Quantifying Occupational Stress in Intensive Care Unit Nurses: An Applied Naturalistic Study of Correlations Among Stress, Heart Rate, Electrodermal Activity, and Skin Temperature)

Phase 1 & Expansions Of Burnout Grant

Tariq Nisar, MPH
Biostatistician

HOUSTON Methodist® LEADING MEDICINE

Contents

- Research Objective
- Study Design/ Data Collection Process
- Data Abstraction- Collaborative work
- Methodology, Trends & Analytic Results
- Key conclusions
- Data driven expansion projects
- Acknowledgments
- Feedbacks

Tariq Nisar

2014-2016

2015-2016

2016

2016-2018

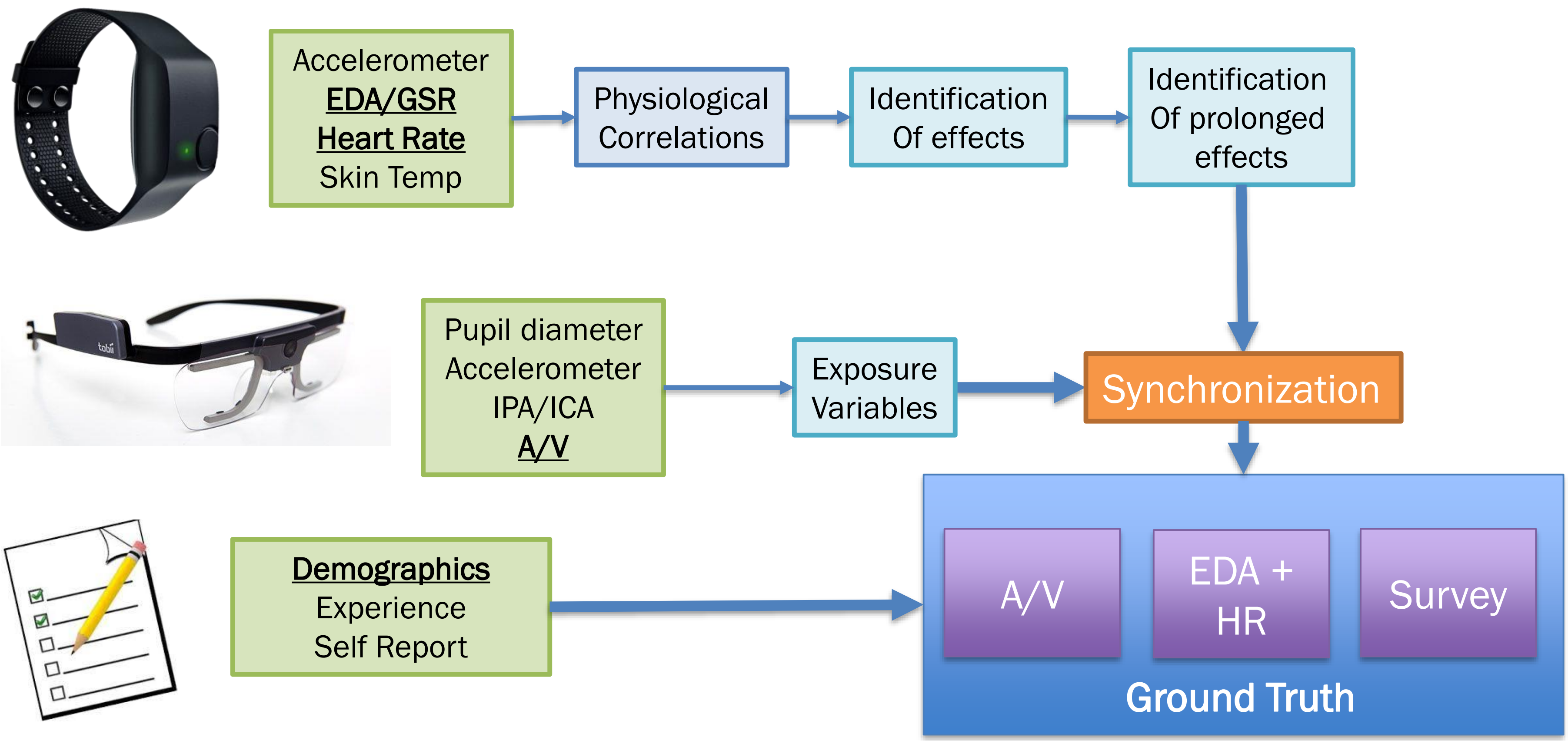
2018-2019

2019- Present

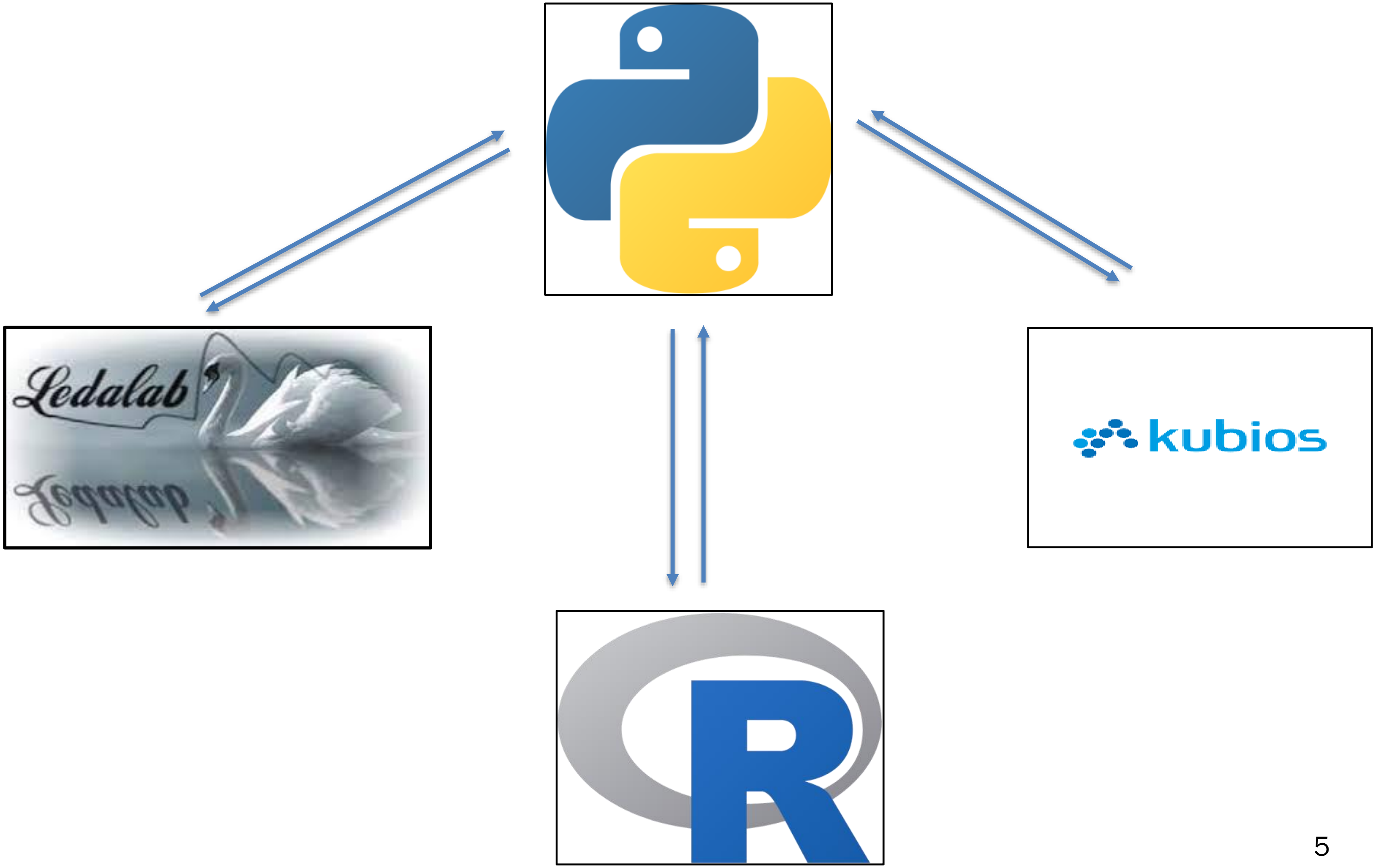
Research Objective

- To identify physiological correlates to stress in intensive care unit nurses
- Why?

Study Design



Data Collaboration/Processing



Why the research objective

- A need for validation
- Ground standard for Naturalistic Vs. Lab Design Study

Variables

- Stress Index & Stress zones
- Variable of interest

- ❑ Heart Rate
- ❑ Phasic EDA Peak
- ❑ Raw EDA
- ❑ Skin Temperature

List of other variables in the data set

- Age
- Gender
- BMI
- Marital Status
- Children
- Shift
- Emotional exhaustion
- Depersonalization
- Personal Accomplishment
- Experience
- Sleep

Major Outcome

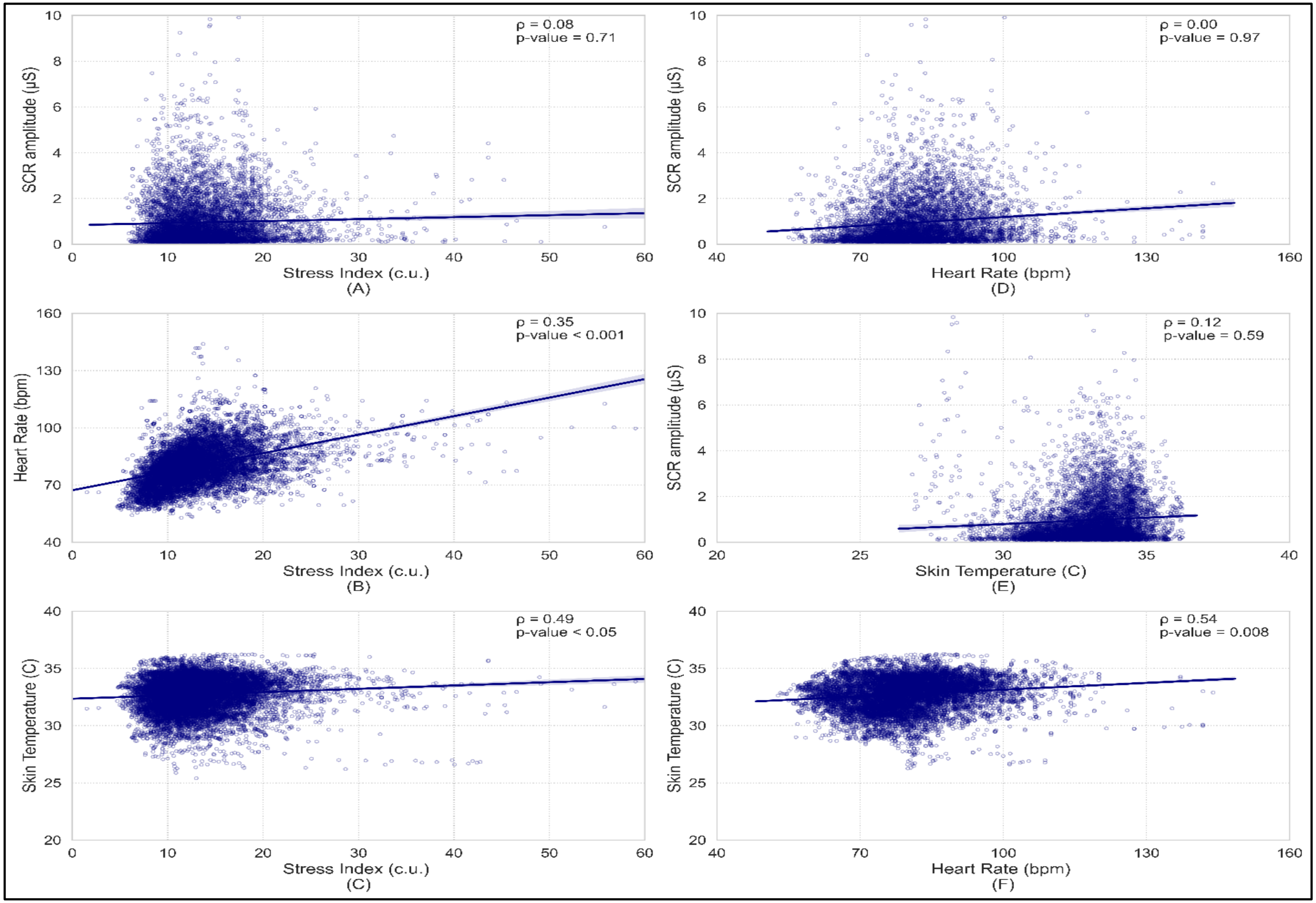
- SI = $$\frac{AMo}{(2Mo) \times (MxDMn)}$$

- AMo = Amplitude of the most frequent inter-beat interval (IBI) ; Mo = Mode of the most frequent IBI & MxDMn = Range of IBI.

- Baevsky's SI : between 50-150 is considered normal;
- Square root of this range was used to define the intensity of sympathetic cardiac activation stress index—
- Stress zone (normal stress zone (reduced activation): SI ≤ 12.2 and high-stress zone (high activation): SI > 12.2)

Naturalistic Correlations

HOUSTON Methodist LEADING MEDICINE



Reference for Statistical Correlation On Repeated Measurements : Bakdash, J. Z., & Marusich, L. R. (2017). Repeated measures correlation. *Frontiers in psychology*, *8*, 456.

Lab setting Vs. Naturalistic setting

HOUSTON Methodist LEADING MEDICINE

Feature	Known Correlations/Lab	Observed Correlations/Naturalistic
Stress and Phasic EDA Peak	+	No correlation
Stress and HR	+	+
Stress and skin temperature (dorsal wrist)	No correlation	+
Phasic EDA Peak and HR	+	No correlation
Phasic EDA Peak and skin temperature (dorsal wrist)	+	No correlation
HR and skin temperature	Not studied	+

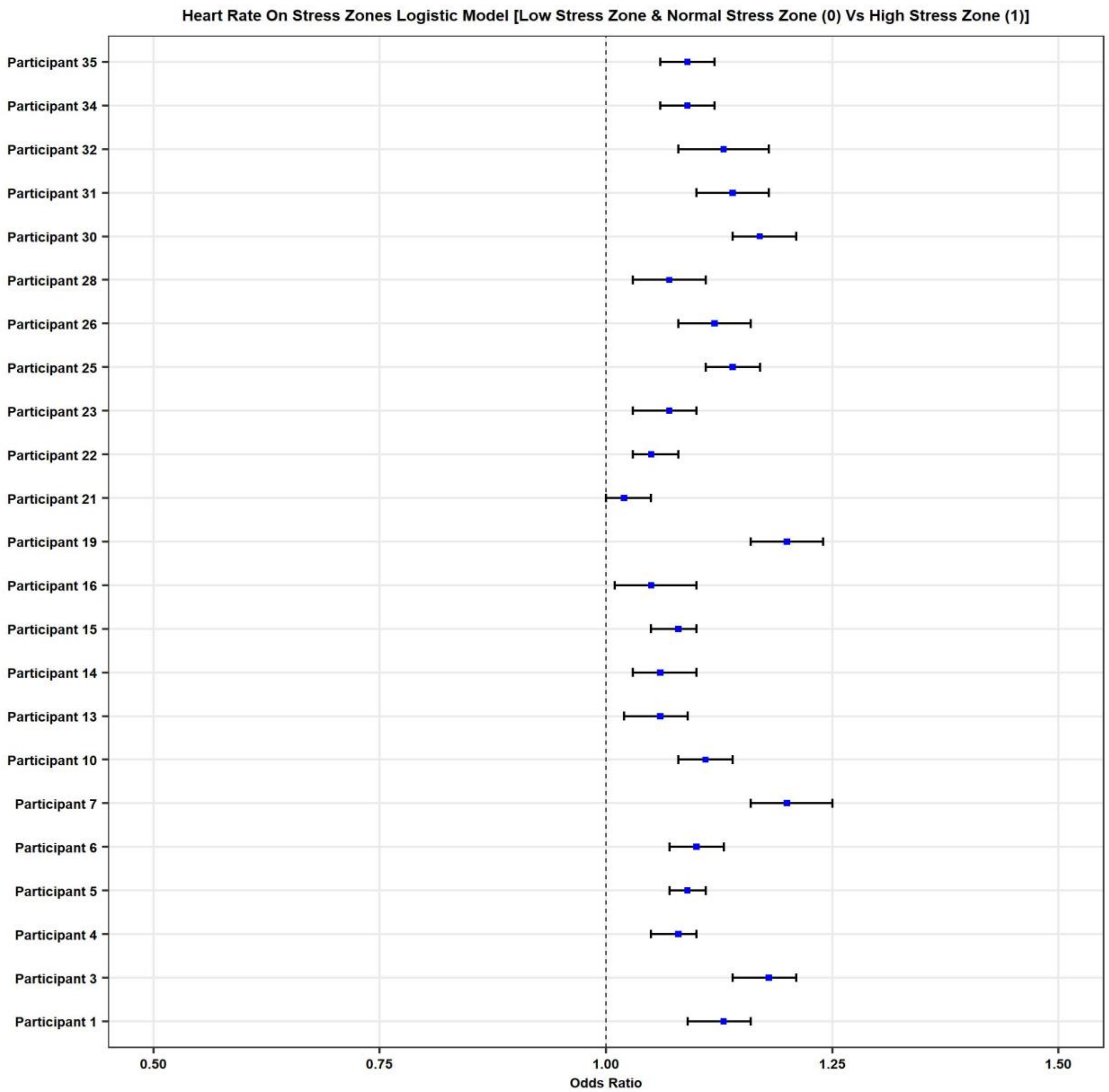
Overall summary by two groups

Variables		
	Normal Stress N= 7,117	High Stress N =8,756
Heart Rate (Mean, SD)	76.1 (±8.6)	85.7 (±11.6)
Max. Heart Rate (Mean, SD)	84.3 (±11.2)	91.2 (±13.0)
Phasic EDA Peak (Mean, SD)	0.9 (±1.0)	1.0 (±1.1)
Raw EDA (Mean, SD)	2.0 (±3.6)	2.2 (±4.0)
Skin Temperature (Mean, SD)	36.0 (±15.7)	37.9 (±34.3)

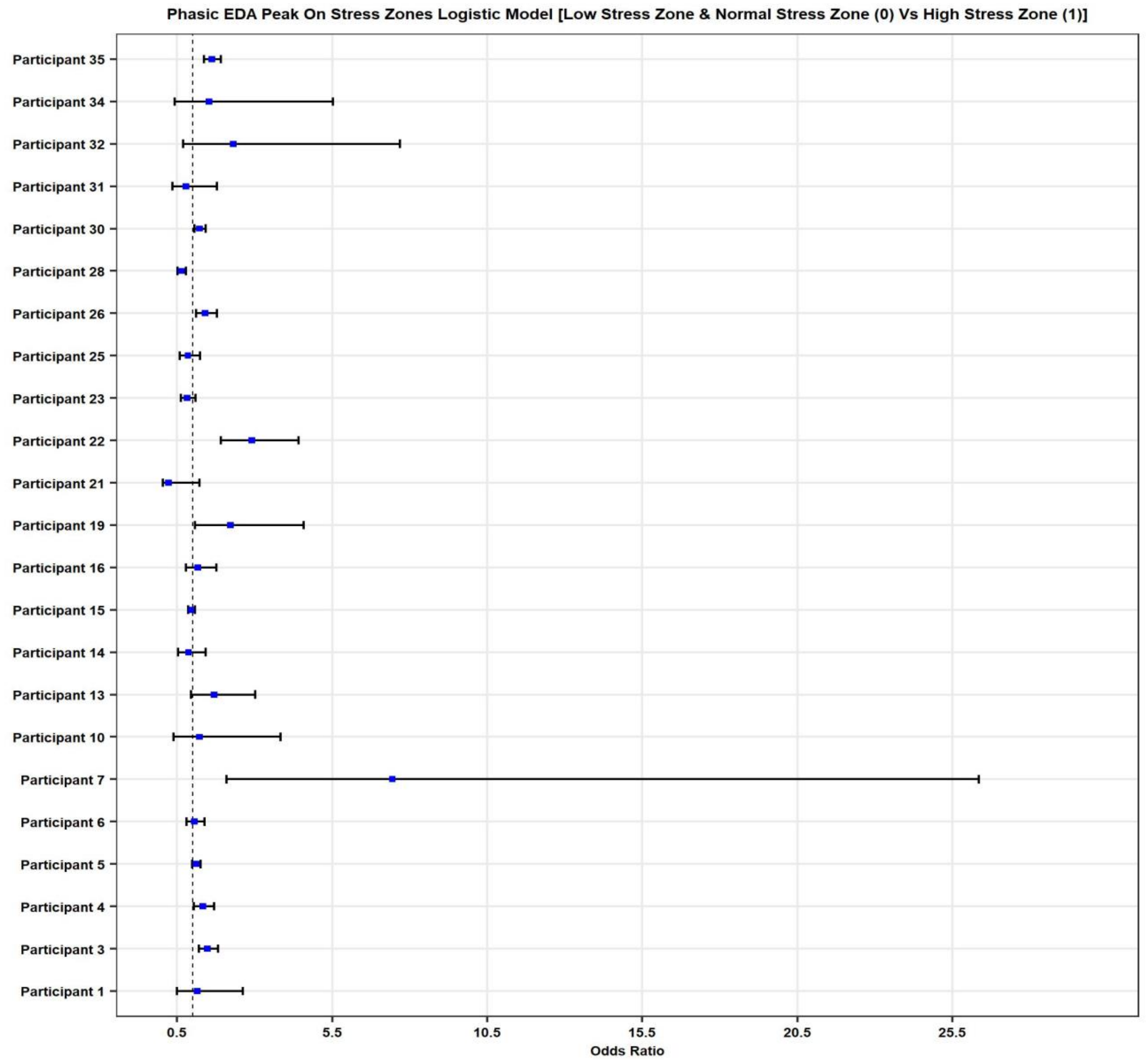
Individual Participant Analysis

HOUSTON Methodist LEADING MEDICINE

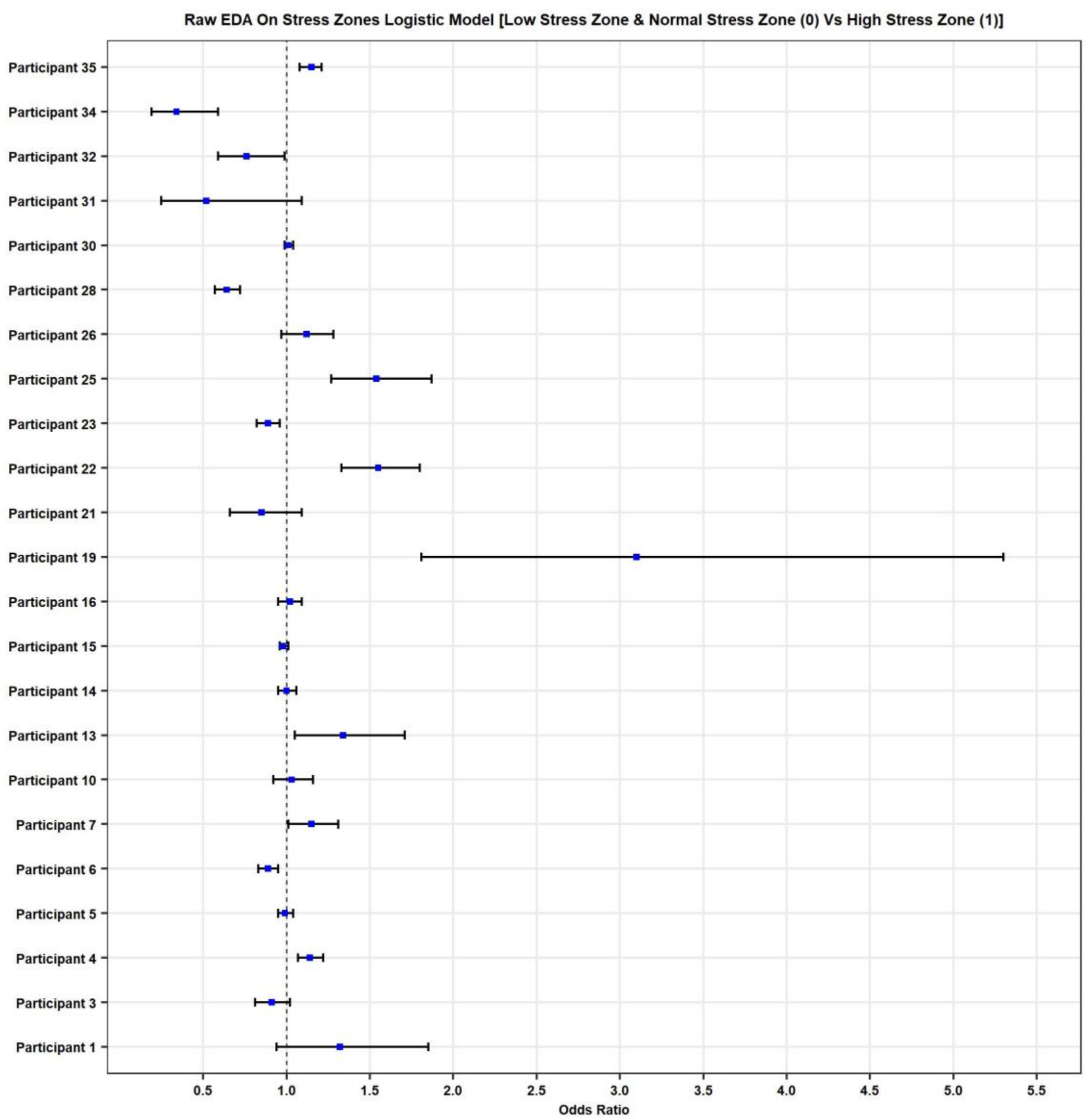
Stress zone ~ Heart Rate



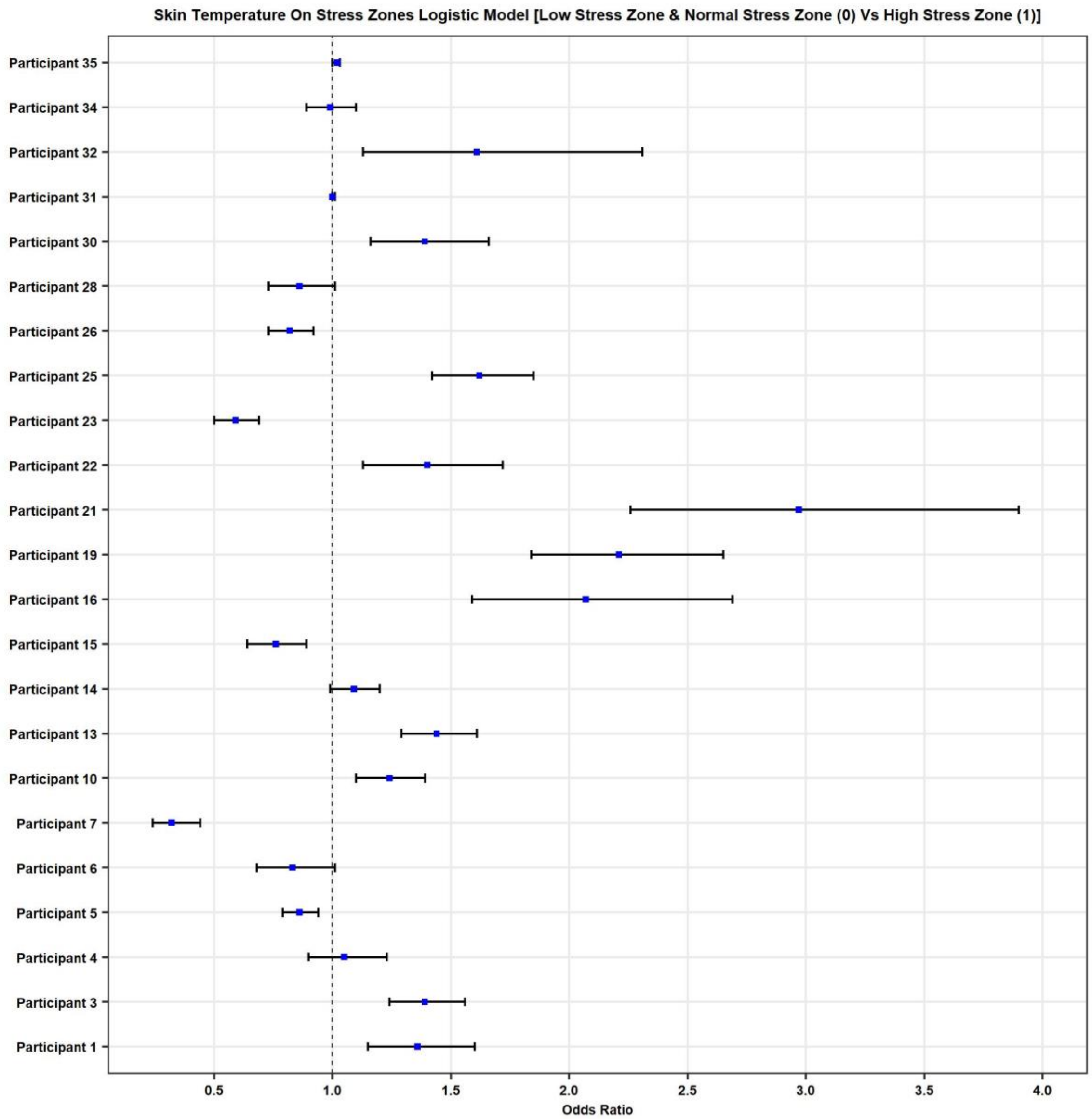
Stress Zone ~ Phasic EDA Peak



Stress Zone ~ Raw EDA



Stress Zone ~ Skin Temperature



Model on Over all data

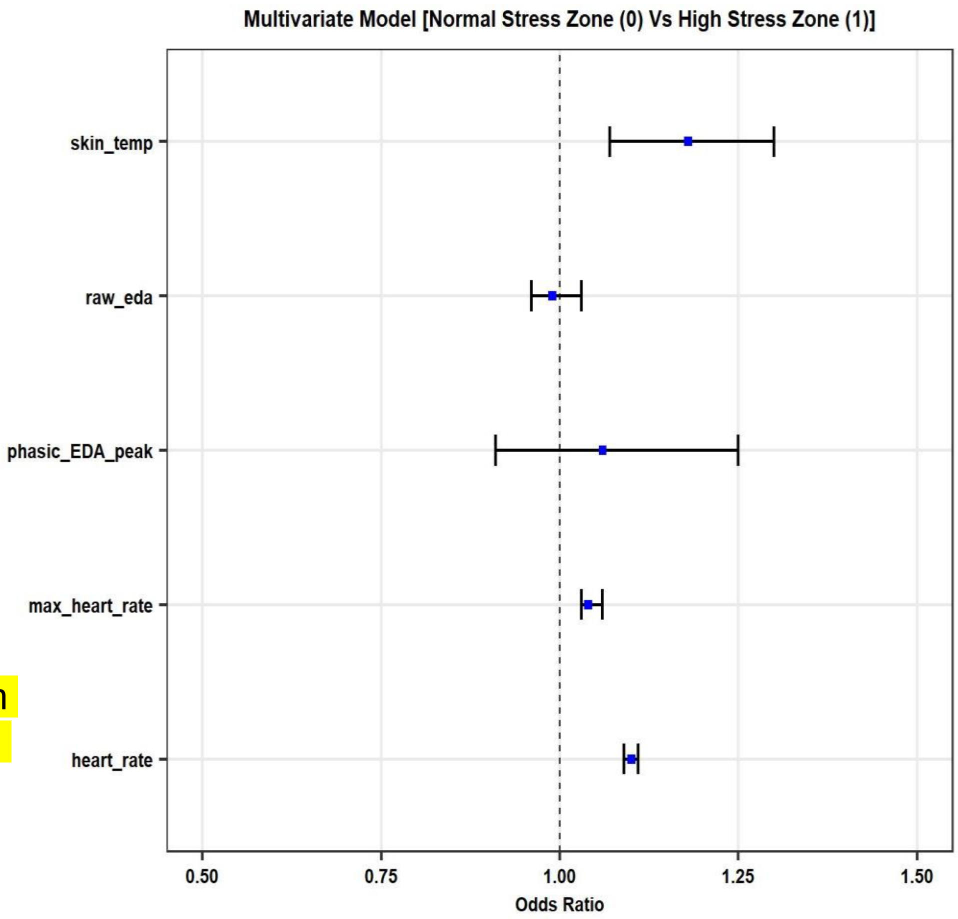
Multivariable Model adjusted for Age, Marital Status and number of Children yielded,

1. For every one unit increase in heart rate, participants were 1.10 times more likely to be in a high stress zone, i.e. (increases by 10%)(OR = 1.10, 95% CI =[1.09, 1.11]; p<0.001)

2. For every one unit increase in max heart rate, participants were 1.04 times more likely to be in a high stress zone, i.e. (increases by 4%)(OR = 1.04, 95% CI =[1.02, 1.06]; p<0.001)

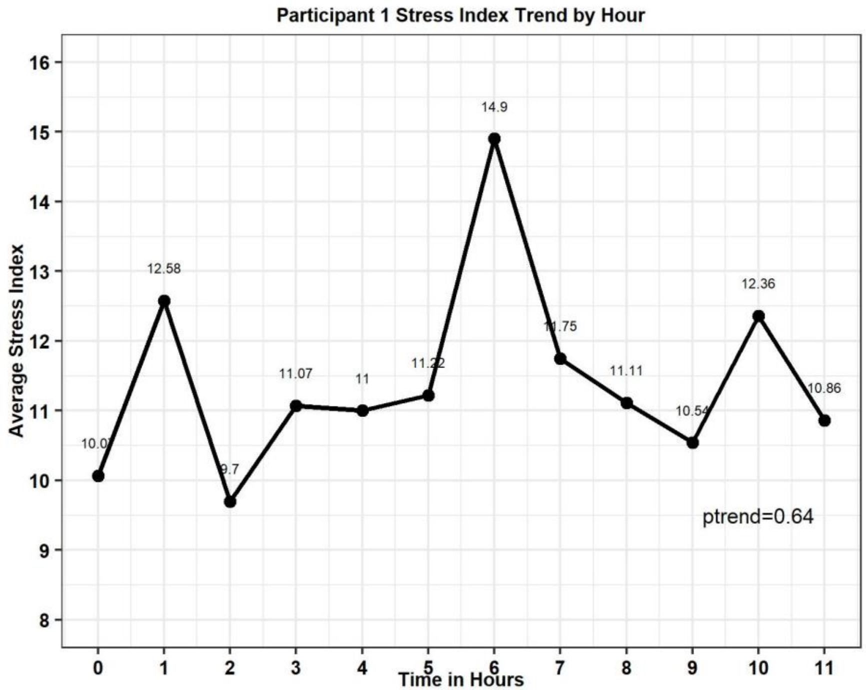
3. For every one unit increase in skin temp., participants were 1.18 times more likely to be in high stress zone, i.e. (increase by 18%) [OR = 1.18, 95% CI [1.07, 1.30]; p<0.001)!!!

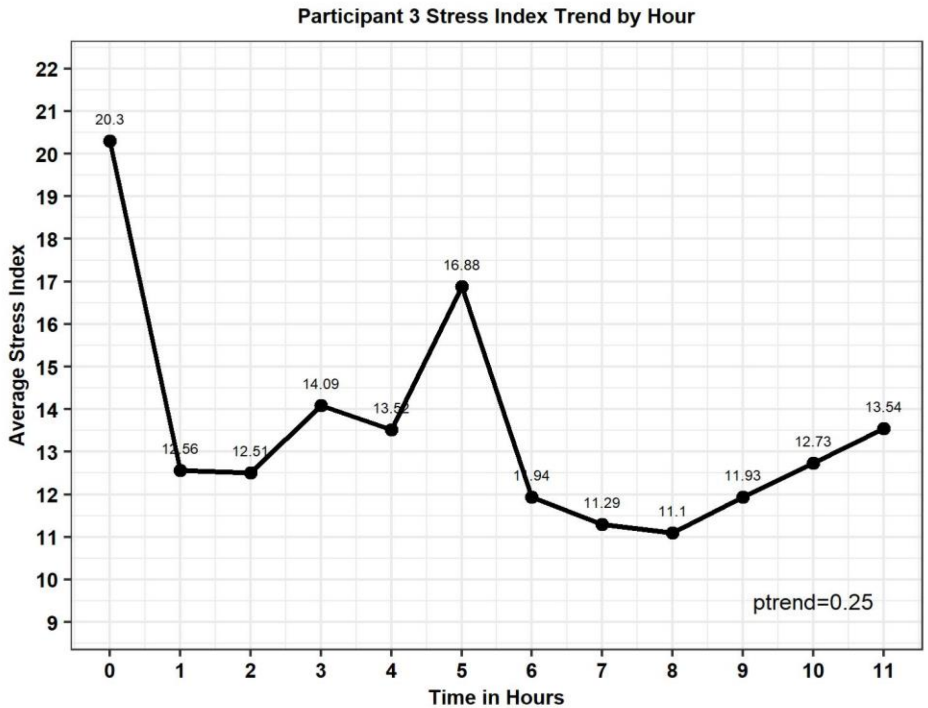
4. Additionally, we did not found any significant association of skin temperature, phasic EDA, and raw EDA on stress zones



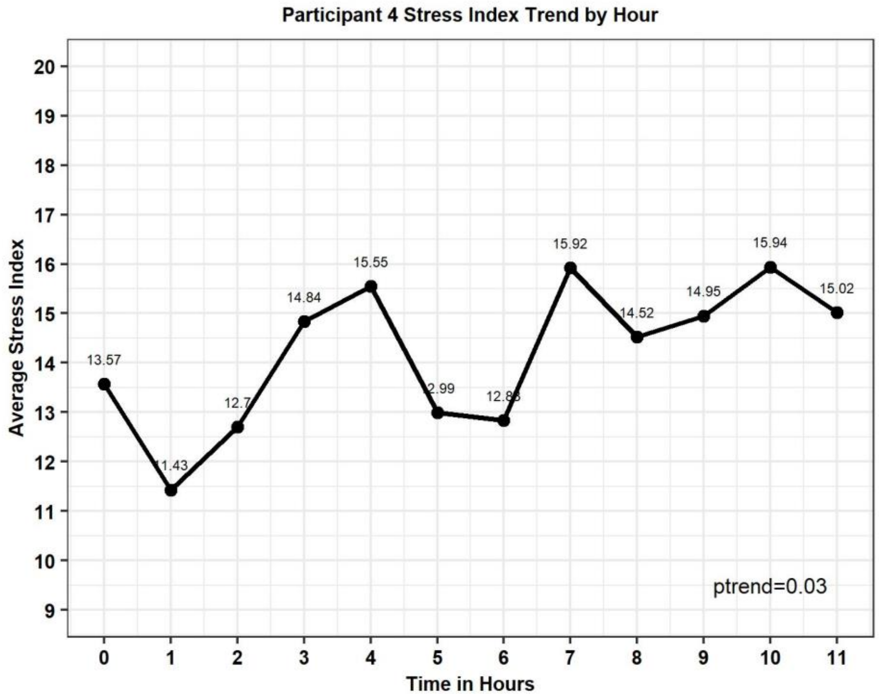
Trend Analysis

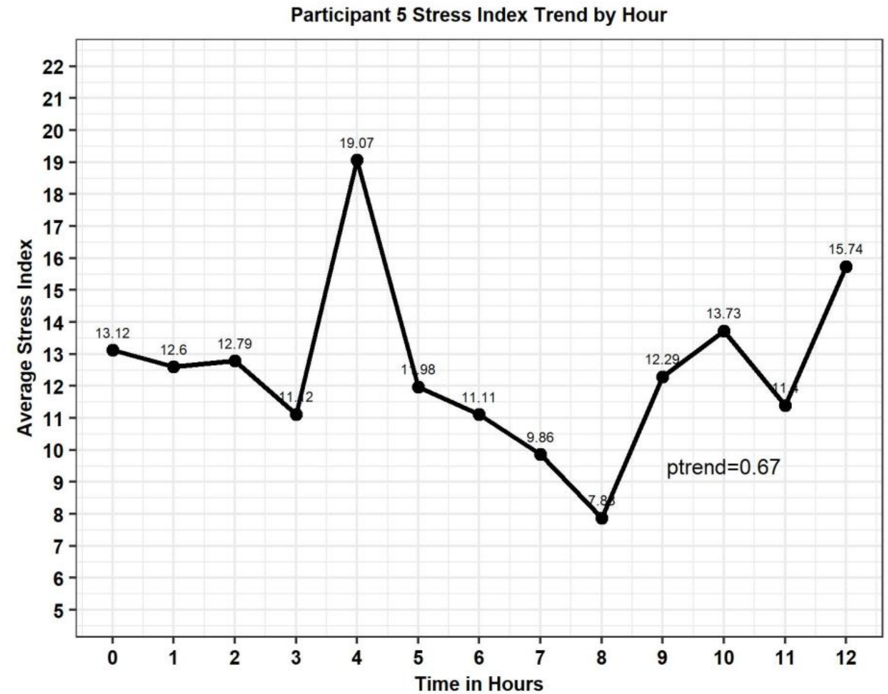
Participant 1 & 3



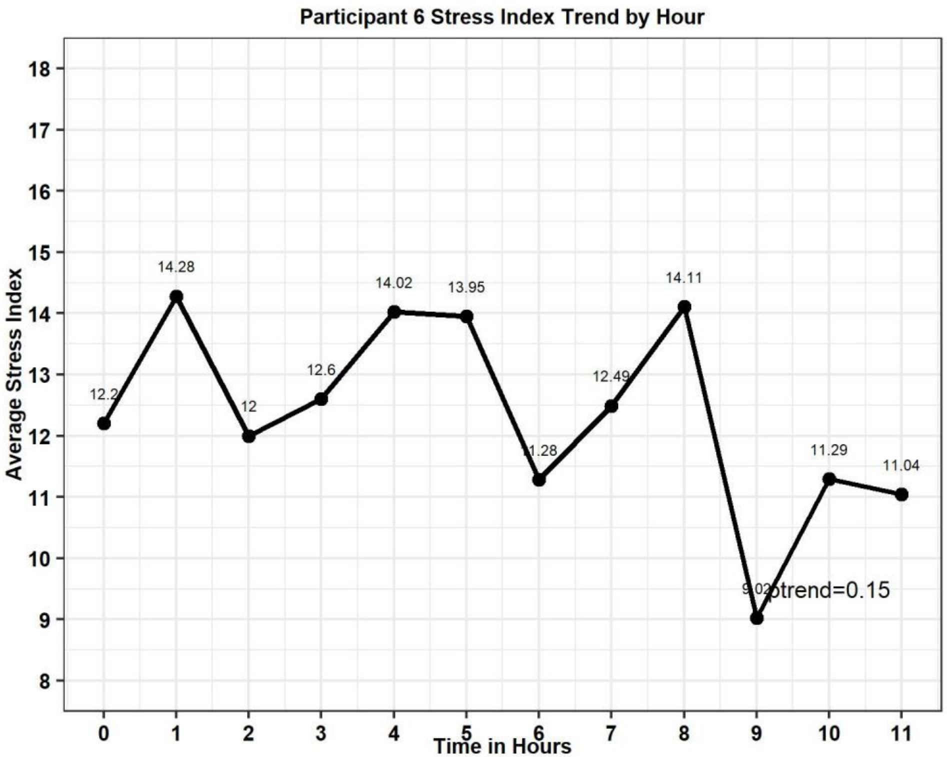


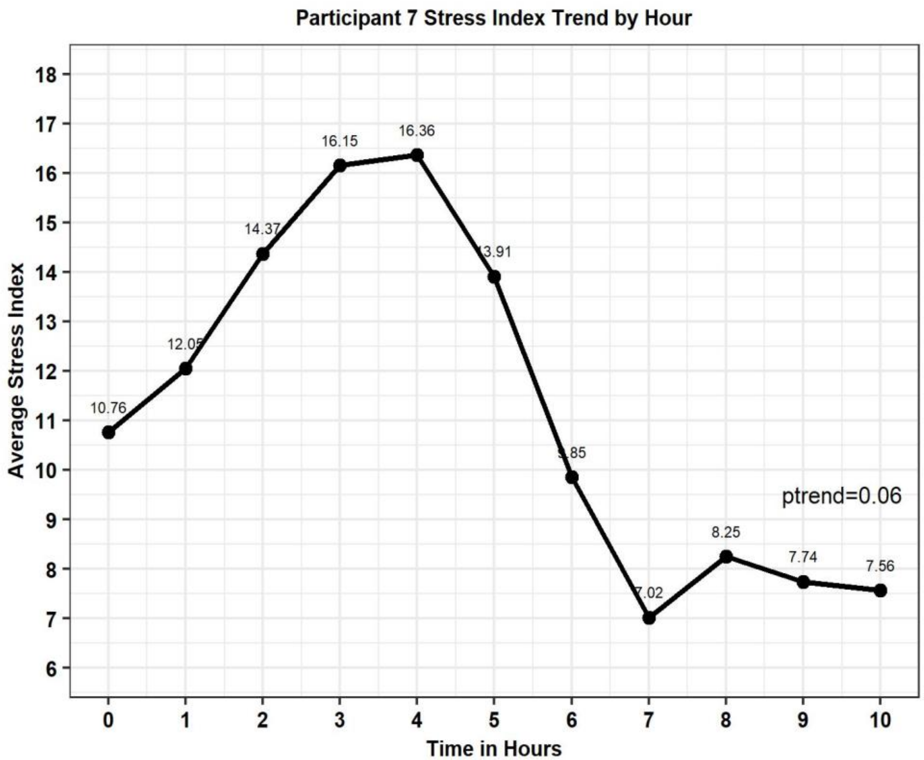
Participant 4 & 5



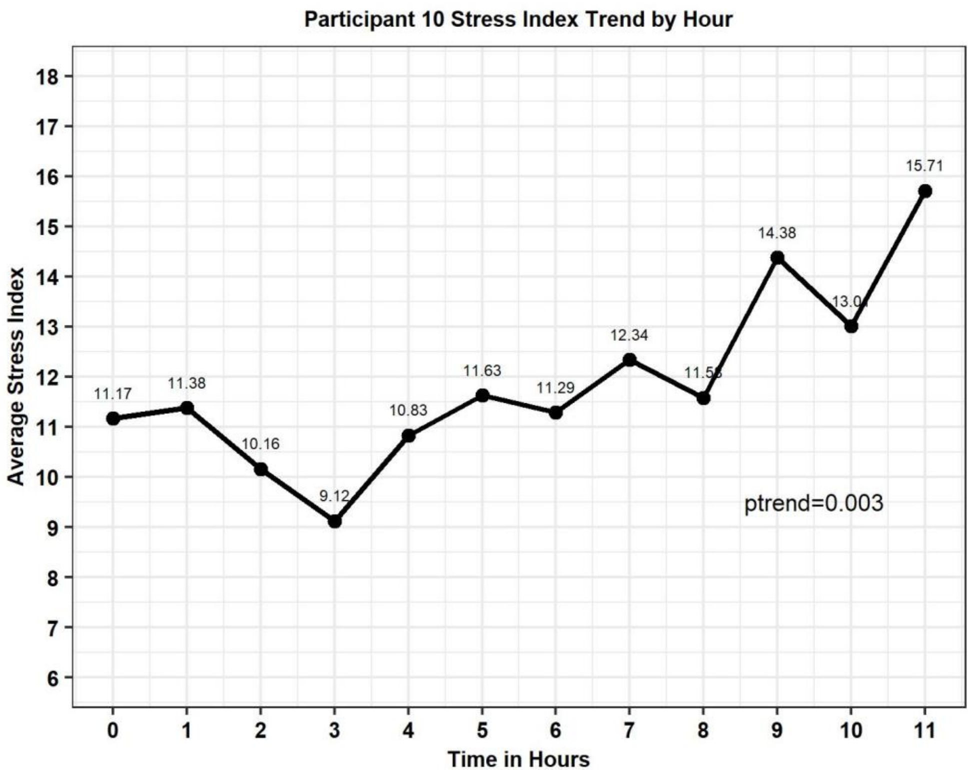


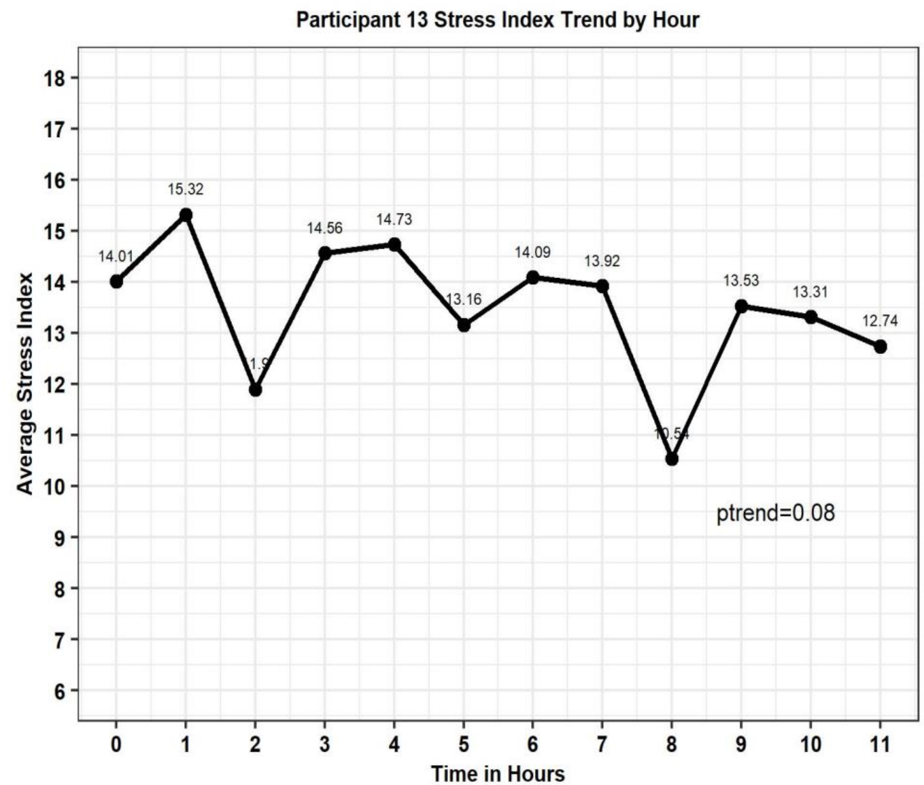
Participant 6 & 7



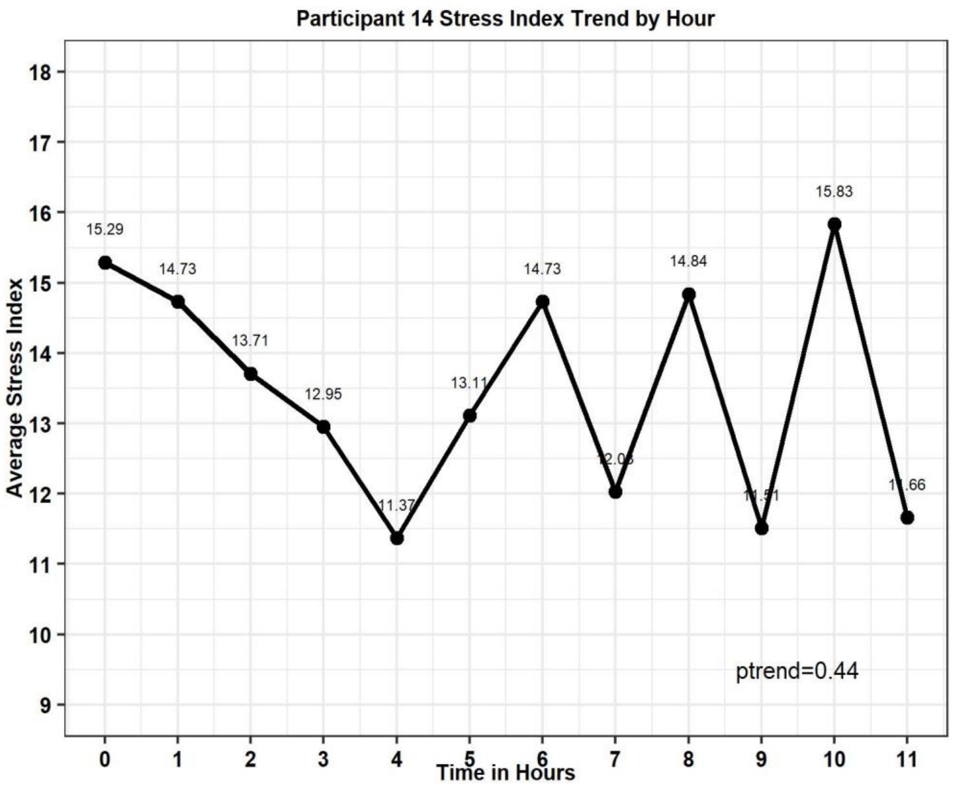


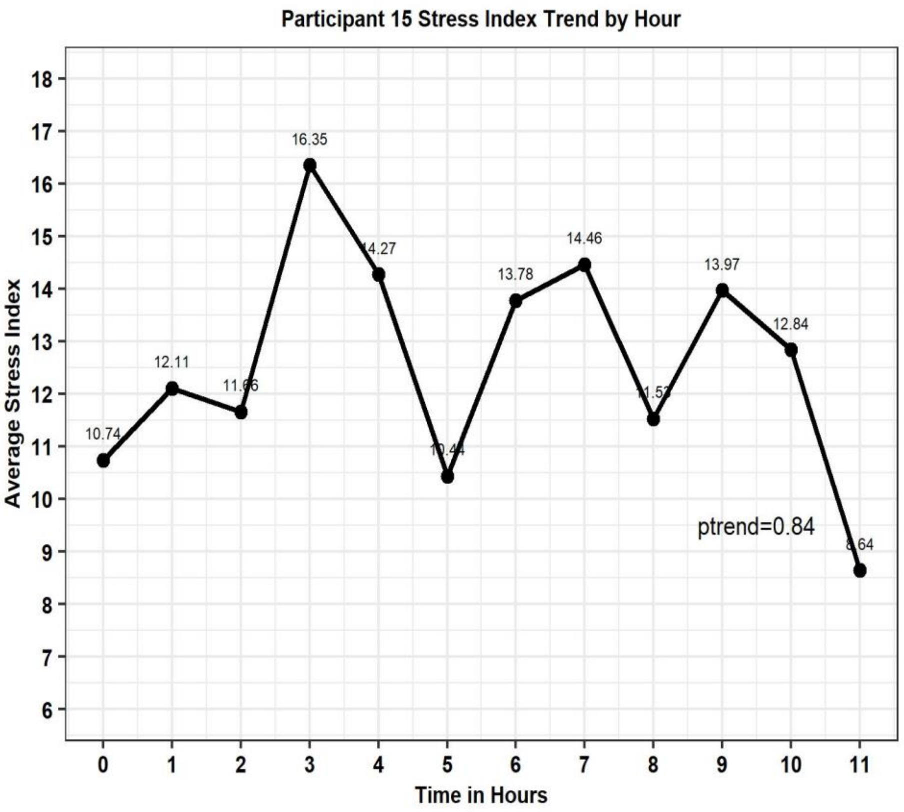
Participant 10 & 13



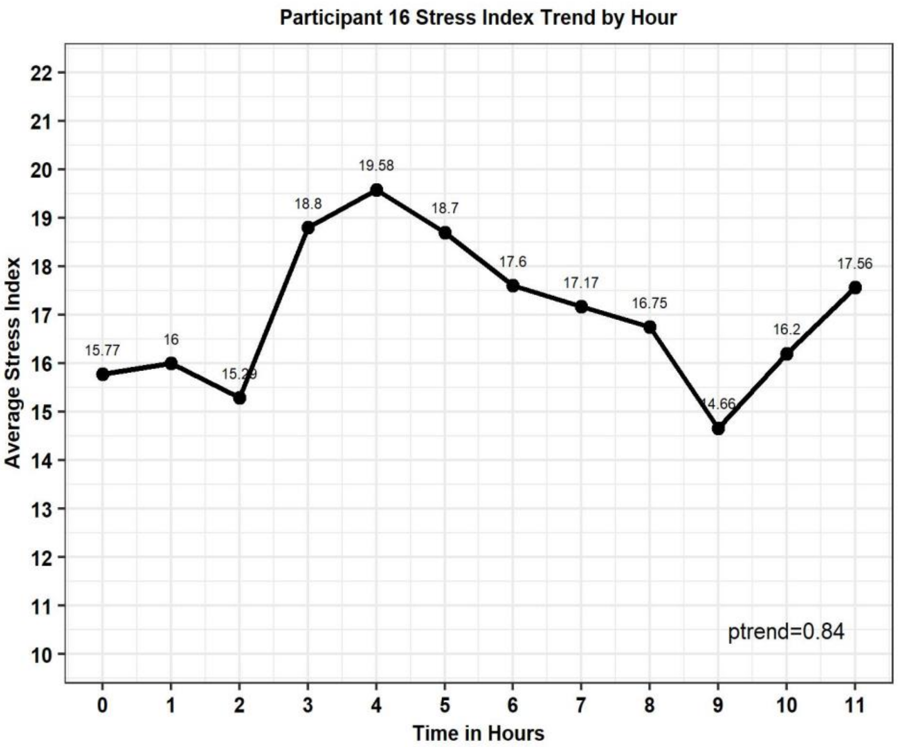


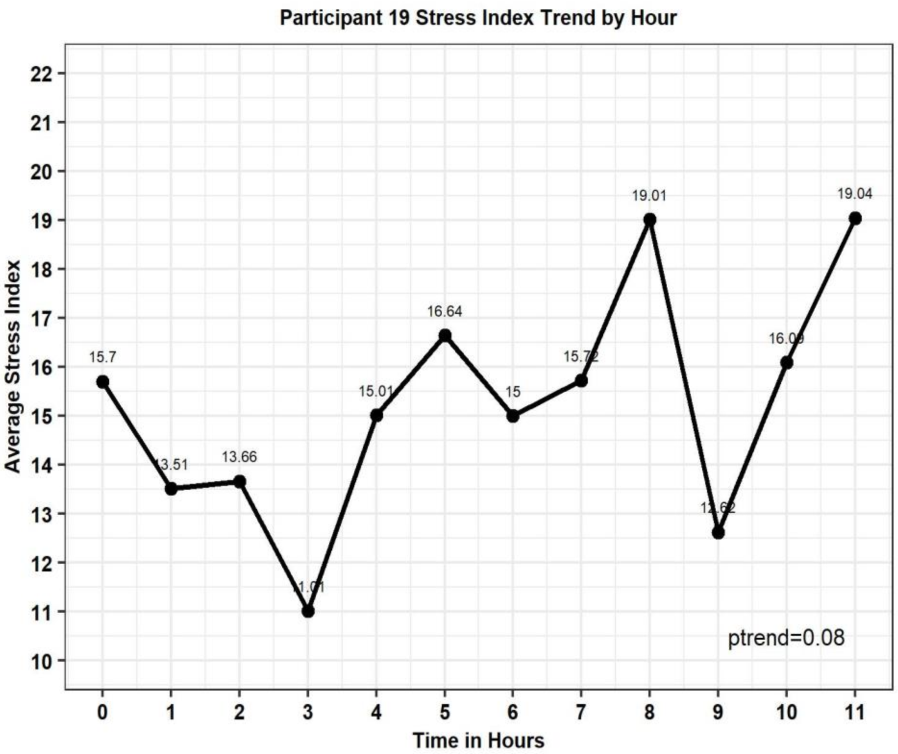
Participant 14 & 15



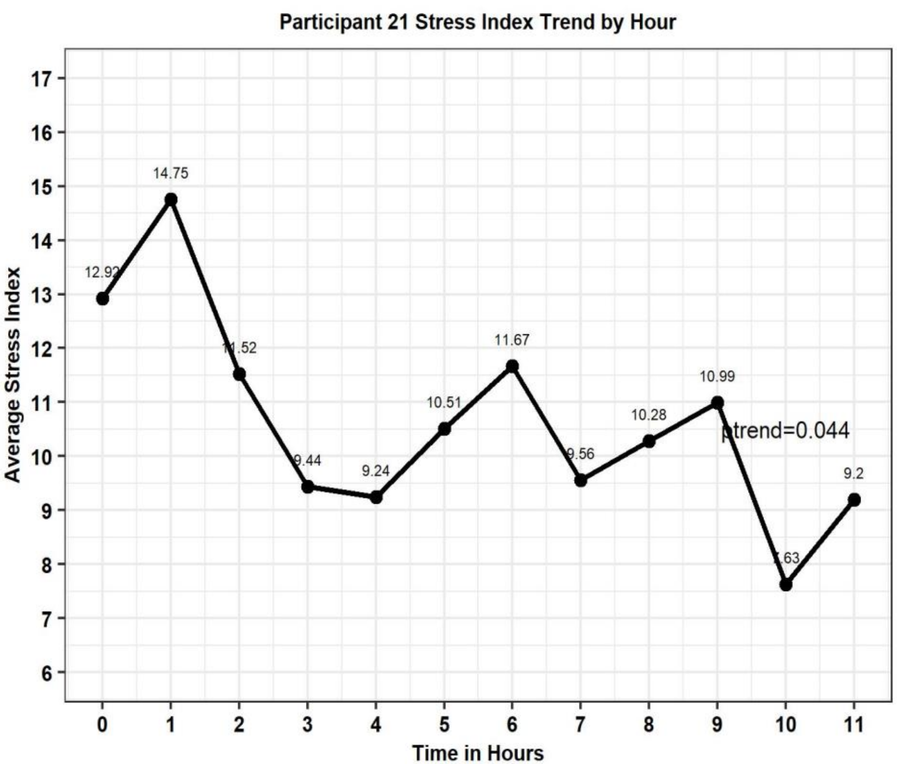


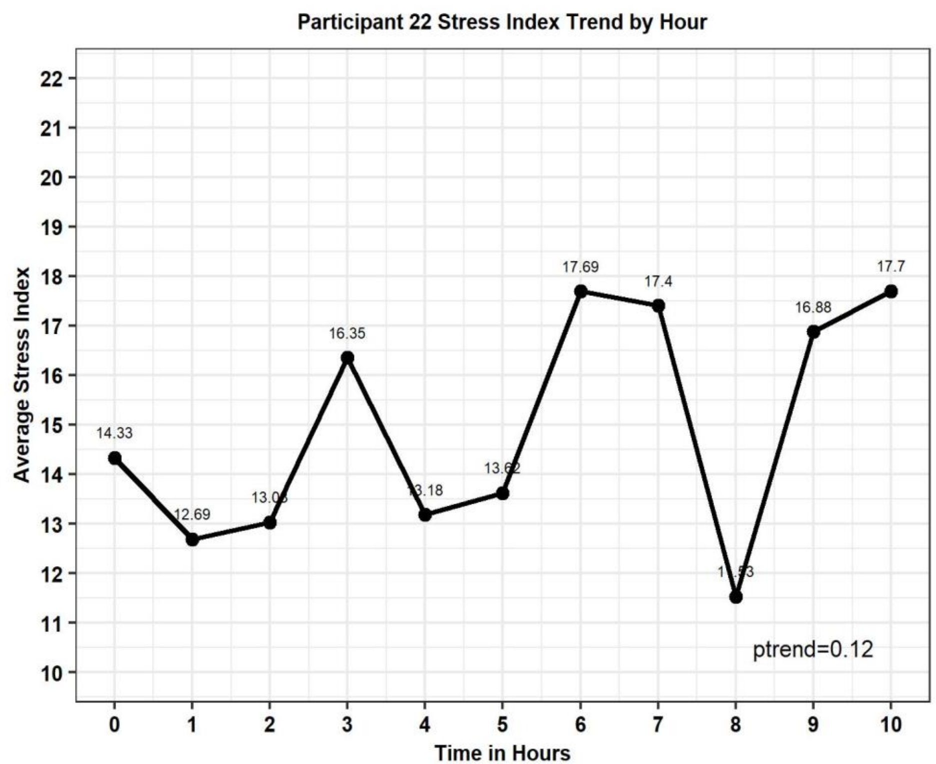
Participant 16 & 19



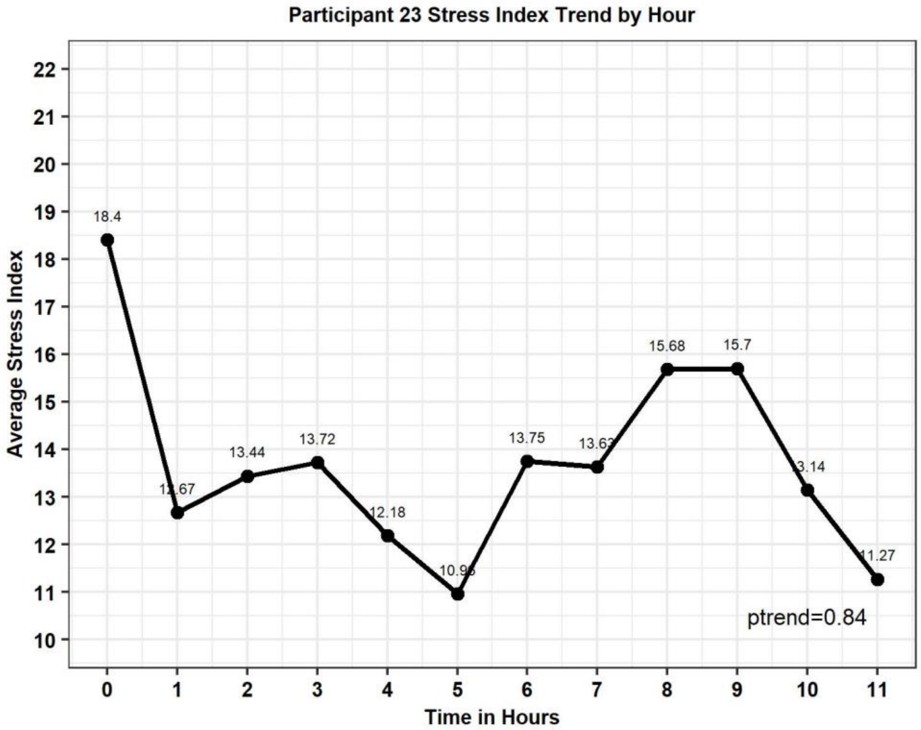


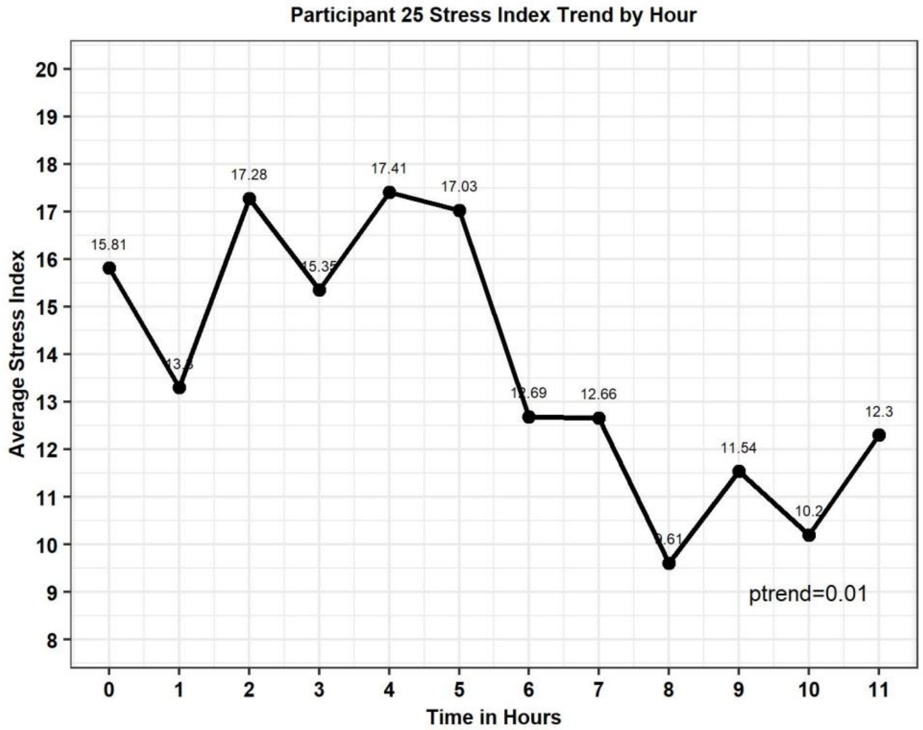
Participant 21 & 22



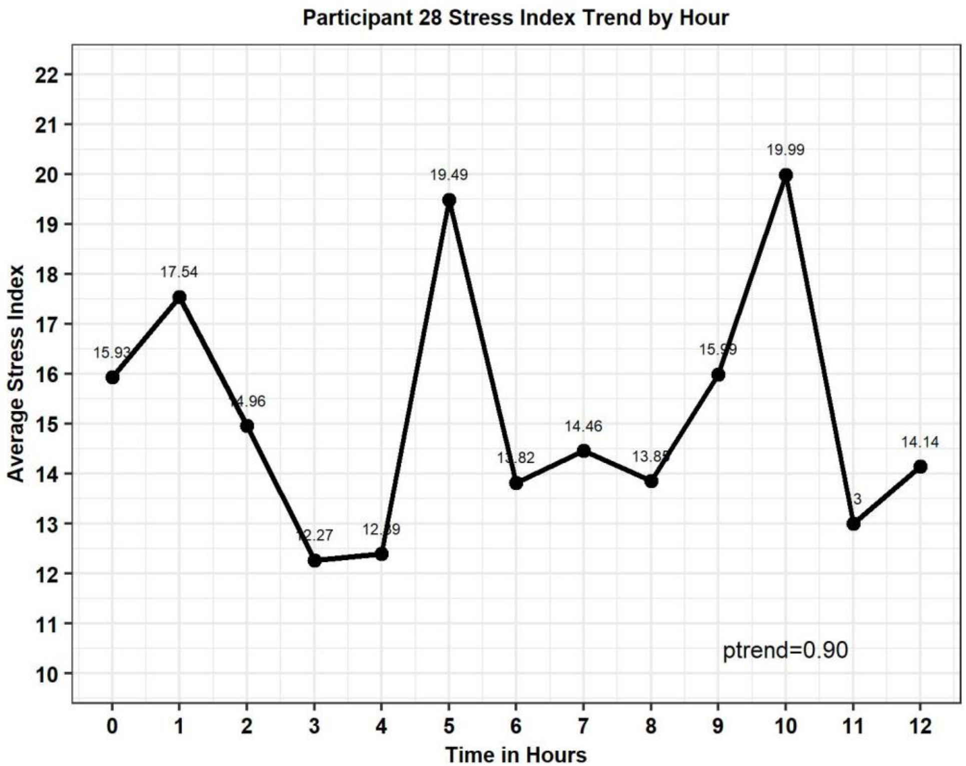


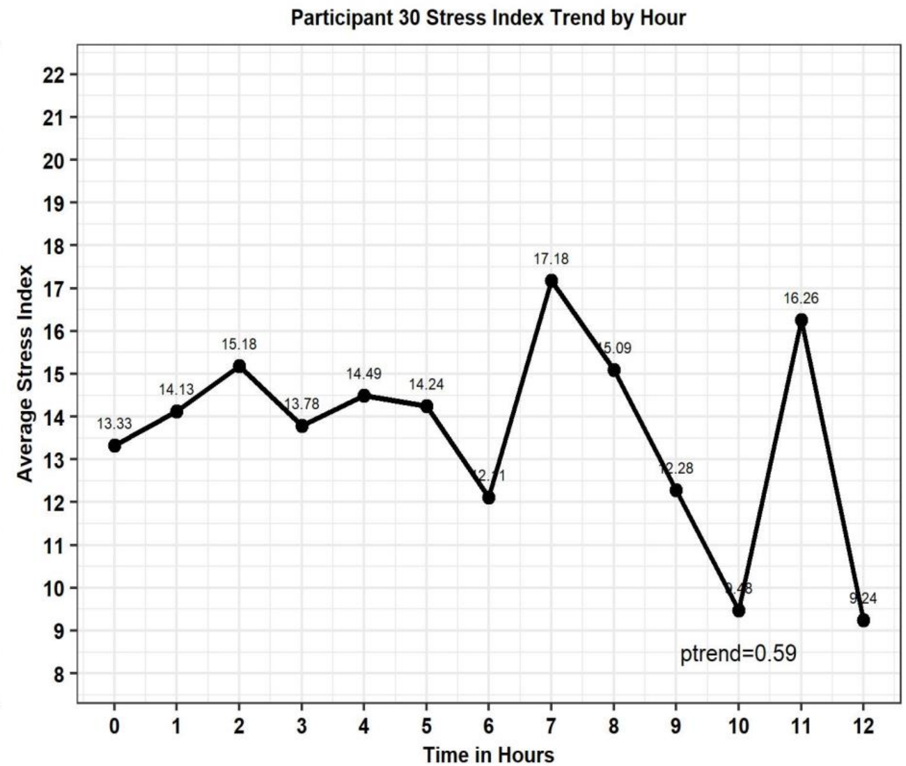
Participant 23 & 25





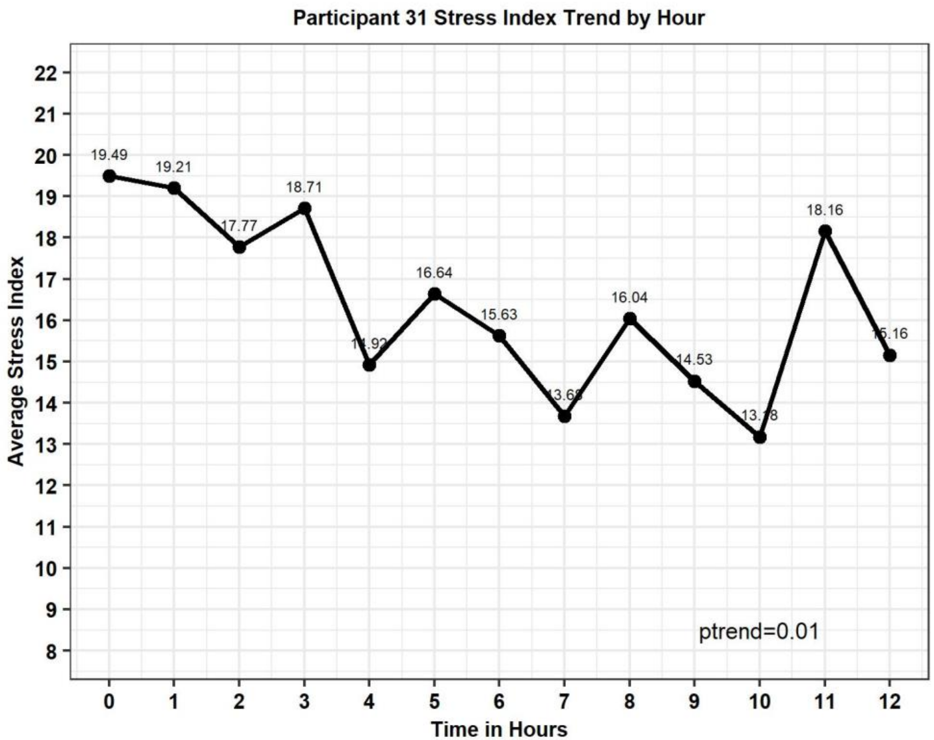
Participant 28 & 30

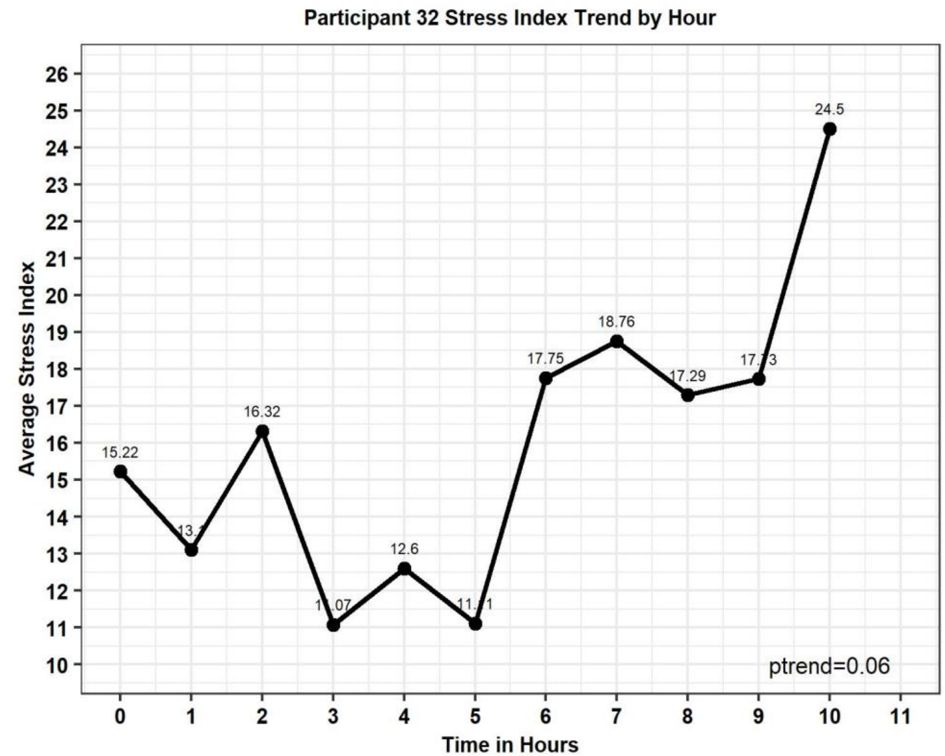




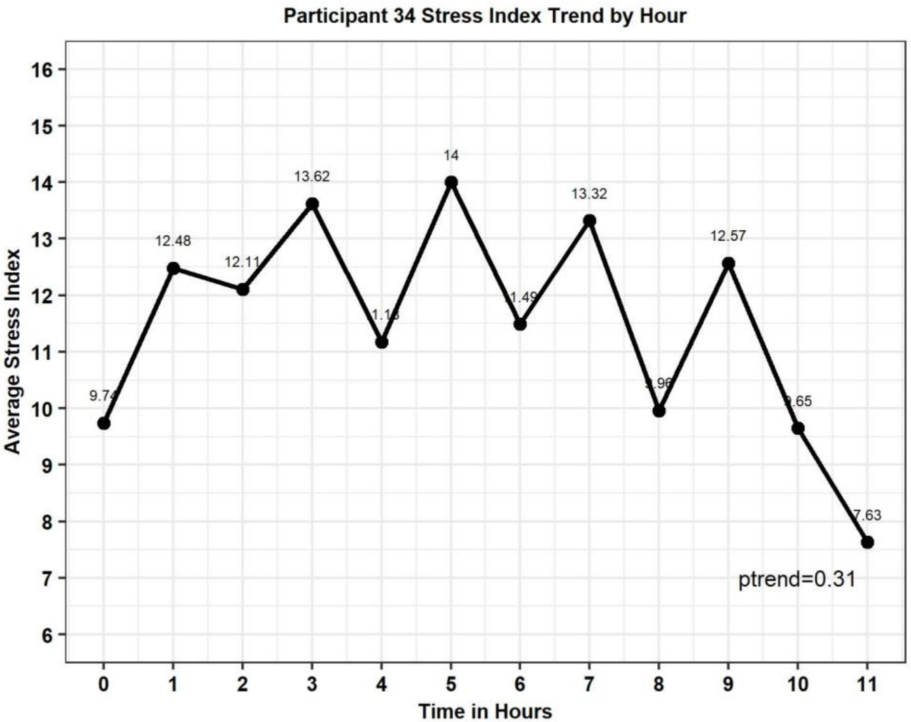
Participant 31 & 32

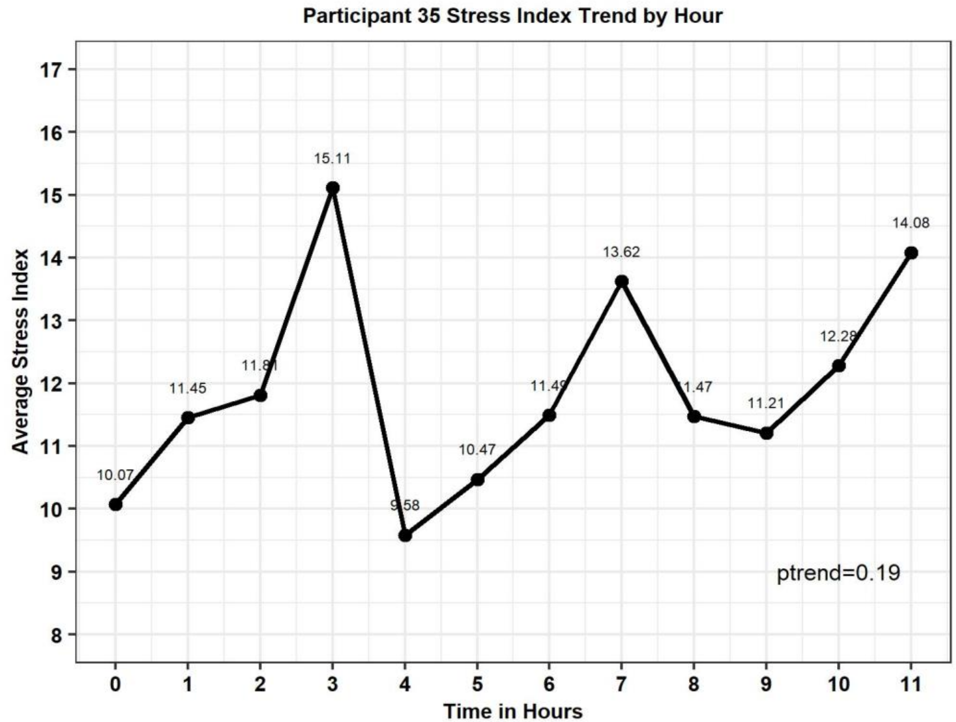
HOUSTON Methodist LEADING MEDICINE



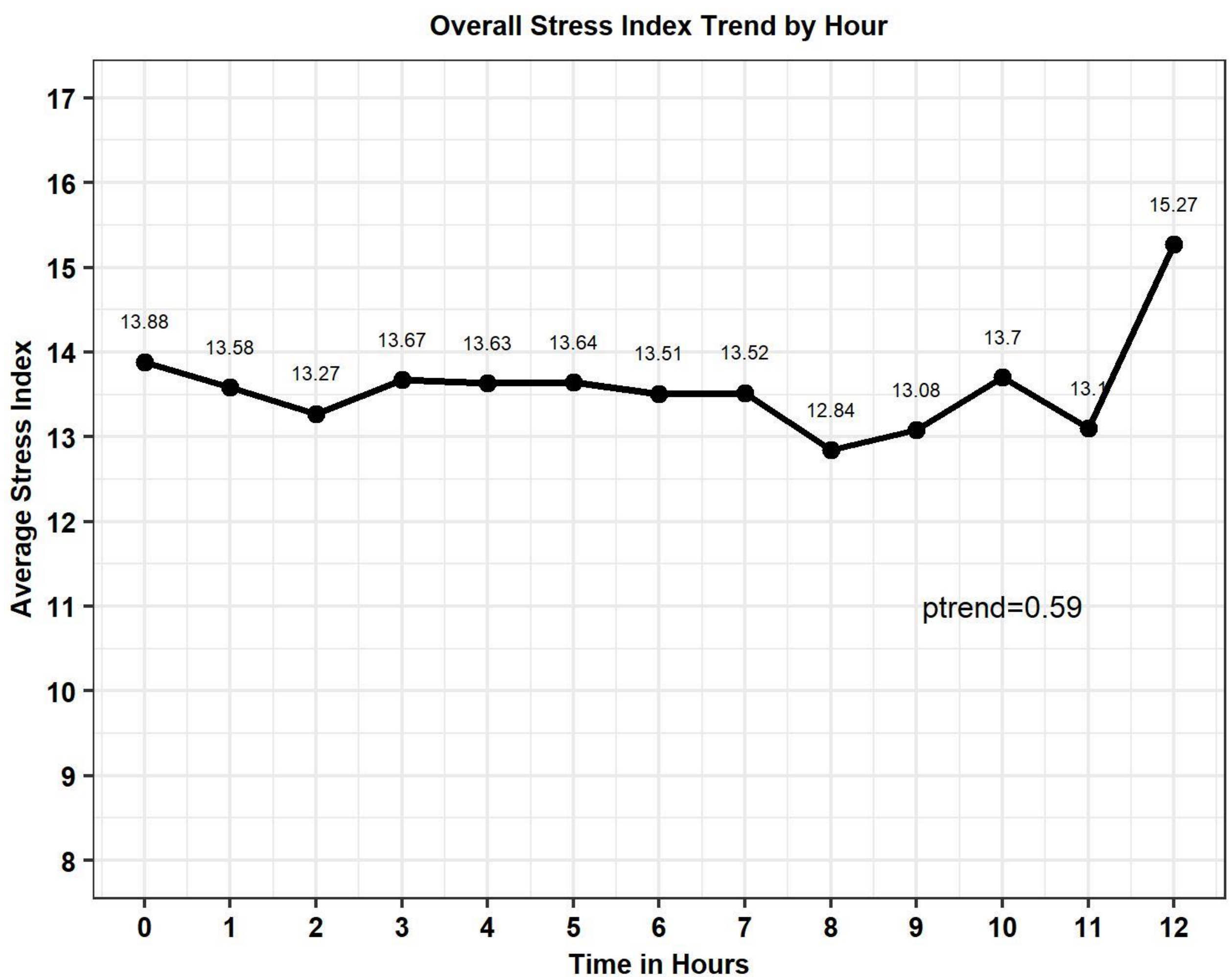


Participant 34 & 35





Over all Trend of Stress Index



Key Conclusions/ Take away message

Houston Methodist LEADING MEDICINE

- Validation

❖ Ground standards for future studies with a naturalistic vs. lab environment using wearable devices

- This study can be used as a reference to formulate policies in improving the conditions of the work environment
- These methods are suggestive in studying extreme stressful conditions among military training personnel.

Fun fact: You can download your HR, BP activities and create your own data set using "apple tool kit" from your watch

Publication

Quantifying Occupational Stress in Intensive Care Unit Nurses: An Applied Naturalistic Study of Correlations Among Stress, Heart Rate, Electrodermal...

journals.sagepub.com • 1 min read

https://journals.sagepub.com/doi/10.1177/00187208211040889

Data Driven Expansion

HOUSTON Methodist
LEADING MEDICINE

Expansions (With Video Files)

HOUSTON Methodist LEADING MEDICINE

Technological Contributors

Energy Expenditure

Resting Days Analysis

On going data collection for COVID ICU units

Sentiment Analysis

Code Blue & It’s effects

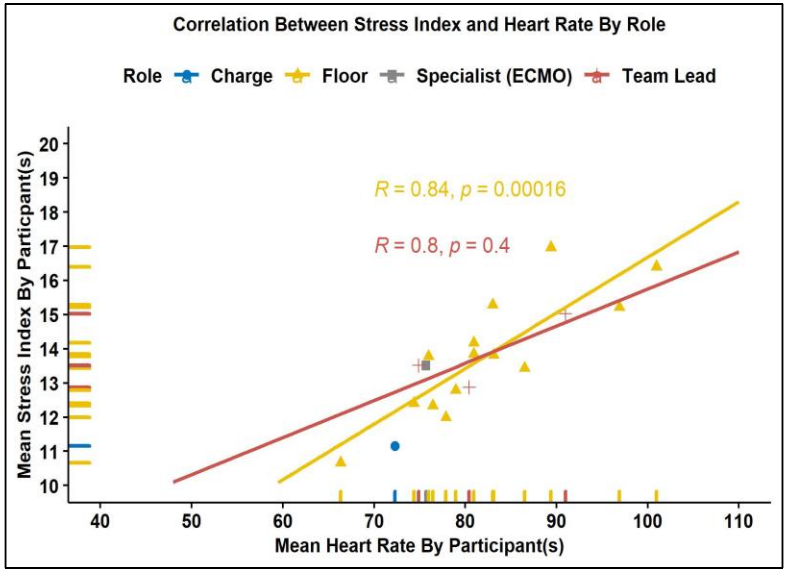
ICU Burnout- Technological Contributors

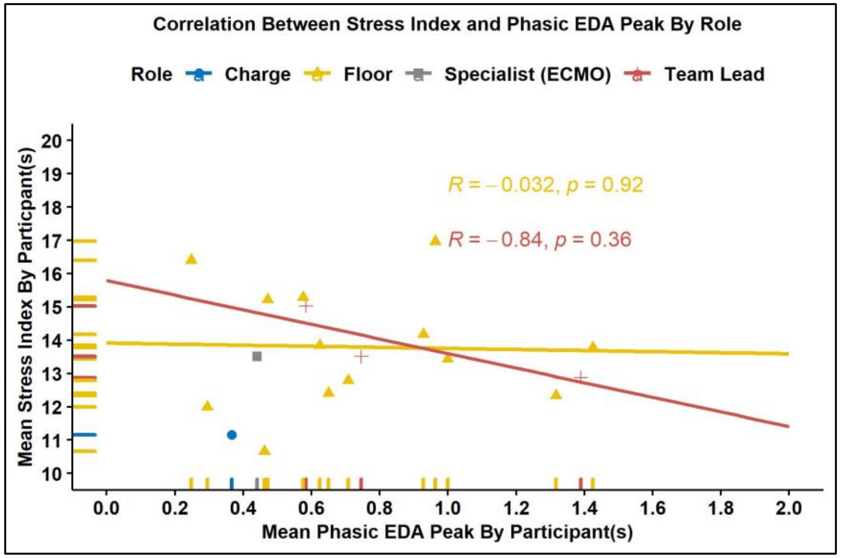
HOUSTON Methodist LEADING MEDICINE

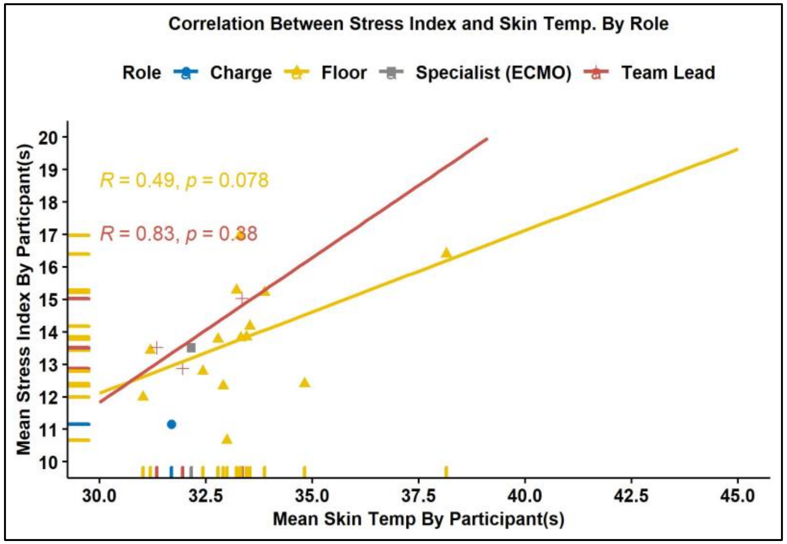
Tags By Stress Zones

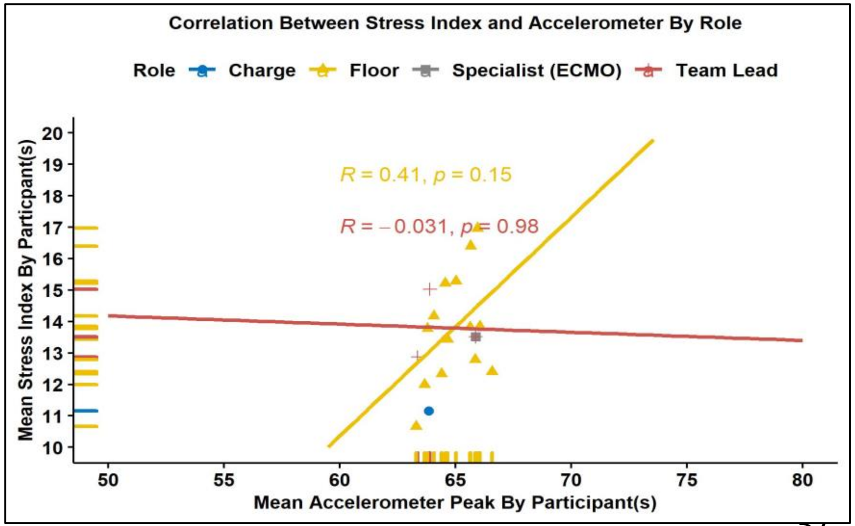
	High No. 274,625	Very High No. 211,061
Tag (N,%)		
Bedside Vitals Monitor	11,251 (4.10%)	9,410 (4.46%)
Bladder Scanner	171 (0.06%)	1,172 (0.56%)
Blanket Warmer	46 (0.02%)	0 (0.00%)
Cellphone	4,789 (1.74%)	7,395 (3.50%)
Dialysis	1,916 (0.70%)	914 (0.43%)
Doppler	6,789 (2.47%)	5,144 (2.44%)
ECMO	3,567 (1.30%)	1,610 (0.76%)
Electronic Thermometer	1,271 (0.46%)	1,572 (0.74%)
IABP	433 (0.16%)	0 (0.00%)
Impella Ventricular Support Systems	183 (0.07%)	4,024 (1.91%)
Infusion Pump	8,334 (3.03%)	6,910 (3.27%)
Kangaroo Pump	252 (0.09%)	644 (0.31%)
Medic Tube	330 (0.12%)	678 (0.32%)
Nursing Station Monitor	373 (0.14%)	240 (0.11%)
Pyxis MedStation System	12,909 (4.70%)	6,841 (3.24%)
Sonosite Ultrasound Machine	1,740 (0.63%)	721 (0.34%)
Ventilator	908 (0.33%)	474 (0.22%)
Vigileo Monitor	9 (0.00%)	229 (0.11%)
Workstation - Alcove	96,769 (35.24%)	80,894 (38.33%)
Workstation - Bedside	75,203 (27.38%)	66,197 (31.36%)
Workstation - Nursing Station	2,678 (0.98%)	1,456 (0.69%)
Workstation - Office	43,716 (15.92%)	14,404 (6.82%)
Workstation - Pyxis Room	988 (0.36%)	132 (0.06%)

Correlations ~ Role









Physiologic Stress and Critical Care Nursing - Complex Technology Use in the Intensive Care Unit

HOUSTON Methodist Leading Medicine

Weill Cornell Medicine

Nisar, Tariq[1]; Sasangohar, Farzan[1]; Ahmadi, Nima[1]; and Danesh, Valerie[2]

[1] *Houston Methodist Research Institute, Houston Methodist Hospital, Houston Texas*

[2] ***University of Texas at Austin, Austin Texas***

Research Objective

Critical care nurses providing direct patient care deliver complex care to critically ill patients. Both cognitive work and physical exertion contribute to physiologic stress experienced by nurses working in Intensive Care Units. The quantification of physiologic stress in critical care nurses is not well studied. Continuous physiologic data and eye tracking data were obtained using wearable technologies. Our objective was to identify complex technology use in the ICU work environment that is associated with high levels of physiologic stress by critical care nurses.

Study Design

We conducted continuous physiologic monitoring of critical care nurses caring for critically ill patients in a Cardiovascular ICU during 12-hour shifts. Critical care nurse participants wore eye tracking glasses, which captured continuous audio and video data (Figure 1). Physiological data, including heart rate, skin temperature and electrodermal activity was collected. Physiologic stress was quantified using Bavesky Stress Index (SI) and classified into high and very high stress zones.

$$SI = \frac{AMo}{(2Mo) \times (MxDMn)}$$

AMo = Amplitude of the most frequent inter-beat interval (IBI) ; ***Mo*** = Mode of the most frequent IBI & ***MxDMn*** = Range of IBI.

Audio-visual data and physiological data were linked to code physiologic stress data with nursing activities. An association between complex technology use based on locations within the ICU and the high and very high stress periods was established using logistic regressions with random effect models. We report the odds ratio (OR) and 95% confidence intervals (CI).

Population Studied

22 ICU nurses participated, with data reported from twenty-two (22) 12-hour nursing shifts.

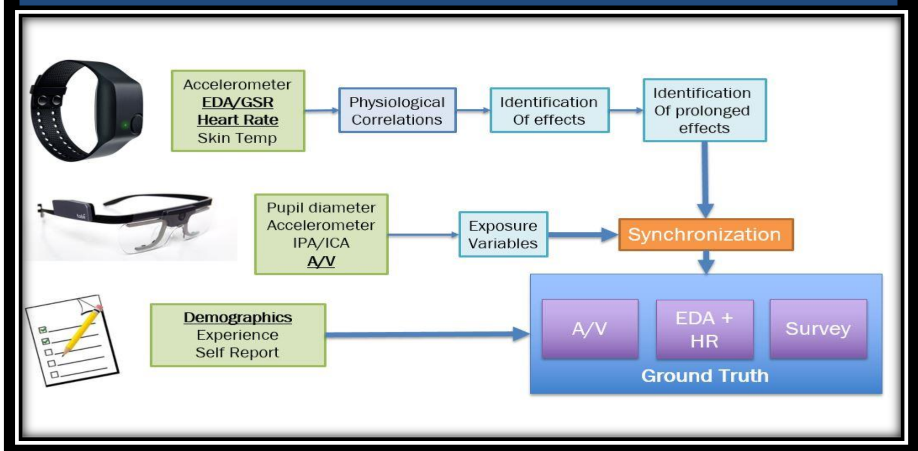
Principal Findings

Critical care nurses experienced high stress periods when performing patient care tasks requiring complex technology use. Nurses caring for patients with Left Ventricular Assist Devices (LVAD) were 29 times more likely to be in a very high-stress zone (OR=28.4; 95% CI [24.5 -32.3]). Nurses caring for patients requiring procedural care with bedside ultrasound were 9 times more likely to be in a very high-stress zone (OR=8.7 ;95% CI [7.4 –9.2]). Nurses performing routine care including the use of continuous enteral feeding were 3 times (OR=3.2; 95%CI [2.8 -3.7], while use of infusion pumps were only 1.07 (OR =1.07; 95% CI [1.04 -1.1]) times more likely to be in very high-stress zone.

Conclusions

Our analysis suggests that complex technology use is associated with critical care nurses experiencing high physiologic stress zones.

Figure 1



Implications for Policy or Practice

While continuous physiologic monitoring of critically ill patients is routine in the Intensive Care Unit setting, our approach extends physiologic monitoring to the healthcare workers providing complex care to ICU patients to contribute quantified measures of physiologic stress. Insights into the etiologies of physiologic stress in critical care nurses can offer dramatic insights to guide intervention development to promote safe staffing, workflow and evidence-based design in the ICU work environment to support and protect critical care nurses.

References

1. Acerbi, G., Rovini, E., Betti, S., Tirri, A., Rónai, J. F., Sirianni, A., Agrimi, J., Eusebi, L., & Cavallo, F. (2017). A wearable system for stress detection through physiological data analysis. In F. Cavallo, V. Marletta, A. Monteriù, & P. Siciliano (Eds.), Ambient Assisted Living (pp. 31–50). Springer International Publishing. https://doi.org/10.1007/978-3-319-54283-6_3

2. Aiken, L. H., Clarke, S. P., Sloane, D. M., Sochalski, J., & Silber, J. H. (2002). Hospital nurse staffing and patient mortality, nurse burnout, and job dissatisfaction. JAMA, 288(16),1987–1993. https://doi.org/10.1001/jama.288.16.1987

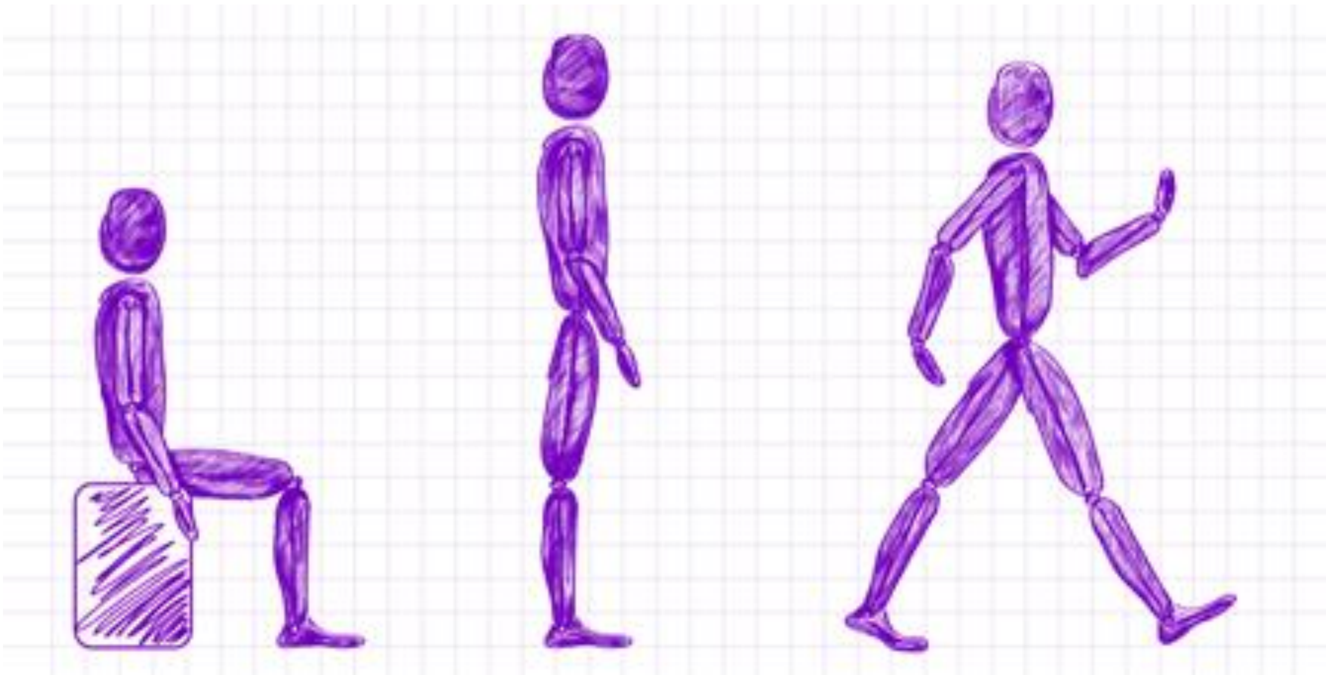
3. Baevsky, R. M., & Berseneva, A. P. (2009). Use KARDiVAR system for determination of the stress level and estimation of the body adaptability: Standards of measurements and physiological interpretation. Kardivar.TV. https://pdfs.semanticscholar.org/74a2/92bfafca4fdf1149d557348800fcc1b0f33b.pdf

4. Donchin, Y., & Seagull, F. J. (2002). The hostile environment of the intensive care unit. Current 456 Opinion in Critical Care, 8(4), 316–320. https://doi.org/10.1097/00075198-200208000-00008

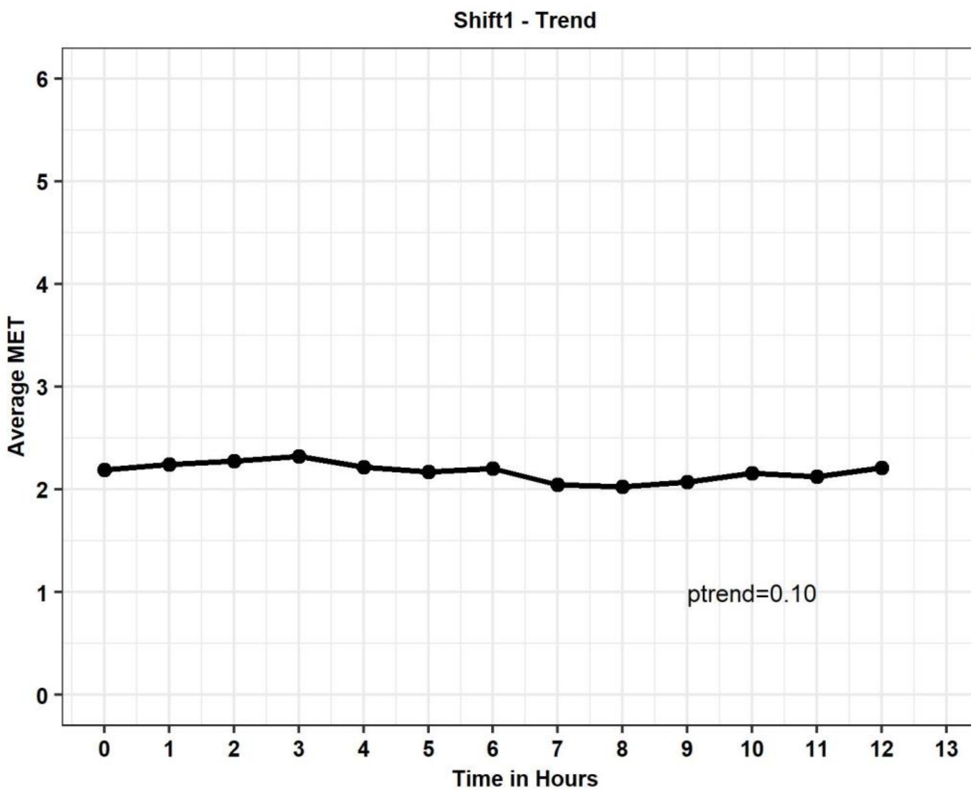
5. Giannakakis, G., Pediaditis, M., Manousos, D., Kazantzaki, E., Chiarugi, F., Simos, P. G., Marias, K., & Tsiknakis, M. (2017). Stress and anxiety detection using facial cues from videos. Biomedical Signal Processing and Control, 31, 89–101. https://doi.org/10.1016/j.bspc.2016.06.020

Acknowledgments: We thank the nurses in the Intensive Care Unit (ICU) who participated in our research at the Houston Methodist Hospital, Houston, Texas.

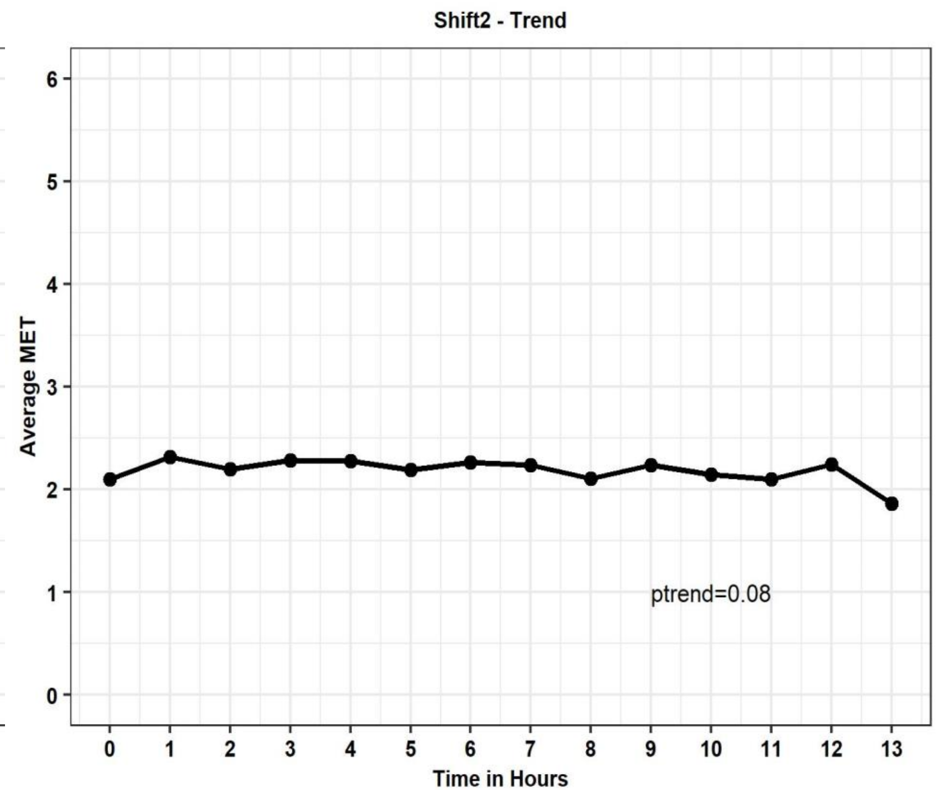
Energy Expenditure (MET)



MET Contd.

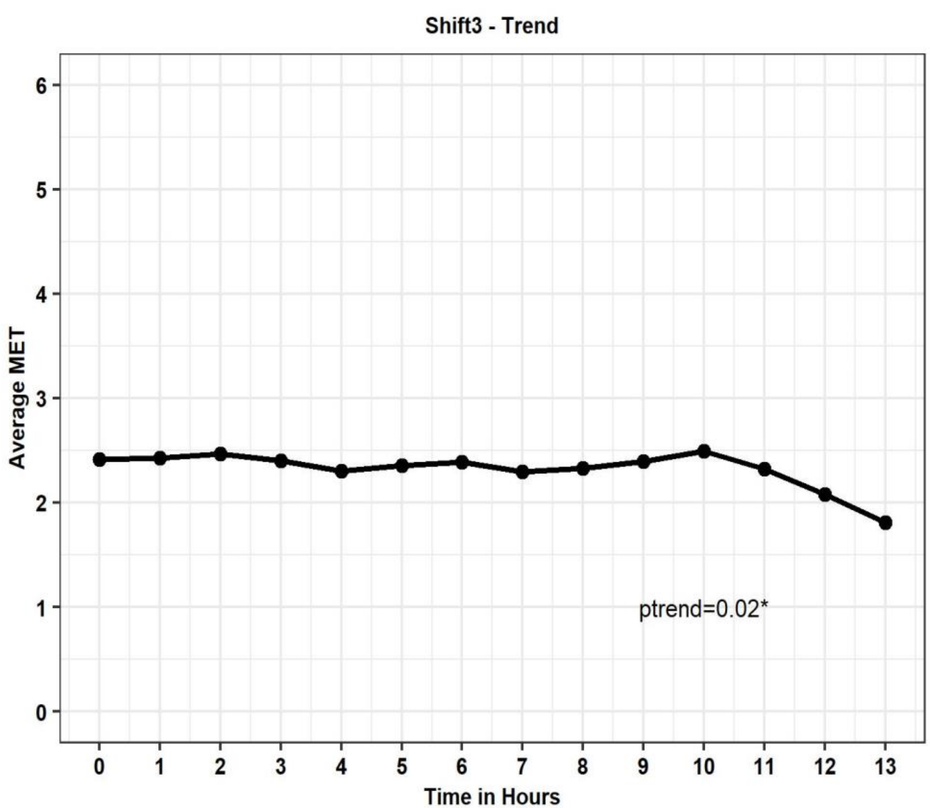


Shift1 - Trend
Average MET
Time in Hours
ptrend=0.10
0
1
2
3
4
5
6
7
8
9
10
11
12
13

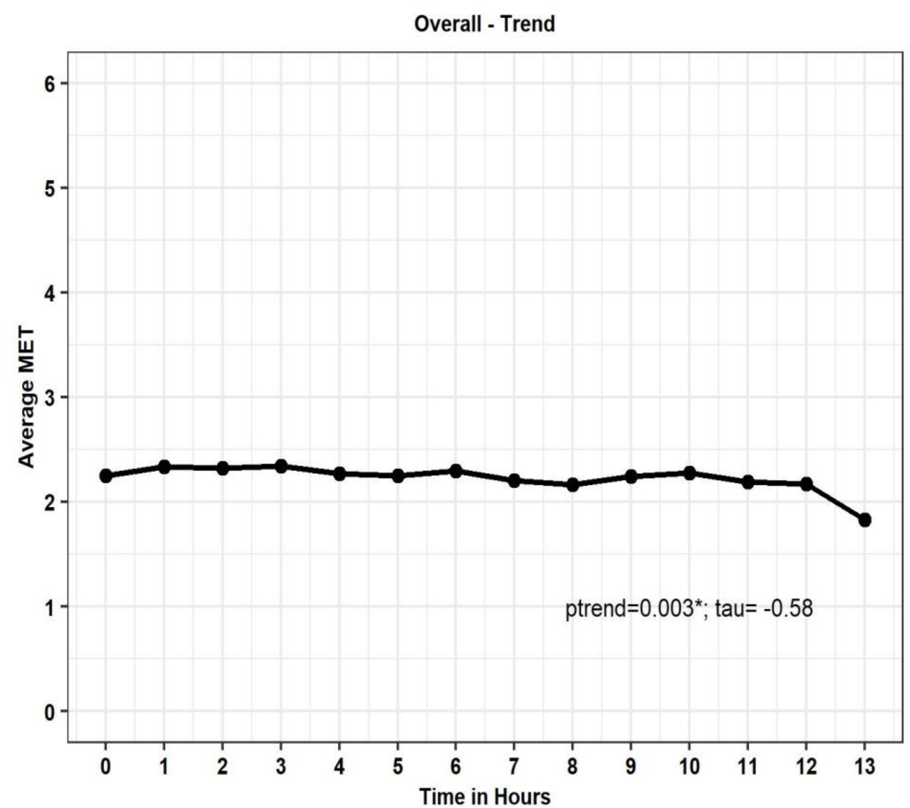


Shift2 - Trend
Average MET
Time in Hours
ptrend=0.08
0
1
2
3
4
5
6
7
8
9
10
11
12
13

MET Contd.



Shift3 - Trend
Average MET
6
5
4
3
2
1
0
ptrend=0.02*
0
1
2
3
4
5
6
7
8
9
10
11
12
13
Time in Hours



Overall - Trend
Average MET
6
5
4
3
2
1
0
ptrend=0.003*; tau= -0.58
0
1
2
3
4
5
6
7
8
9
10
11
12
13
Time in Hours

Acknowledgments

- Dr. Farzan Sasangohar, PhD
- Dr. Valeri Danesh, PhD
- Dr. Nima Ahmadi, PhD
- Dr. Ethan Larsen, PhD (Ex-Post Doc)
- Dr. Ineen Sultana, PhD (Ex- RA)
- Dr. Rita Bosetti, PhD (Ex-Post Doc)
- Clinical PI: Dr. Faisal Masud
- To All the ICU Nurses Participants

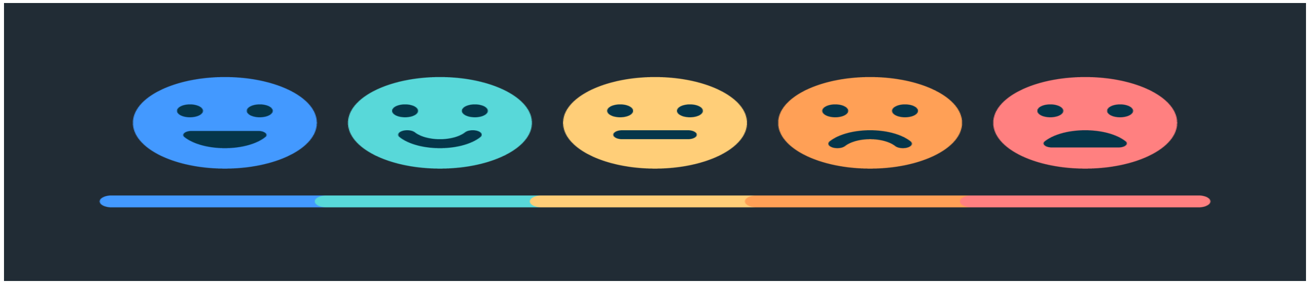
Administrative Support

- Jennifer Taylor, MBA
- Megan Taubert, MHA
- Jacob Kolman, MS (Our awesome scientific writer)

COR Leadership Support

Feedbacks/Questions/Suggestions

HOUSTON Methodist LEADING MEDICINE



HOUSTON
Methodist®
LEADING MEDICINE