BRIEF REPORT

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The Characterization of the Toll of Caring for Coronavirus Disease 2019 on ICU Nursing Staff

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OBJECTIVES: Coronavirus disease 2019 pandemic exercised a significant demand on healthcare workers. We aimed to characterize the toll of caring for coronavirus disease 2019 patients by registered nurses.

DESIGN: An observational study of two registered nurses cohorts.

SETTING: ICUs in a large academic center.

SUBJECTS: Thirty-nine ICU registered nurses assigned to coronavirus disease 2019 versus noncoronavirus disease 2019 patients.

INTERVENTIONS: None.

MEASUREMENTS AND MAIN RESULTS: Skin temperature (t [°C]), galvanic skin stress response (GalvStress), blood pulse wave, energy expenditure (Energy [cal]), number of steps (hr^{-1}), heart rate (min^{-1}), and respiratory rate (min^{-1}) were collected using biosensors during the shift. National Aeronautics and Space Administration Task Loading Index measured the subjective perception of an assignment load. Elevated skin temperatures during coronavirus disease 2019 shifts were recorded (Δt_{COVID} vs $t_{non\text{-}COVID}$ = +1.3 [°C]; 95% CI, 0.1–2.5). Registered nurses staffing coronavirus disease patients self-reported elevated effort ($\Delta Effort_{COVID}$ vs $Effort_{non\text{-}COVID}$ = +28.6; 95% CI, 13.3–43.9) concomitant with higher energy expenditure ($\Delta Energy_{COVID}$ vs $Energy_{non\text{-}COVID}$ = +21.5 [cal/s]; 95% CI, 4.2–38.7). Galvanic skin stress responses were more frequent among coronavirus disease registered nurse ($\Delta GalStress_{COVID}$ vs $GalvStress_{non\text{-}COVID}$ = +10.7 [burst/hr]; 95% CI, 2.6–18.7) and correlated with self-reported increased mental burden ($\Delta TLXMental_{COVID}$ vs $\Delta TLXMental_{non\text{-}COVID}$ = +15.3; 95% CI, 1.0–29.6).

CONCLUSIONS: There are indications that registered nurses providing care for coronavirus disease 2019 in the ICU reported increased thermal discomfort coinciding with elevated energy expenditure and a more pronounced self-perception of effort, stress, and mental demand.

KEY WORDS: coronavirus disease 2019; critical care; mental demand; National Aeronautics and Space Administration Task Loading Index; registered nurses; stress

The sheer number of cases, infectiousness, and complexity of coronavirus disease 2019 (COVID-19) exposed critical care providers to fatigue, discomfort, and traumatic stress (1). Yet, the precise characterization of the degree and nature of burden needs to be elucidated (2). Here, we quantified the burden of caring for COVID-19 patients by registered nurses (RNs) using biosensors and a Task Loading Index (TLX) survey (3).

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METHODS

Biosensors registered skin temperature (t [°C]), galvanic skin stress response (GalvStress), blood pulse wave, energy expenditure (Energy [cal]), number of steps (hr^{-1}), heart rate (min^{-1}), and respiratory rate (min^{-1}) (4). At the end of each shift, RNs completed the National Aeronautics and Space Administration TLX survey to assess the subjective self-assessment of effort, frustration, self-performance satisfaction, and perception of mental, physical, and temporal demand (3). Additionally, we collected some demographic information. Data were acquired in a standardized fashion (**Supplement Material 1** http://links.lww.com/CCX/A564). Three-hundred sixty hours of biosensor data were obtained from RNs caring for COVID-19 patients and 264 hours from RNs treating non-COVID patients.

Descriptive statistics demonstrated means (X), median (M_e), SD, and interquartile ranges. Bivariable comparisons of ΔX with 95% CIs were used to compare COVID-19 versus non-COVID-19 groups utilizing. Regression included GalvStress with assignment type and assigned bed count. R v3.6.0 (R Core Team, Vienna, Austria) was used for analysis except for *p* values (Matlab 2019b). Mann-Whitney-Wilcoxon tests were used to calculate significance between studied group. Statistical significance was set at two-sided *p* value of less than 0.05.

The study was approved by the University of Pennsylvania Institutional Review Board (IRB) (No. 834594).

RESULTS

The average participants' age was 35.3 ± 7.23 years. Average time from graduation and of ICU experience were 9.4 ± 4.98 and 4.3 ± 4.59, respectively (yr). No difference in Acute Physiology and Chronic Health Evaluation (APACHE) II admission score between COVID and non-COVID-19 patient was seen ($APACHE_{COVID\text{-}19}$ = 36.0 ± 12.58 vs $APACHE_{non\text{-}COVID\text{-}19}$ = 34.3 ± 11.14; $p = 0.62$) in the studied ICUs.

COVID-19 RNs self-reported elevated effort ($\Delta X_{TLXEffort}$ = 28.6; 95% CI, 13.3–43.9) concomitant with biosensor registering increased energy expenditure (ΔX_{Energy} = 21.5; 95% CI, 4.2–38.7 [cal/s]) (**Table 1** and **Supplemental Digital Content 2**, http://links.lww.com/CCX/A565). A significant increase in skin temperature during COVID-19 shifts was demonstrated (Δt_{COVID} vs $t_{non\text{-}COVID}$ = +1.3°C; 95% CI, 0.1–2.5). Phasic galvanic skin responses indicating the emergence of stress response were more frequent in COVID-19 RNs ($\Delta GalStress_{COVID}$ vs $GalvStress_{non\text{-}COVID}$ = +10.7; 95% CI, 2.6–18.7) (**Supplement Material 3**, http://links.lww.com/CCX/A566). Significant correlations of biosensor registered indices of stress (GalStress) with TLX self-reported effort ($r^2 = 0.5$; $p < 0.001$) and mental demand ($r^2 = 0.18$; $p = 0.04$) was observed. Additionally, GalStress correlated with energy expenditure (r^2 = 0.4; $p = 0.01$) (Supplemental Digital Content 2, http://links.lww.com/CCX/A565). RNs caring for COVID-19 patients reported increased mental burden as well ($\Delta X_{TLMental}$ = +15.3; 95% CI, 1.0–29.6).

DISCUSSION

Increased self-perception of mental burden and effort concomitant with biosensors registering increased energy expenditure tend to be more prevalent among RNs taking care of COVID-19 patients. The increased energy expenditure and perception of effort may be linked to overheating registered as elevation in skin temperature, most likely secondary to wearing personal protective equipment (PPE). No difference in RN steps was registered between the two cohorts, underscoring PPE as a cause of increased energy expenditure. This is consistent with COVID-19–specific hospital policy limiting the movement of RN in/out ICU rooms and recommending PPE (5). Increased mental demand could be related to a novelty of the COVID-19 pandemic during the study itself (1, 4). It correlated with several indices, including galvanic stress responses. This perceived demand was not high enough to trigger profound physiologic changes like respiratory rate or skin blood flow changes (4–6).

Study limitations include reliance on a single hospital, pilot nature of the data, and presence of unaccountable confounders. Although we controlled for some clinical characteristics using APACHE, other clinical measurements would be more accurate, but the IRB protocol excluded their collection. Also, we do not monitor the activity of the RNs specifically while wearing the sensors, but all our participants were provided with detailed instructions and in-service. The study did not account for the effect of gender and socioeconomical background as we did not collect this information per IRB regulation (7). Finally, the effect of stress depends on several individual psychologic traits, especially coping strategies and resilience (8).

TABLE 1.

Differences in Provider Stress Metrics Between Coronavirus Disease 2019 and Standard ICU Shifts

Stress Measure	Statistical Analyses	Coronavirus Disease 2019 Shift	Standard ICU Shift	Difference (95% CI)	*p*
Task Loading Index survey responses					
n		24	15		
Effort	Mean (SD)	76.3 (18.8)	47.7 (17.5)	28.6 (13.3–43.9)	< 0.001
	Median (IQR)	80 (70–90)	50 (35–58)		
Frustration	Mean (SD)	56.3 (27.4)	48.7 (25.2)	7.6 (–10.1 to 25.3)	0.34
	Median (IQR)	60 (39–71)	50 (28–68)		
Mental demand	Mean (SD)	69.0 (20.8)	53.7 (19.7)	15.3 (1.0–29.6)	0.02
	Median (IQR)	75 (64–80)	50 (43–68)		
Performance	Mean (SD)	16.7 (12.7)	15.7 (9.8)	1.0 (–6.7 to 8.7)	0.66
	Median (IQR)	15 (10–20)	20 (10–23)		
Physical demand	Mean (SD)	65.6 (17.6)	57.3 (18.1)	8.3 (–3.7 to 20.3)	0.22
	Median (IQR)	70 (54–80)	45 (40–75)		
Temporal demand	Mean (SD)	55.4 (25.4)	47.0 (18.2)	8.4 (–6.9 to 23.7)	0.26
	Median (IQR)	60 (40–71)	50 (30–65)		
Biometrics during shift					
n		9	11		
Blood pulse wave	Mean (SD)	3.01 (0.58)	2.91 (0.75)	0.10 (–0.52 to 0.73)	0.46
	Median (IQR)	2.77 (2.65–3.36)	2.65 (2.50–2.98)		
Energy expenditure (cal/s)	Mean (SD)	52.2 (19.8)	30.7 (9.7)	21.5 (4.2–38.7)	**0.01**
	Median (IQR)	52.7 (36.5–61.7)	27.7 (25.3–31.2)		
Galvanic skin response (peaks/hr)	Mean (SD)	12.6 (8.9)	2.0 (2.1)	10.7 (2.6–18.7)	**0.03**
	Median (IQR)	14.5 (6.3–18.9)	1.1 (0.5–3.0)		
Heart rate (min^{-1})	Mean (SD)	89 (15)	82 (16)	7.3 (–7.8 to 22.5)	0.33
	Median (IQR)	89 (77–100)	81 (72–89)		
Respiratory rate (min^{-1})	Mean (SD)	21 (4.2)	19 (3.9)	1.6 (–2.2 to 5.4)	0.55
	Median (IQR)	20 (17.5–21.6)	19 (18.1–20.1)		
Skin conductance (μS)	Mean (SD)	1.01 (0.87)	0.29 (0.16)	0.72 (0.04–1.41)	0.10
	Median (IQR)	0.94 (0.29–1.48)	0.22 (0.17–0.41)		
Skin temperature (°C)	Mean (SD)	34.0 (1.1)	32.8 (1.2)	1.3 (0.1–2.5)	**0.04**
	Median (IQR)	34.0 (33.3–35.0)	33.2 (31.7–33.6)		
Steps (hr)	Mean (SD)	619 (187)	734 (238)	–115 (–322 to 92.0)	0.30
	Median (IQR)	572 (505–699)	675 (562–809)		

IQR = interquartile range.

Boldface values represent significant *p* values.

Our study had several strengths. We used FDA-approved biosensors for high data accuracy to measure stress objectively (6). Stress correlated with perception of demand as expected. Energy expenditure correlated with the TLX survey is a well-recognized tool to measure task load (3). For the pilot study, we had a sizeable number of RNs involved logging several work hours, similarly to other studies (6). During planning the subsequent study, we calculated preliminary power analysis suggesting a similar number of individuals will be sufficient to conduct investigation with robust statistical power. Our RNs had similar assignment ratios and APACHE II in COVID-19 and non-COVID-19 group, an essential factor determining load (7, 9). All collections were done over a short period, reducing the time-lag–related variability that was particularly intense during the beginning of the pandemic.

Few had quantitatively monitored the COVID-19–related strain (2, 5, 10). Recognizing and alleviating staff strain is an essential strategy to maintain care quality and well-being after the COVID-19 era (1, 2, 9, 10). This study's result can be potentially applicable to other providers, but COVID-19 presented with unique stress. Also, while ICU environment-related stress is unique, factors leading to burnout seem to be similar (9).

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Dr. Laudanski involved in study concept, institutional review board approval, data collection, article preparations, and supervision. Dr. Moon involved in study concept and design, obtaining funding, analysis and interpretation of data, drafting and review of article, and supervision. Mr. Singh involved in study concept and design, and analysis and interpretation of data. Mrs. Chen involved in data collection and recruitment. Ms. Restrepo involved in data collection and article preparation. All authors reviewed the final version of the article and agreed to its publication.

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The Institutional Review Board approved the study at the University of Pennsylvania (No. 834594).

The datasets used and/or analyzed during the current study are available from the corresponding authors on reasonable request.

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