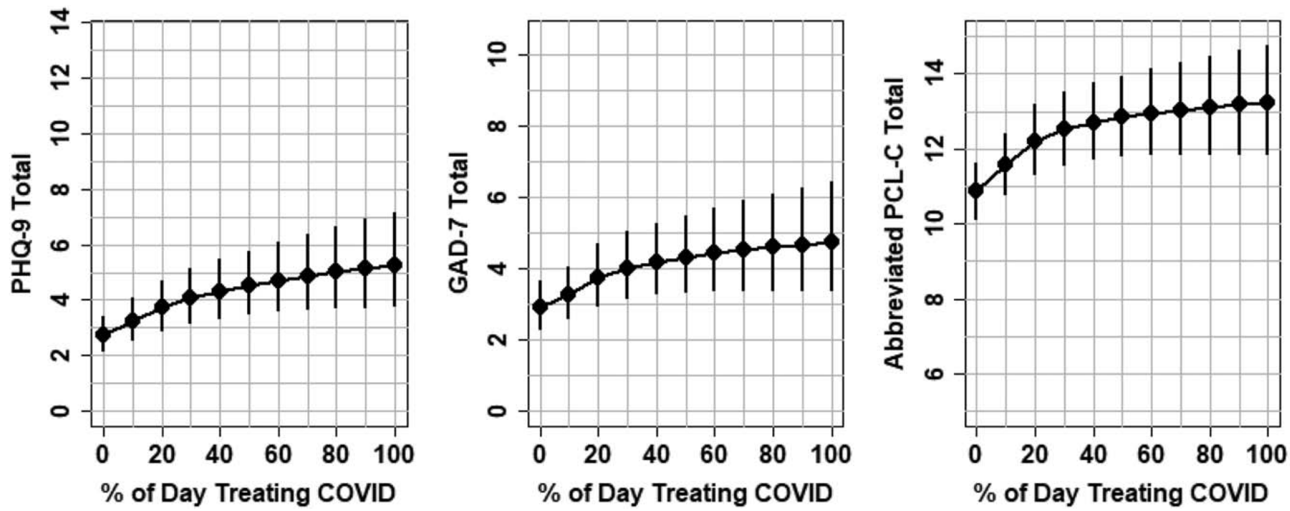

FIGURE 1. Estimated PHQ-9, GAD-7, and APCL total scores (and 95% confidence interval) versus % of day treating COVID-19 at the most common level of other covariates (vertical range is the minimum to half the maximum value of each outcome). PHQ-9, Patient Health Questionnaire-9.

significantly between residents and attendings (Fig. 2). Among physicians who do not treat COVID-19 patients, residents had lower scores than attendings. However, among those who do treat COVID-19 patients, trainees had worse mental health scores.

Although the proportion of day treating COVID-19 × specialty interaction was not strong, it is interesting to note that, unlike other specialties, infectious disease physicians reporting more time treating COVID-19 patients reported less severe mental health scores (see Fig. 3). This observation is based on only 39 respondents, but the effect was notably large.

Age and sex were strongly associated with all three outcomes. Race was associated with anxiety, and specialty with PTSD scores. Controlling for all other variables, female physicians who participated in the survey scored higher than male physicians on all three scales ($P < 0.001$; regression coefficients and 95% confidence intervals in Table 3; see Fig. 4) and minority physicians scored significantly lower than white physicians in mean total GAD-7 ($B = -0.15$, 95% CI $= -0.26, -0.04$, $P = 0.006$; Table 3). In this analysis, race, along with a number of other variables, was adjusted for as a potential confounder of the primary association of interest. However, when examining the association between race and mental health directly, the other variables may instead be mediators of that association, so the magnitude of the estimated effect in this analysis should be interpreted with caution. In unadjusted analyses, there was no difference in mean GAD-7 between races.

Average total abbreviated PCL-C score differed between specialties ($P = 0.014$; regression coefficients and 95% confidence intervals in Table 3; see Fig. 5). Pairwise comparisons with $P < 0.05$ were Obstetrics & Gynecology versus Emergency Medicine, and each specialty in set A versus each in set B, where A = {Obstetrics & Gynecology, Anesthesiology, Pathology, IM Specialties, Surgery, Other, Pediatrics} and B = {Psychiatry, Internal Medicine, Neurology}. However, there were no pre-specified contrasts and after

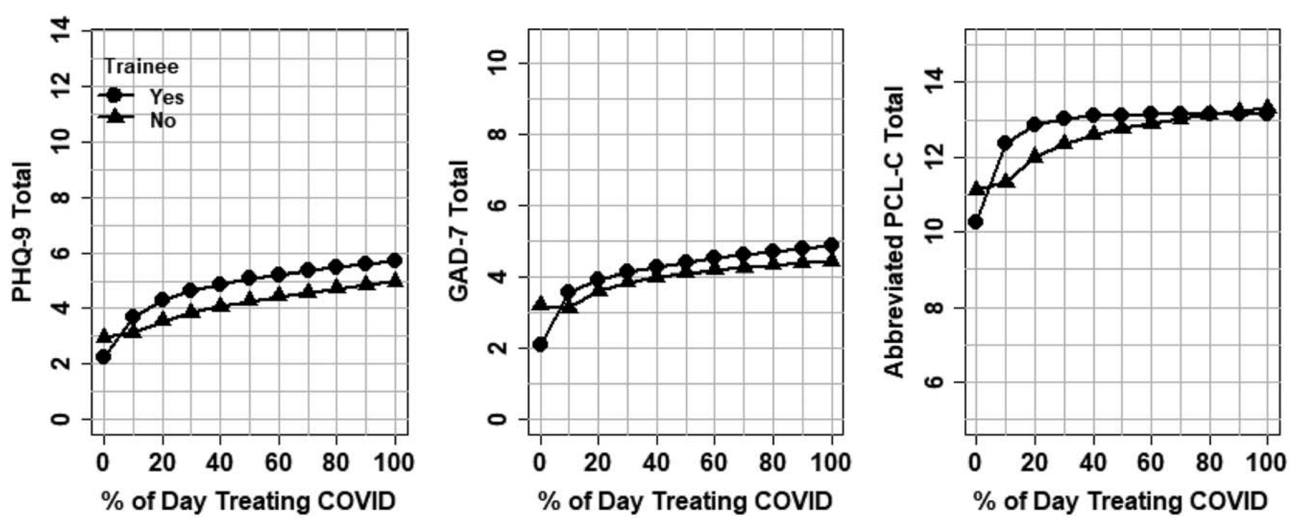

FIGURE 2. Trainee interaction: estimated PHQ-9, GAD-7, and APCL total scores versus proportion of day treating COVID-19, by trainee, at the most common level of other covariates. PHQ-9, Patient Health Questionnaire-9.

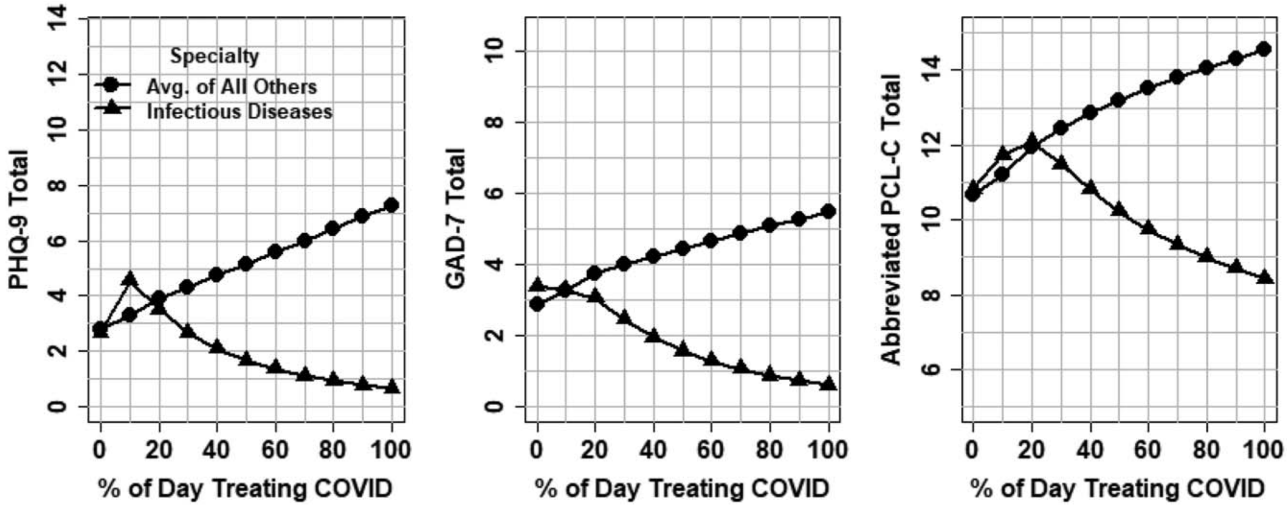

FIGURE 3. Specialty interaction: estimated PHQ-9, GAD-7, and APCL total scores versus proportion of day treating COVID-19, by specialty, at the most common level of other covariates. PHQ-9, Patient Health Questionnaire-9.

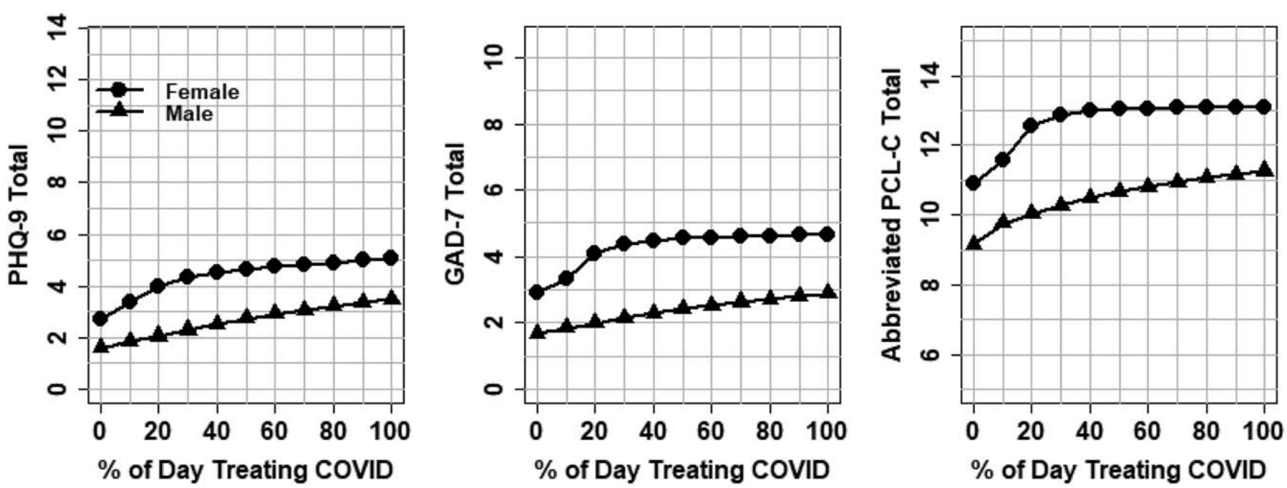

FIGURE 4. Estimated PHQ-9, GAD-7, and APCL total scores versus % of day treating COVID-19, by gender, at the most common level of other covariates. PHQ-9, Patient Health Questionnaire-9.

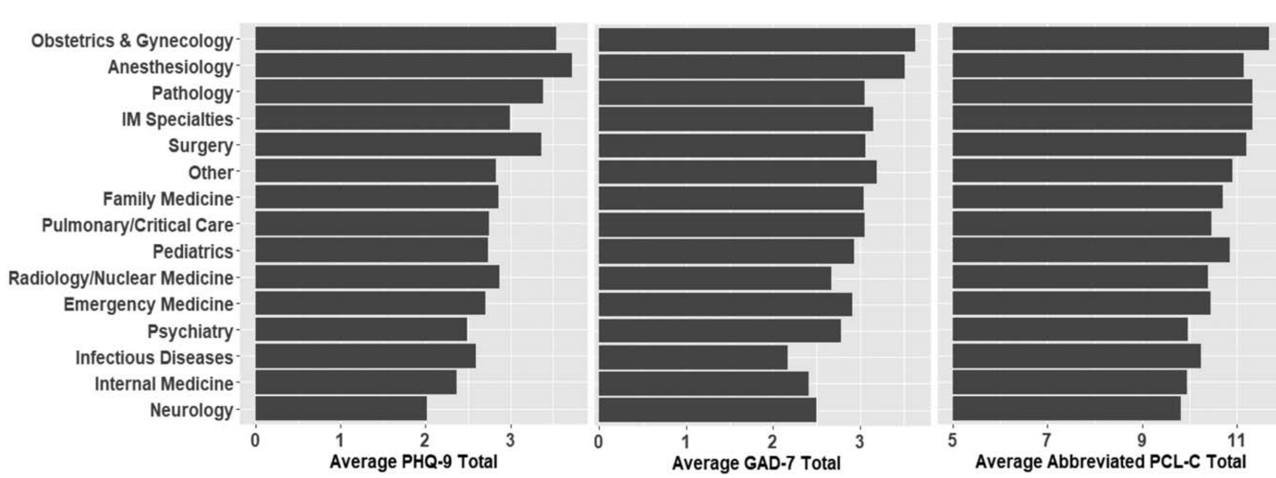

FIGURE 5. Estimated PHQ-9, GAD-7, and APCL total scores by specialty, at the most common level of other covariates, ordered by average ranking across all three outcomes. PHQ-9, Patient Health Questionnaire-9.

adjusting for post-hoc multiple comparisons over all possible pairwise comparisons there were no significant differences.

Confounder main effect and interaction results were based on secondary, exploratory, analyses and so should be considered hypothesis generating rather than confirmatory.

DISCUSSION

In the Spring of 2020, many physicians across the world were suddenly faced with unexpected and potentially life-threatening experiences created by the COVID-19 pandemic. This global health crisis required physicians and other healthcare workers to abruptly alter occupational practices within their workplace. Although physicians may face stress or trauma while providing patient care, this novel virus created unfamiliar experiences, such as working with inadequate personal protective equipment, quarantined or infected coworkers, possible staffing shortages, potential pay cuts, and a lack of knowledge about methods of transmission or most effective treatments. These experiences, combined with the significant mortality rate associated with COVID-19, may have intensified mental health symptoms of physicians on the frontline.[32]

Our cross-sectional study included 1724 US physicians and revealed that physicians who spent a greater proportion of their workday treating patients with COVID-19 in Spring of 2020 experienced greater symptoms of depression, anxiety, and PTSD. Young, female trainees may be more susceptible to experiencing greater levels of anxiety. These data are consistent with other studies examining the mental health of physicians treating COVID-19.[1,33,34] Several systematic reviews have also indicated that numerous cross-sectional studies across the world have found a high prevalence of anxiety and depressive symptoms in healthcare workers during the pandemic as well as a correlation of worsening mental health symptoms with occupational exposure to patients infected with COVID-19.[32,35–38] Physicians specifically who treat COVID-19 patients in Turkey,[39,40] China,[1] and Pakistan[41] are similarly experiencing an increase in depression and anxiety symptoms. Furthermore, healthcare workers in Italy[42] and China[43] who treated patients with COVID-19 experienced an increase in PTSD symptomatology, with similar findings to our data.

Among all physicians in our study, those who spent more time treating COVID-19 patients had worse mental health outcomes. However, our data suggests that the impact of COVID-19 caseload may be greater for trainees. A recently published study by Kannampallil et al[34] found that resident trainees at one academic medical center who treated COVID-19 patients reported significantly higher levels of stress and burnout. Yet, academic training centers vary in practices and policies around the country. The response to COVID-19 has also differed across the country among various residency training programs. These residency programs may have needed to change resident call schedules, create virtual educational presentations due to limitations on large gatherings, or adjust staffing practices to reduce transmission amongst residents.[44] In our data, we observed that among physicians who treated COVID-19 patients, residents across the country had worse average mental health scores than attendings. These resident trainees may be experiencing challenges associated with balancing clinical duties, long work hours, and educational responsibilities exacerbated by the new stressors created by the global pandemic. Our data suggests that residents who are treating COVID-19 may benefit from additional mental health support or resources, shift breaks, or time off to address mental or emotional fatigue.[15] Furthermore, residency programs should place an emphasis upon the mental health of trainees and offer resources to address potential psychiatric symptoms of residents, regardless of occupational exposure to COVID-19.

Among the survey respondents, Emergency Medicine physicians spent the greatest proportion of their workday treating COVID-19 patients. It might be expected that Emergency Medicine physicians would demonstrate a higher level of depression, anxiety, and PTSD scores due to their direct contact with COVID-19 patients. However, when comparing physician specialties after adjusting for all other variables, their scores were not significantly greater than other specialties. Interestingly, Infectious Disease physicians reporting more time treating COVID-19 patients reported less severe mental health scores. Infectious disease physicians were the smallest specialty group in this study, and this finding may be due to selection bias since the survey was conducted in Spring of 2020 when the infectious disease physician workforce was likely busier than usual. Infectious disease physicians may also be better prepared than other physicians to deal with a pandemic, by understanding the epidemiology and disease course of a novel virus, possibly mitigating the impact upon mental health scores.

In our study, female physicians scored higher than male physicians on all three scales, but the impact of the COVID-19 caseload on depression, anxiety, and APCL scores was the same for men and women. These findings are consistent with previous studies that have examined sex differences among physicians.[45] Other studies that have examined mental health outcomes during the COVID-19 pandemic in Oman,[46] Italy,[42] and China[1] have also found that female healthcare workers have higher rates of depression and anxiety, independent of COVID-19 occupational exposure. As women physicians may be making sacrifices in their personal and professional lives during the COVID-19 pandemic,[47] this global trend of increased mental health symptoms in female healthcare workers should be of interest for future longitudinal studies.

Our study had several limitations. We solicited responses from voluntary participants using online/email recruitment methods, so the possibility of selection bias should be considered. A response rate was not calculated due to the anonymity of the survey. We were unable to capture a representative sample of physicians, though we did capture a broad range of specialties and ages. Due to the method of recruitment, 56.4% of the physicians in our sample work in an academic setting, so our descriptive results that do not adjust for work setting over-represent this group. According to physician census data compiled by the Federation of State Medical Boards (FSMB), 64.0% of actively licensed physicians are men, 35.1% are women, and 0.9% are unknown.[48] This differs from our sample of 44% men, 56% women, and 5 participants who identified as non-binary. Our sample was younger than the data compiled by the FSMB, but the FSMB study also excludes residents from their data.[48] The use of multiple imputation mitigated the impact of incomplete surveys and item non-response under the assumption that data were missing at random given the observed data.

Because we wished to maintain anonymity, we did not verify occupational status or IP addresses and individuals could have possibly completed the survey more than once. We used self-report measures instead of diagnostic interviews, but felt that anonymity was necessary to accurately determine psychological states and symptoms among medical professionals.[49] We also used validated instruments that physicians may easily recognize as those they use for their patients. Furthermore, while the PHQ-9, GAD-7, and APCL are widely used in research, they are unable to comprehensively conceptualize psychological distress in the context of a global pandemic.

Self-report measures can introduce biases and participants may have hidden or exaggerated symptoms.[50] Furthermore, this cross-sectional survey method does not allow us to conclude causality for the associations described in this study. We also used a non-validated question for the COVID-19-workload question and we did not include a measure related to insomnia or burnout, which can overlap significantly with depressive symptoms.[51] Due to the study limitations, the observed characteristics of the study sample may not generalize to the target population (practicing US physicians). While, more confidence can be placed in the generalizability of the adjusted regression results, findings from this voluntary cross-sectional survey are still limited by the study design.

Our study revealed some differences compared with other studies from around the world. For example, Zhang et al[52] found that healthcare workers in China who lived in rural areas experienced more anxiety symptoms than those living in urban areas. Our study questionnaire asked physicians about the location of their work setting (US county) and we found no statistically significant association between county-level proportion of rural population and any of the three rating scales. Minority participants in our study had lower scores on the GAD-7, independent of COVID-19 caseload, although this finding may be due to adjusting for mediators and warrants further examination. Race and ethnicity were not always collected in other studies around the world. Few other studies have focused only upon physicians[5,41] and limited data are available from the United States, so this is difficult to compare.[53] These topics should be investigated further in future studies.

In conclusion, the findings of our study suggest that physician workplaces should establish and maintain a positive organizational culture that supports emotional health and wellness and implement evidence-based programs that support clinician wellbeing for those treating COVID-19. Tools and strategies to recognize burnout and mental health symptoms should be offered to all healthcare workers during this challenging time in medicine. Adequate staffing, support, personal protective equipment, and rest must be provided to all physicians to ensure and promote health and wellbeing.[54] Nationally, we must reduce stigma related to mental health and eliminate treatment barriers for physicians. Long-term mental health resources should be provided to physicians without repercussions.[55] Lastly, future studies should investigate the long-term mental health effects of COVID-19 upon physicians. Longitudinal studies with the primary purpose of studying the impact of the pandemic and how it relates to race, medical specialties, or sex may be of additional interest.

ACKNOWLEDGMENTS

The authors wish to thank the following individuals for their contributions to this project: Julie Gentile, MD, Allison Cowan, MD, William M. Klykylo, MD, Bethany Harper, MD, Randon Welton, MD, Katherine Caujolle-Alls, MD, Sabina Bashir, Katelynn Alcorn.

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