University of Cincinnati

Date: 10/20/2023

I, Thomas Gerding, hereby submit this original work as part of the requirements for the degree of Doctor of Philosophy in Industrial Hygiene (Environmental Health).

It is entitled:

Stressed At Work: How Occupational Stress Affects Salivary Cortisol Fluctuations

Student's name: **Thomas Gerding**

This work and its defense approved by:

Committee chair: Jun Wang, Ph.D.

Committee member: Roman Jandarov, Ph.D.

Committee member: Mingming Lu, Ph.D.

Committee member: Nicholas Newman, D.O.

47824

Stressed at Work: How Occupational Stress Affects Salivary Cortisol Fluctuations

A dissertation submitted to the

Division of Research and Advanced Studies

of the University of Cincinnati

in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

in the Department of Environmental and Public Health Sciences of College of Medicine

October 20, 2023

by

Thomas Gerding

MPH, Eastern Kentucky University, Richmond, KY, USA, 2019, Public Health

B.S., Northern Kentucky University, Highland Heights, KY, USA, 2017, Environmental Science

Committee Chair:	Jun Wang, Ph.D.
Committee Members:	Mingming Lu, Ph.D.
	Nicholas Newman, Ph.D.
	Roman Jandarov, Ph.D.

ABSTRACT

Sustained stress exposure has long been known to be linked with multiple chronic diseases, detrimental mental health outcomes, and a poor quality of life. Occupational stress, especially its relationship with physiological responses, has not been as researched until recent years. The objective of the first study included in this dissertation was to gain an understanding of how the COVID-19 pandemic affected occupational stress in a variety of career fields. The rationale for this effort was to determine 1) which aspects of these careers was related with a noticeable amount of stress and 2) which career fields to target in future occupational stress research. While stress had naturally picked up in every career field, due to the existence of the global pandemic permeating all aspects of life, certain sectors were affected to varying degrees. Healthcare, for instance, experienced a large increase in stress due to the pandemic. For this reason, this sector was the focus of the final study once methodology validation occurred in the second study. Methodology validation in the second study entailed evaluating the relationship between subjective occupational stress exposure as documented in stress diaries and fluctuations in salivary cortisol levels collected through multiple saliva samples provided over the course of multiple working days.

Overall, this dissertation consists of three studies (Study A – C). In Study A, a cross sectional survey was employed which was used to determine some of the occupational stress trends seen in multiple working sectors during a global pandemic. For instance, although some occupational stress trends rang true for all work sectors investigated, other trends were more specific to certain career fields, such as healthcare seeing noticeable increases in workloads to the greatest degree. On the other hand, all investigated industries found time management

difficult during the pandemic which was again seen, in some regards, during the successive two studies.

Study B provided methodology validation regarding the use of self-administered saliva sample collections in conjunction with work stress diaries while simultaneously collecting information on the various occupational stressors seen in multiple careers represented in the general working population that served as the study population. Here, it was clear that, although the healthcare industry represented a minority of the participants, they provided nearly half of the intense stressors documented within the work stress diaries, demonstrating the higher stress seen in this career field that a variety of others.

Lastly, Study C focused specifically on a subsection of the healthcare industry: home healthcare workers. Unfortunately, no statistically significant relationship between fluctuations in salivary cortisol levels with levels of stress self-reported nor between fluctuations in salivary cortisol levels with exposure to air pollutants could be determined. However, future work which employs a greater number of participants, samples collected, or between quality air monitors may help to improve either of these relationships.

Overall, results showed that occupational stress had worsened due to the COVID-19 pandemic, naturally affecting healthcare to a large degree. The novel methodology of allowing participants to collect multiple saliva samples throughout each study day to compare these to subjective stress levels appeared to have some merit, albeit in a small degree and in a general working population, though a much greater depth and breadth of research is warranted.

This page is intentionally left blank

ACKNOWLEDGEMENTS

Looking back on the last four and a half years, I recognize that I would not have been able to attain this terminal degree without those around me. First, and most clearly, the assistance my advisor, Dr. Jun Wang, provided me was second to none in providing guidance with how I could reach the next step along my way. His professional experience and willingness to not only serve as my committee chair, but to keep me entertained with other projects along the way, was pivotal in my success as a graduate student under his tutelage. I feel grateful for having had Dr. Wang as an advisor who taught me how to progress through the program and the inner workings of research and academia.

I would also like to express my appreciation for my other committee members: Drs. Roman Jandarov, Mingming Lu, and Nick Newman. Their insights and advice provided during our meetings helped rudder the ship of my dissertation and keep the water out of the boat when things got choppy.

I also extend my appreciation to the support staff of my program and the entire Department of Environmental and Public Health Sciences. The instances when they jumped in to find solutions to technical problems were innumerable, not to mention the department would have been left on its knees if our IT team hadn't diligently moved classes online during the pandemic. Jessica Bloomer, Nick Meece, Amy Itescu, and many others, your work doesn't go unnoticed.

It is acknowledged the studies described in this dissertation were supported by the National Institute for Occupational Safety and Health through the Pilot Research Project Training Program of the University of Cincinnati Education and Research Center Grant #T42OH008432 and I was supported through a university graduate assistantship. I also received

scholarships during my time at UC which helped me make ends meet during my time as a student from the following organizations: The Ohio Valley Section of the American Industrial Hygiene Association & the Dotson Memorial Scholarship, the Gary & Bonnie Olmstead Scholarship, and the BCSP Scholarship, each of which were through the American Industrial Hygiene Association, and the 3M PSD Occupational Health and Safety Scholarship Program.

I'd be remiss if I included my gratitude to the students who came before me, who helped guide me through the challenges they conquered in the year or two prior to my experiencing them. Vishal Nathu, Ashley Turner, Christina Kander, and Rachel Zeiler, I appreciate you all for the feedback and advice you gave me and I hope that I reflected this spirit well upon the underclassmen I knew.

I would like to express my gratitude towards my wife, Shelby F. Gerding, and our friends and family for their endless support, having faith in me, and always being willing to listen to me vent. Thank you for believing in me. Finally, and most importantly, I'd like to thank my God who helped me navigate not only the challenging academic program, but the last four years in general, who made navigating this time possible.

Thomas Gerding

Cincinnati, OH

June 13, 2023

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS

AIHA – American Industrial Hygiene Association

ANOVA – Analysis of Variance

AOD – Average Optical Density

B/B_0 – Bound vs. Unbound

COVID-19 – Coronavirus disease 2019

CVA – Cerebral Vascular Accident

CVD – Cardiovascular Disease

EAP – Emergency Action Plan

ELISA – Enzyme-Linked Immunosorbent Assay

ERC – Education and Research Center

HHCW – Home Healthcare Workers

HPA Axis – Hypothalamus-Pituitary-Adrenal Axis

NIOSH – National Institute for Occupational Safety and Health

NO_2 – Nitrogen Dioxide

NORA – National Occupational Research Agenda

OD – Optical Density

OSHA – Occupational Safety and Health Administration

$PM_{2.5}$ - particulate matter < 2.5 μm in aerodynamic diameter

PM_{10} - particulate matter < 10 μm in aerodynamic diameter

RCI – Relative Cortisol Index

SAM Axis – Sympathetic-Adrenal-Medullary Axis

TBI – Traumatic Brain Injury

TMB – Tetramethylbenzidine

UC – University of Cincinnati

USD – United States Dollar

VOC – Volatile Organic Compound

WFH – Work From Home

INTRODUCTION

This dissertation presents results on 1) the evaluation of occupational stress during the COVID-19 pandemic in multiple sectors, 2) an assessment of how occupational stressor events might be related to the physiological response of changes in cortisol levels, and 3) a case study utilizing this stressor-response methodology on a population of home healthcare workers (HHCWs) in addition to evaluating how closely related air quality was to cortisol. This dissertation consists of three related studies (A-C), which are described in individual manuscripts.

A. An Investigation into Occupational Related Stress of At-Risk Workers During COVID-19
B. Stressed at Work: Investigating the Relationship between Occupational Stress and Salivary Cortisol Fluctuations
C. Work Stress and Air Pollution Exposures to Home Healthcare Workers

HYPOTHESES

I. Healthcare, as a work sector, will be affected by occupational stress to a greater degree than other evaluated sectors following the start of the global COVID-19 pandemic.
II. There will be a positive and strong relationship between the occurrence of stressor events and increases in cortisol levels afterward.
III. Salivary cortisol will be directly dependent on experiencing stress while taking diurnal fluctuations into account.

IV. Home healthcare workers will experience occupational stress that will correlate with increased salivary cortisol levels to a statistically significant degree ($\rho \leq 0.05$).

V. Air pollution data, such as $PM_{2.5}$, will be correlated with cortisol data in a linear manner

SPECIFIC AIMS

1. Assess increased stress & work conditions experienced by workers from different sectors during the COVID-19 pandemic through a cross-sectional survey.
2. Evaluate the feasibility of a longitudinal study of daily stressors using daily diaries and a biomarker of stress. Three consecutive days using a stress diary & multiple daily measures of salivary cortisol.
3. Determine if the relationship between occupational stress exposure and salivary cortisol levels hold true specific to the home healthcare workforce.
4. As an exploratory aim, determine if a relationship exists between the air pollution data collected by the HHCW study population and their respective cortisol levels.

EXECUTIVE SUMMARY

Stress has been associated with a variety of detrimental health outcomes in numerous way and is related to the death of 120,000 people in the U.S. each year due to multiple factors (Aro, 1984; Malamardi et al., 2015; Sun et al., 2011; Goh et al., 2015). The World Health Organization reports that 83% of the U.S. workforce suffers from work-related stress while 54% have stated work stress affects their home life (WHO, 2023). The importance of mitigating work stress has been gaining notoriety over the last few years to the point that the U.S. Occupational

Safety and Health Administration (OSHA) has created a webpage to provide training resources and outreach materials on the topic (OSHA, 2022).

The long-term goal of this dissertation consisting of three studies (A-C) was to determine how occupational stress was affected by the COVID-19 pandemic and to seek quantitative metrics which could indicate ways in which occupational stress should be reduced. Occupational stress not only affected the physical health of the worker, but can affect company's performance as well. According to a recent Gallup poll, those who stated their overall mental health was "fair" or "poor" tended to miss nearly 12 workdays per year compared to those who stated their mental health was "excellent", "very good", or "good" who missed 2.5 days per year (Witters & Agrawal, 2022). If stressor events could be quantified based on their severity, it posses the idea that companies would be able to combat these greater stressors so as to improve overall morale, thereby improving their bottom line, as well. In one way, the overall goal of this dissertation was to see how various types of stressor events in the workplace could be quantified through the marrying of salivary cortisol values with the subjective stress levels assigned to events occurring most recently prior to a saliva sample being provided.

Physiologically, cortisol is the body's main stress hormone and is regulated by the hypothalamus-pituitary-adrenal (HPA) axis. Cortisol is typically released in the body through a diurnal pattern of highest in the morning to help awake the individual and then tapers off throughout the day to make it easier to fall asleep (Thau et al., 2022; Thomas et al., 2009). Experiencing stress, however, causes the HPA axis to release additional hormones, including cortisol. Prior literature has examined cortisol changes throughout the day, but lacking the implementation of a study tool like a diary inhibits the ability to pair an experience with a

quantitative chance in cortisol (Kunz-Ebrecht et al., 2004; Stalder et al., 2009; Wolf et al., 2005; Wright, 2011; Bruschini et al., 2018).

In **Study A (Chapter 1)**, we first explored how the COVID-19 pandemic affected the work stress present within multiple work sectors within the U.S. through the implementation of a cross-sectional survey. This was beneficial in that, while we provided a summary of the stress experienced by sectors including: manual labor, business/office service, education, and healthcare, this also allowed us to determine who best to target for future work stress research. The survey was distributed and available from October to November of 2021, roughly 18 months into the global pandemic. Results were analyzed via Kruskal-Wallis one-way analysis of variance (ANOVA) to find trends within the sectors.

Our results found multiple trends, most notably that a slight majority of the study population experienced an increased workload since the onset of the pandemic. However, 80% of those specific to healthcare noted an increased workload. Similarly, 55% of the study population believed they could be exposed to the COVID-19 virus in their workplace, but this ranged from 52% of those in a business/office setting to 77% of healthcare workers. It was concluded that regardless of the specific stressor, it was found that many stressors could be exacerbated due to the occurrence of external factors such as a pandemic and it would be beneficial to employers to include the possibility of future pandemics into their emergency action plan (EAP).

Having concluded that work stress exists in different forms depending on the type of employment, our next goal was to then determine the feasibility of a methodology in which a working population was provided with a work stress diary and multiple salivary sampling vials with which we could correlate one with another. In this regard, participants in **Study B (Chapter**

2) were given nine saliva sampling vials to collect three samples per three consecutive work shifts upon clocking in, the start of their lunch break, and the conclusion of their shift. Concurrently, they were provided with a work stress diary with sections to include the following information: time of day, intensity of stress (0-5), duration of stress, details of situation, triggering event (if applicable), emotional behavioral reactions, their occupation, and whether they would consider that day typical in their job. Upon the return of study materials, the saliva samples were analyzed via enzyme-linked immunosorbent assay (ELISA) to determine cortisol levels.

Following statistical analyses, it was found that cortisol levels followed typical diurnal patterns overall, though there were deviations following documentation of stressor events contained within the participants' diaries. When the data from all study participants was pooled together, the cortisol-stressor relationship was found to be statistically significant via linear regression analysis ($\rho = 0.042$). Additionally, a qualitatively portion was completed within this study where the documented stressors were compared between the studied working sectors. In this portion, we found that although those who worked in the healthcare industry only accounted for one-third of the study population, they reported 42% of the more severe occupational stressors experienced (level 3, 4, or 5 out of 5). Frequent emotional behavioral reactions to experiencing these stressor events included feelings of stress, frustration, anger, anxiety, or overwhelm. In this study, we not only found that occupational stress, including stress related to the pandemic, was seemingly worse in the healthcare industry than others, but also posited that targeting reductions in the workplace experiences related to the greater stressor levels could potentially improve morale within the workplace.

To expand upon the work stress trends experienced by healthcare workers, the research team then decided to investigate home healthcare and what occupational stress this working population experiences in **Study C (Chapter 3)**. Based on the two previous studies, it was assumed the statistical relationships would be stronger than the previous, methodology validation study (i.e., H_a = linear regression of reported stress levels with cortisol levels where $\rho \leq 0.042$). Towards this aim, twelve home healthcare workers were recruited from the Greater Cincinnati area and was composed of a speech language pathologist, a medical social worker, a personal specializing in those with developmental disabilities, two registered nurses, four physical therapists, and three occupational therapists. Participants completed this study from January – March of 2023.

Similar methods were employed as with Study B, though participants completed the study over the course of one full work week instead of three consecutive work days. Depending on whether participants worked four 10-hour days or five 8-hour days, each participant provided either a total of 12 saliva samples or 15 samples. Additionally, the self-reported stress level for each diary entry was expanded from a 5-point Likert scale to a 10-point scale to improve specificity. Lastly, as an exploratory aim, personal air quality monitors (Flow 2, Plume Labs Inc., Paris, France) were provided to each participant with the end goal of comparing the air pollutant levels participants were exposed to with their cortisol fluctuations.

Unfortunately, for a variety of potential reasons, neither the stress levels from the diaries ($\rho = 0.754$), nor the air pollution data, held statistically significant relationships with the cortisol levels. There were, however, trends within the diaries themselves. Of all the stress diary entries, 40% of them were considered a greater stressor event (level 6 – 10).

Further, the lone speech language pathologist accounted for 18% of these greater stressor events. Common emotional behavioral reactions documented within the diaries again included feelings of frustration and anger, typically directed at situations. It was concluded that as there wasn't much in the way of statistical findings to report, replicating the study for a larger duration, collection a greater number of samples, and / or recruiting a larger number of participants within the home healthcare career field might improve the veracity of the study.

CHAPTER 1. AN INVESTIGATION INTO OCCUPATIONAL RELATED STRESS OF AT-RISK WORKERS DURING COVID-19

INTRODUCTION

Occupational-related stress is a global public and occupational health concern, contributing to many aspects of health disparities (Wieclaw et al., 2005; Soori et al., 2008; Sun et al., 2011; Kang et al., 2015; Malamardi et al., 2015). Such stress not only undermines the quality of life but is also a risk factor for hypertension, cardiovascular disease (CVD), and poor mental health outcomes (Belkic and Nedic, 2007; Sarafis et al., 2016; Hasan et al., 2018; Faraji et al., 2019; Jin et al., 2019). Occupational-related stress costs American companies more than $300 billion per year through a combination of health costs, absenteeism, and poor performance. (Center for the Promotion of Health in the New England Workplace, 2021). According to the American Institute of Stress (AIS, 2020), experiencing occupational stress is commonly caused by an overbearing workload, interpersonal issues, poor work-life balance, and lack of job security. Occupational stress has noticeably picked up since the onset of the global coronavirus disease 2019 (COVID-19) pandemic, especially among the first responders, healthcare workers, educators, and to a lesser extent, working from home (WFH) populations (Zhang et al., 2020). Additionally, a recent study found that more than half of the US workforce felt burned out and 40% were considering changing jobs to resolve stress (Talkspace, 2021). While the influence of occupational-related stress on the health of workers is increasingly being recognized (Kinnunen-Amoroso and Liira, 2014; Bruschini et al., 2018; Jukic et al., 2020; Doyle et al., 2021), relatively

little research has been conducted with a focus on how the ongoing pandemic has exacerbated these occurrences.

Various industries were affected to different degrees after the onset of the pandemic, exposing some workers to different levels and types of occupational stress. For example, in addition to their regular work-related stress, home healthcare workers (HHCWs) often assume a large portion of irregular working hours, therefore their family and childcare responsibilities may be more likely to spill over into their work. Spillover of stress due to working conditions has been well documented, especially during the COVID-19 pandemic (Soubelet-Fagoaga et al., 2021; Uddin, 2021; Gerding and Wang, 2022; Karataş et al., 2022). Regarding WFH populations, stress and burnout would further negatively impact those who may already be experiencing physical discomfort due to ergonomic problems, which have proven to be an issue since the onset of the pandemic (Gerding et al., 2021). Research involving occupational stress experienced by those who work in atypical settings (i.e., workload, job insecurity, role conflict, and physical demands) has demonstrated that work-related stressors are associated with greater depression, anxiety, and suicidality (Quick and Henderson, 2016). Additionally, COVID-19-unit ICU nurses were more than twice as likely to report lacking sufficient sleep and 3 times as likely to be planning to leave their current department but were nearly twice as likely to feel confident in their care for patients compared to their non-COVID-19 unit counterparts (Tamrakar et al., 2021). Little work-stress research has been conducted with certain sub-sectors of typically high-stressed workforces such as home healthcare workers, despite frequently experiencing a disproportionate share of exposure such as COVID-19 and annual influenza outbreaks (NIOSH, 2019). The public safety sector who works in atypical working conditions like shift work and deals with traumatic experiences regularly may also have elevated stress (NIOSH, 2019).

Finally, there is a lack of understanding regarding stress for those who work from home (NIOSH, 2020).

Research examining the relationship between work stress and health across industries is limited. Knowledge of work-related stress may be particularly salient in certain industries, which can contribute to health disparities among workers who are at risk of experiencing a greater degree of occupational stress. The objective of the study was to assess increased stress and work conditions experienced by workers from different sectors during the COVID-19 pandemic through a cross-sectional survey.

MATERIALS AND METHODS

Study Design and Survey Distribution

The online survey was a cross-sectional evaluation of the subjective stressors experienced while working during COVID-19. The study was approved by the University of Cincinnati Institutional Review Board under protocol #2021-0681. The link to access the survey was distributed via email lists within National Institute for Occupational Safety & Health (NIOSH) and American Industrial Hygiene Association (AIHA) professional networks, as well as social media (LinkedIn and Facebook), who were then encouraged to share the survey with others in their circles who may be experiencing stress due to the pandemic. The survey was developed in REDCap (Vanderbilt University, Nashville, TN) and was available to complete online from 8 October 2021 through 15 November 2021. By this time, no city/state government continued to have a stay-at-home order in place, however, employers may have continued with a work-from-home approach depending on the job or industry. Additionally, a range of employers had begun requiring COVID-19 vaccinations by this point (i.e., i.e., healthcare and government).

A majority of questions were taken from validated work-stress questionnaires used in previously published work, one from NIOSH, directly (NIOSH, 1999; Holmgren et al., 2009). The survey questions were then edited to focus specifically on working conditions since the pandemic began (i.e., altering "Has your workload increased?" to "Has your workload increased since COVID-19?" with a follow-up question "If yes, do you perceive that as stressful?" appearing if the respondent answered "Yes" to the former). The full list of survey questions can be found in the Supplementary Materials online; there were up to 71 questions for participants to respond to (only if responses triggered all follow-up questions possible via branching logic). Four participants were drawn at random to receive a $25 gift card as appreciation for completing the survey.

The survey inquired about (i) demographic information: gender, age, and race; career path, years in a career, (ii) working conditions: irregular working hours, work pace, (iii) living conditions: work/life boundaries, sleep difficulty, social time, recreation time, change in weight, and if there are children or elderly that live with the participant and receive care from the participant, (iv) how COVID-19 affected employment: loss of employment, increased workload, time to finish work assignments since beginning of pandemic and time management, workplace communication, workplace conflict, WFH, lack of commuting, access to work supplies, increased exposure potential to COVID-19, quarantine, and (v) how the employer has acted: compensated fairly, adequate COVID-19 policy, adequate personal protective equipment (PPE), and presence of a vaccination policy. Questions were then triggered through branching logic to inquire about the level of stress experienced based on the response of the participant. For example, if a participant responded they lost or changed their job due to COVID-19, the question "Did you experience increased stress levels due to a loss or change in job?" appeared. If the

participant responded they did not lose or change their job, the follow-up question did not appear and is accounted for as "N/A" within responses to follow-up questions. Possible stress-related answer options were rated "not stressful at all," "somewhat stressful," "stressful," and "very stressful" as appropriate.

Study Population

The survey was available to individuals currently employed and 18 years of age or older. The job options included in the survey were determined to be too numerous, and were consolidated into four categories: business/office service, manual labor, education, and healthcare for analysis. Business/office services included: sales, real estate, finance and insurance, software or IT service, telecommunications, broadcasting, publishing, legal services, scientific or engineering services, religious, and arts, entertainment, and recreation. Labor included: agriculture, forestry, fishing, and hunting, mining, construction, manufacturing, utilities, transportation and warehousing, military, and hotel/food services.

Data Analyses

Descriptive statistics were computed for each survey question, including the number and percentage of individuals who responded. Statistical analyses consisted of univariate correlations of all occupational stressors and their respective responses and a Kruskal–Wallis one-way analysis of variance test to determine whether responses about stressors varied between job categories. All statistically significant relationships found through the Kruskal–Wallis test, as defined by a P-value ≤ 0.05, were then developed into frequency charts and are presented within the results section.

Finally, the overall degree of stress the entire study population reported was compared using the composite scoring methodology. For instance, in a follow-up question asking the participant if they viewed a workplace change due to COVID as stressful, answer options were listed as “not stressful at all,” “somewhat stressful,” “stressful,” and “very stressful” which were then coded as 1, 2, 3, and 4, respectively. The number of responses selected in a given option was then multiplied by the associated number, and the four products were then added together and divided by the total sample population asked this question.

RESULTS

Survey Respondents

In total, 676 individuals completed surveys about their occupational stress in relation to the ongoing COVID-19 pandemic (see Table 1-1). Most respondents were either within the business/office service (n = 298) or manual labor industries (n = 252), followed distantly by education (n = 69), healthcare (n = 51), and “other” (n = 6), which accounted for anyone not working in the four former options. Due to the extremely small sample size in the “other” category, these respondents were omitted from frequency analysis, resulting in 670 total submissions. A majority of the respondents were male (n = 444, 66.3%). A large majority of the survey population was 39 years of age or under (n = 551, 82.2%). Regarding race, a large majority of respondents were white (n = 457, 68.2%), followed distantly by American Indian/Alaska Native (n = 78, 11.6%), black or African American (n = 53, 7.9%), Hispanic/Latino (n = 35, 5.2%), Asian (n = 24, 3.6%), Native Hawaiian/Pacific Islander (n = 18, 2.7%), or multi-racial (n = 2, 0.3%).

Participants' number of years of experience in their career showed a large majority of respondents were either in a manual labor or business/office service-related industry with 15 years of experience or less (31.3% and 39.3%, respectively). The overall number of individuals sharply waned as the years of experience in their industry increased as 8.5% reported 16–25 years, 5.7% reported 26–35 years, and 0.6% reported more than 35 years of experience. Within each industry category, workers were predominantly more concentrated at 25 or less years of experience with only 6.3% of individuals with 26–35 years of experience.

Survey Response Frequencies

The Kruskal–Wallis test identified fourteen questions related to stress that had statistically significant differences among the job categories (Table 1-2).

Irregular working hours or working night shift was concentrated among manual labor and business/office service workers, but a majority of each type of industry involved irregular hours or night shifts at least sometimes: manual labor (86.9%), business/office service (72.5%), education (56.5%) and healthcare (84.3%). Overall, 77.2% of all individuals surveyed worked irregular hours or night shifts at least sometimes.

As shown in Figure 1-1A, roughly one-half of the entire study population reported an increase in workload since COVID-19 started, but this was not reported equally among the job categories. Eighty percent of respondents in healthcare reported an increased workload, while only 44% of respondents in business/office service reported an increased workload.

A majority of respondents (85.8%) had the ability to decide their work pace at least sometimes. When stratified by industry, the largest portion of workers who never had the ability to decide on their work pace were those in healthcare at 35.3% of healthcare workers while the

smallest portion belonged to education (10.1%). As shown in Figure 1-1B, an overwhelming majority reported they had enough time to finish work assignments since COVID-19 started, at least sometimes (85.5%). Upon stratification, only about half of all survey participants reported always having enough time to finish work assignments, with 56.0% of manual labor workers, 55.1% of education workers, 49.6% of business/office service workers, and 29.4% of healthcare workers.

Video conferencing software usage for work was reported to be frequently utilized by the majority of respondents (68.5%), and the software identified included Zoom, WebEx, or Microsoft Teams. Differences between industries were found with manual labor at 64.3%, business/office service at 71.1%, and education at 85.5% rating "frequently used video conference software," only 51.0% of those in healthcare stated the same.

The percentage of respondents in each job category who worked from home varied (Figure 1-2A). Overall, 37.8% of respondents were required to work from home, while 23.6% voluntarily worked from home, and 38.7% did not work from home at all. Nearly half of the healthcare workers (45.1%) volunteered or were required to work from home during COVID-19. Among manual labor workers, half (50.4%) were able to work from home while more than two-thirds of business/office service workers (70.1%) were able. Only one-quarter of education workers (24.6%) did not work from home due to the pandemic.

If the respondents stated they worked from home, they were then asked if they felt their job performance changed since beginning to work from home (Figure 1-2B). Overall, 22.1% stated they experienced an increase in job performance since beginning to work from home. Alternatively, 23.7% experienced decreased job performance while 9.4% did not experience any change. Industry fluctuations included 22.2% of manual labor workers experiencing increased

performance, while 19.4% had decreased performance. Additionally, 23.5% of business/office service workers experienced an increase while 28.9% experienced a decrease. Respondents who worked from home were also asked if they felt their time management abilities suffered while WFH. A majority of those who work from home (59%) reported finding task management difficult while WFH. Finally, while examining each industry individually, a majority of those asked this question in each industry found time management harder while WFH besides healthcare (manual labor: 68.4%, business/office service: 57.9%, education: 59.5%, and healthcare: 23.5%).

Unsurprisingly, the only industry in which a majority of respondents stating their job directly involved dealing with COVID-19 was healthcare. Here, 70.6% of healthcare workers responded their job involved COVID-19, such as taking care of "high-risk" patients or entering "high-risk" places, followed by 39.7% of manual labor workers, 36.9% of business/office service workers, and 30.4% of education workers. Overall, 39.9% of all survey respondents chose "yes" to this question.

As shown in Figure 1-3A, healthcare had a large majority of participants responding in the affirmative in that they believed they could potentially be exposed to the SARS-CoV-2 virus at their workplace. In fact, all industries had at least a slim majority of respondents stating they believed they could be exposed to the virus (manual labor: 54.0%, business/office service: 51.7%, education: 53.6%, and healthcare: 76.5%). When examining the entire study population as a whole, 54.6% believed they could be exposed to COVID-19 in their workplace.

More than two-thirds of the respondents stated there was a mandated vaccination policy in place (70.6%, Figure 1-3B), and the percentage of respondents reporting this was similar across the job categories (62.7–73.9%).

A majority of all participants in each industry stated it was difficult to spend time with friends and relatives due to social distancing and travel restrictions at least sometimes. As a whole, 36.6% stated it was always hard to find time, 39.6% stated it was sometimes hard to find time, and 23.9% stated it wasn't hard at all to find the time. Within each industry, only a majority of those within the healthcare industry claimed that it was always hard 58.8% while the slight majority of the remaining categories claimed that it was only "sometimes" difficult to spend time with friends and family. Within the manual labor workers, 35.3% stated it was always hard while 36.5% stated it was sometimes hard. Regarding business/office service workers, 33.9% stated it was always hard while 42.3% stated it was sometimes hard. In education, 36.2% shared it was always hard while 47.8% said it was sometimes hard. Although about half the respondents did not have children living with them (49.7%), a follow-up question asking whether there were children 19 years old or older living with the individual was found to be statistically significant. When focused on the populations who had adult children living at home, healthcare workers had adult children living with them much more frequently than manual labor, business/office service, or education workers, at a rate of 9.8% with 1 adult child and 7.8% with three or more adult children living at home.

Finally, a majority of all participants with children (n = 283) stated childcare distracted them from their work at least somewhat (79.2%), regardless of industry. Although the majority response within each industry maintained childcare distracted from work at least somewhat, this percentage differed between each type. Regarding manual labor workers with children, 83.7% stated childcare distracted them from their work. Within business/office service workers with children, 80.6% stated childcare distracted them from their work. Nearly three-fourths of education workers with children (72.4%) stated childcare distracted them at least somewhat.

Finally, a slight majority of healthcare workers with children (57.1%) responded childcare was at least somewhat distracting.

Finally, composite scores marking the degree of stress experienced related to the various workplace attributes can be found in Table 1-3. The higher the composite score, the more individuals from the sample population experienced a greater degree of stress due to the respective attribute. The most predominant factor subjectively causing stress in the sample population was associated with working irregular hours or night shifts with a composite score of 3.05. Other experiences commonly deemed stressful in one's workplace included a loss or change in job (2.59), difficulty communicating and relying on coworkers (2.59), involvement in workplace conflicts since COVID-19 (2.59), and the perception of potentially being exposed to SARS-CoV-2 in the workplace (2.56). Alternatively, the workplace factors that were the least frequently reported as a source of stress included both the presence and the absence of a mandated vaccination policy (1.89 and 2.14, respectively), attending many virtual meetings (1.96), decreased job performance while WFH (2.15), and working after the individual's normal working hours (2.17).

DISCUSSION

The results show that although only about half of the respondents noted an increased workload since the pandemic began, there were noticeable trends in stress factors and COVID-related concerns correlating with stress seen in the study population. A majority within all industries accounted for reported the possibility of being exposed to COVID in the workplace. This increase in stress could certainly be explained by the strength and quantity of correlations between stress factors and various ways the pandemic has impacted workplaces of all types such

as increased workloads, poor occupational autonomy, and the blurring of the line between one's work-life and home life (see Table 1-2). Work conducted prior to the pandemic had already shown that a noticeable concentration of workers considered their job very or extremely stressful (40.0%), were burnt out (26.0%), or were very stressed at work (29.0%) (NIOSH, 1999). Since the onset of the pandemic, however, various reasons for stress and burnout materialized. Working irregular hours or night shift work was common in many industries, especially manual labor workers (86.9%), healthcare workers (84.3%), and business/office service workers (72.5%) although it was not inquired whether or not the irregular working hours began as a result of the pandemic. Frequent use of video conferencing was found in all industries inquired, and a third of all respondents felt time management was harder while WFH. There were trends found between the data gathered in this study as well as some of the common sources of occupational stress such as interpersonal issues, struggling to maintain a work/home life balance, or a lack of job stability (Center for the Promotion of Health in the New England Workplace, 2021; Gerding et al., 2021; AIS, 2020; Gerding et al., 2021). Composite score analysis presented the common mean values provided by all respondents regarding stress-related inquiries ranging from time management to childcare needs. Prior research has shown a variety of factors related to stress following the sudden work-from-home transition experienced at the beginning of the pandemic, such as the age of the worker, glare on the work surface, using laptop keyboards as opposed to external keyboards, family-work conflict, and lacking colleague support (Oakman et al., 2020; Galanti et al., 2021; Gerding et al., 2021). However, those who work irregular hours or the night shift were not without job stressors of their own. This question had the highest related composite score associated. On average, nearly all of the questions related to the individual's stress had a composite score greater than 2.0 (Table 1-3), except for attending many virtual meetings (1.96)

and stress related to the presence of a mandated vaccination policy (1.89). Many of these stressors have been recognized prior to COVID-19 (Hasan et al., 2018; Zhang et al., 2020; Doyle et al., 2021). Finally, besides the loss of a job, other greater stressors related to COVID-19 based on the composite scores included believing you might be exposed to the virus in the workplace (2.56), stress related to quarantining due to either testing positive or being exposed to someone who tested positive (2.55), or stress related to direct involvement with the virus through caring for "high-risk" patients or entering "high-risk" places (2.49), especially common within the healthcare sector. As the study presented here was a cross-sectional analysis investigating potential relationships between occupational stressors and pandemic-related stressors, one may not determine the causation, simply the correlation, of these factors. While it's not possible to evaluate whether those stressed due to COVID were stressed at work for other reasons prior to the pandemic, it is clear many of these stressors were felt at the present time. Determined through the statistical analysis presented, it appears if an employer were to increase their stance on COVID by requiring vaccinations and implementing preventative measures, especially protecting the elderly and immunocompromised (Patel et al., 2021), workplaces may feel more secure to the worker and positive effects may ripple through, improving workers' professional relationship with their supervisors and the companies with which they work. Employers increasing the availability of PPE such as masks or cleaning materials such as hand sanitizer or surface disinfectant, may encourage workers to feel more comfortable in the workplace and less stressed. This had been seen previously where anxiety was lowest among site-based workers who felt their workplace infection control programs and PPE were adequate (Smith et al., 2020).

However, the employer's ability to prevent the spread of COVID-19 while working was not the only occupational factor related to careers and stress during the pandemic. For example,

those who changed jobs due to a loss of employment might have also experienced an increased workload in their new position. Not only would these individuals have to experience the mental stress and upheaval of their normalcy through losing their source of income, but they then encountered a greater level of workload in the new occupation they secured. Secondly, those who were not allowed to decide on the pace of their work are also more likely to work irregular hours such as at night, and were more likely to stress over their workload which was previously commonly seen with those who worked in the healthcare industry (Kinnumen-Amoroso & Liira, 2014; Kang et al., 2015; Jin et al., 2019).

Finally, one must remember people experience stress over more than simply occupational factors. As the pandemic spread throughout the world towards the beginning of 2020, the social distancing and travel restrictions that were implemented overnight discouraged many from seeing friends and family without the assistance of web conference software (Burn and Mudholkar, 2020; Cindrich et al., 2021). Worse yet, those who were already WFH were more likely to experience web conference burnout through frequent use of the software (Gerding et al., 2021). Using these programs to socialize may also be part of the reason why these individuals found it hard to set a boundary between work and social time. Familial stress, such as caring for children, was also a notable distraction from work, especially if one were to work from home. These individuals struggled with time management, finding time for socializing and recreation, and struggled to create a set boundary between work and the rest of their life.

Limitations and future work

The survey utilized in this study was distributed through NIOSH professional networks such as National Occupational Research Agenda (NORA) councils, Education Research Center

(ERC) network, and AIHA Catalyst. For this reason, the findings of this study may not completely reflect general workers' perception of work-related stress, but rather provide insight into common concerns regarding stress during the time of the global pandemic. Furthermore, socioeconomic status was not inquired of within the survey which could have provided a better understanding of the occurrence of stress in our results due to variations in socioeconomic-related stressors experienced by some due to their level of income. While 676 respondents completed the survey, and this was more than initially anticipated, a greater sample size could have provided more generalizable results.

The survey captured the perceptions of the respondents, and this is thus subject to potential bias based on perceptions of occupational descriptors and the degree to which they trigger stress. Perceptions of occupational stress compared to retrospective levels of stress experienced prior to the onset of the pandemic may leave room for recall bias as it can be difficult to gauge "how much" one is stressed currently in the workplace compared to how one felt in a similar setting, albeit two years prior and no pandemic. Future work should investigate the levels to which employees may experience occupational stress during COVID through such means as collecting salivary cortisol during working days in a longitudinal format with regard to typical circadian rhythm (Hansen et al., 2009). Through this effort, it might be more sufficiently determined who could be the most stressed working population through biomonitoring methods instead of simply relying on personal recall.

Although a majority of inquiries made were focused on what the respondent was currently experiencing, some questions asked the respondent to compare their current feelings and experiences with those prior to the onset of the pandemic. For this reason, a control group for this study could not be assigned. It is likely, however, that planned changes in employment or

work arrangements would help to alleviate occupational stressors currently being experienced and including pandemic preparations in an organization's emergency action plan (EAP) may prove beneficial going forward.

CONCLUSIONS

The results from this study showcase the apparent levels of stress experienced by a variety of working populations within the US during the ongoing COVID-19 pandemic. These at-risk working populations included those in manual labor, business/office service, education, healthcare, and "other" which accounted for the remaining respondents. Noticeable levels of stress following the onset of the pandemic were reported in all industries inquired, especially in those who believed they could be exposed to COVID-19 or experienced a change in employment. In addition to the stressors already present in the workplace, the pandemic has created newfound obstacles such as increased workloads (e.g., healthcare), web conference burnout for those WFH, juggling childcare with work, especially in manual labor & business/office service, and time management issues present in all industries. Employers need to ensure their workforce has both the proper practices to combat the SARS-CoV-2 virus as well as the resources to reduce stress caused by both regular work-related and pandemic-related stress.

CHAPTER 2. STRESSED AT WORK: INVESTIGATING THE RELATIONSHIP BETWEEN OCCUPATIONAL STRESS AND SALIVARY CORTISOL FLUCTUATIONS

INTRODUCTION

Work-related stress is a common occupational health concern and contributor to many aspects of health disparities, both in the United States and abroad (Aro, 1984; Malamardi et al., 2015; Kang et al., 2015; Sun et al., 2011; Soori et al., 2008; Wieclaw et al., 2005). Exposure to chronic stress has been related to a variety of possible disease outcomes including cardiovascular disease (CVD), hypertension, and poor mental health outcomes (Belkic & Nedic, 2007; Jin et al., 2019, Faraji et al., 2019; Hasan et al., 2018; Sarafis et al., 2016). Occupational stress has been historically associated with interpersonal issues with co-workers or supervisors, poor work–life balance, poor job security, and overbearing workload stress (American Institute of Stress, 2021). This stress has also been exacerbated by the COVID-19 pandemic. Recent literature has found a majority of individuals experienced an increased workload due to the pandemic, and a majority also believed they could have potentially been exposed to COVID-19 in their workplace (Gerding et al., 2022). Further, certain career fields have been affected to different degrees regarding the pandemic. For example, while about two-thirds of the total participants from a recent study stated their workload increased since COVID-19, and 55% believed they could be exposed to the virus in the workplace, nearly 80% of healthcare workers stated concerns of workload and workplace exposure when stratified by industry (Gerding et al., 2022).

Research on occupational stressors experienced by those working in abnormal settings has shown work-related stressors are associated with greater rates of depression, anxiety, and suicidality (Quick & Henderson, 2016). Further, during the COVID-19 pandemic, COVID-19-unit ICU nurses were more than 200% as likely to lack sufficient sleep and 300% as likely to be planning to leave their current department compared to their counterparts (Tamrakar et al., 2021). Little research has been performed on work-stress within certain sub-sectors of high-stress workforces, such as home healthcare workers (HHCWs), despite frequently experiencing a disproportionate share of exposure such as during COVID-19 and annual influenza outbreaks (NIOSH, 2019). Finally, little time has been spent studying stressors of those who work in a home office setting (NIOSH, 2020). Gaining knowledge on work-related stressors may be particularly beneficial to help towards understanding health disparities experienced by workers.

Workforces already vulnerable to excess stress faced additional stressors due to the pandemic. “Essential workers”, including home healthcare workers (HHCWs), worried about possible exposure in addition to their typical stressors. Although home healthcare is considered one of the fastest growing subsectors of healthcare and is more apt to encounter disproportionate shares of various exposures, it remains an understudied branch of healthcare (NIOSH, 2019; Bien et al., 2020; Qiao et al., 2018). Additionally, office workers, who have been an understudied group regarding occupational stress, faced occupational issues of their own as many were sent to work from home with nothing more than a laptop at their kitchen tables (NIOSH, 2020; Gerding et al., 2021). Most individuals surveyed also noted increased levels of tiredness and stress since working from home (Gerding et al., 2021).

Measuring cortisol changes may provide insights into types of occupational stressors and how these may be minimized. As the body’s main stress hormone, cortisol is regulated by the

hypothalamus–pituitary–adrenal (HPA) axis, which releases the hormone each day, following a circadian rhythm with levels typically highest in the morning and tapering off throughout the day (Thau et al., 2022; Hansen et al., 2006; Björntorp & Rosmond, 2000; Kirschbaum & Hellhammer, 1994; Thomas et al., 2009). However, additional cortisol may be produced due to external stress exposure to scenarios such as shift work, nature of the work, and organizational characteristics of work (i.e., high work demand or conflict with others), resulting in an increased heart rate and respiratory rate (Diez et al., 2011; Lindholm et al., 2012; Bauer et al., 2009). Chronically high cortisol levels can lead to altered immune system responses and digestive system suppression as cortisol stifles what the body considers non-essential functions during high stress scenarios (Vining et al., 1983). Previous literature has found that serum unbound cortisol concentration is a more immediate measure of cortisol levels, as salivary cortisol concentration increases more rapidly as serum cortisol-binding globulin becomes saturated, although this delay was less than five minutes (Hellhammer et al., 2009). However, due to the simple and less invasive, salivary cortisol is still the recommended methodology within longitudinal, community-based studies as this has been found to be directly proportional to serum sampling and correlated well with adrenal function in tests of circadian variation (Hellhammer et al., 2009; Metzenthin et al., 2009). As an individual is subjected to a variety of stressors throughout the day, these increases in cortisol levels could potentially be quantified, thereby correlating them to the stressor events. Upon quantification and characterization of psychological stress based on these biomarkers, it could be determined what scenarios may be deemed the most stressful in the workplace in conjunction with subjective exposures so employers would work towards minimizing the potential of their occurrence through targeted

prevention policies (Kunz-Ebrecht et al., 2004; Stalder et al., 2009; Wolf et al., 2005; Wright, 2011; Bruschini et al., 2018).

While the influence of occupational-related stress on the health of workers is increasingly being recognized (Kinnunen-Amoroso & Liira, 2014; Richman, 1992; Beaton & Murphy, 1993; Doyle et al., 2021; Jukic et al., 2020; Eller et al., 2006), to date, relatively little research has been conducted with a focus on longitudinal salivary cortisol collection in conjunction with the documentation of daily stressor events. One study, by Eller et al. (2006), used survey response answers to describe participants, i.e., age, smoking status, children, and work-related questions, to name a few, but the lack of a diary limited the ability to truly connect cortisol fluctuations with what the participant was exposed to at a given time, on a given day. In essence, this study was able to describe the degree of stress someone in a specific field experienced, but they were not able to explain what could have triggered that increase in cortisol to occur (Rocha et al., 2013). Another study, focused on work stress in nursing, found that average cortisol levels on workdays were 60% higher than during off days and stress scores were lower based on completed surveys (Sanger et al., 2014). Here, again, though, potential reasons for the increases in cortisol levels were not studied during those working days. The ability to determine one's cortisol levels following various stressor events could help to gain a greater understanding of what occupational scenarios quantitatively cause a greater level of stress in the individual. Furthermore, the COVID-19 pandemic highlighted how stress and external factors may negatively impact the mental well-being of the workforce. Although the world may be progressing out of the pandemic, mental health, i.e., stress and its causal factors, should clearly be given a similar level of importance as with the physical hazards present in the workplace to

continually improve working conditions and to make sure employees are able to return home at the end of each day in the same condition in which they arrived.

The present study's goal was to determine the degree of correlation between occupational stress and fluctuations in salivary cortisol, the most non-invasive approach to monitoring one's cortisol levels, to physiologically characterize the impact of perceived stress experienced while working. No known study has been performed which used a work stress diary in addition to real-time saliva sampling by the participant in a working capacity instead of cortisol sampling within a clinical setting.

MATERIALS AND METHODS

Sampling Strategy

Fifteen participants were recruited for this mixed nature, descriptive, and transversal study through convenience sampling via email and social media for this study, which was approved by the University of Cincinnati Institutional Review Board under protocol #2021-0681, ensuring the scientific design, methodology, study procedures, participant population, recruitment procedures, and consent processes all adhered to the code of ethics. Emails were concentrated on participants of a recent occupational stress study completed by the authors. Exclusion criteria included smoking status, lacking full-time employment, and diagnosis of Cushing's Syndrome (a disorder affecting cortisol production). As individuals were recruited, each was given a work stress diary, sampling log, study protocol, and nine saliva sampling vials (Salimetrics, State College, PA, USA) in a cryostorage box (Salimetrics, State College, PA, USA). During three consecutive working days, participants were asked to document anything causing stress during working hours within the diary which included sections for occupation (i.e.,

nurse), date, time of day, intensity of stress on a 0–5 (none– highest) scale, stress duration, situation description, triggering event, if applicable, and any emotional behavioral reaction. They were also asked to describe whether the day would be considered typical of their job.

Concurrently, participants provided three saliva samples per day: once at the start of their shift, once at the start of the lunch break, and once at the end of their shift. It was initially planned to provide a stricter sampling schedule (i.e., 8:00, 12:00, and 4:00, for example), but was decided against to be as inclusive as possible to those who worked night shift or other schedules, such as three twelve-hour shifts or four ten-hour shifts per week. Participants were encouraged to use the small cryostorage box to keep samples organized and refrigerated within the refrigerator in their workplace, or home if they worked from home. Sampling logs were used to document the identification number of the sample vial and time/date when the sample was taken. Following the third sampling day, study materials were returned for enzyme-linked immunosorbent assay (ELISA) analysis. Participation in the study occurred from March through to April of 2022. Preliminary power calculations found that a total of 135 samples (fifteen participants providing three samples per day) was sufficient in conjunction with an α error probability of 0.05 and a power of 0.80 towards the completion of a two-way ANOVA.

Salivary Cortisol Analysis

As the participants returned the study supplies, all saliva samples were stored in a freezer set at −20 ◦C until there were four participants' samples which would fill the 96-well plate in addition to the necessary standards, controls, and blanks. No participant's samples were stored in a freezer for longer than one week although they may be frozen for up to six months according to the assay kit's manufacturer instructions (Salivary Cortisol Enzyme Immunoassay Kit,

Salimetrics, State College, PA, USA). When enough samples were collected to warrant an analysis, all reagents were brought to room temperature and all samples were thawed completely, vortexed, and centrifuged at 1500× g for 15 min. Two of the wells in the microplate were replaced with non-specific binding wells and 25 µL of standards, controls, saliva samples, and assay diluent were pipetted into various wells as appropriate. All wells were run in duplicate. A 1:1600 enzyme conjugate was diluted by adding 15 µL of the conjugate to 24 mL of assay diluent and 200 µL of this solution was added to each well using a multichannel pipette.

The contents of each well were then mixed using a plate rotator for five min at 500 rpm and was then incubated at room temperature for one hour. After the hour concluded, the plate was then washed four times with a wash buffer solution by pipetting 300 µL of the wash buffer into each well and blotting the plate with a paper towel prior to up righting the plate between each wash. Next, 200 µL of tetramethylbenzidine (TMB) substrate solution was added to each well and the plate was again mixed on a plate rotator for an additional five minutes at 500 rpm. The plate was then incubated at room temperature for an additional 25 min at which point 50 µL of a stop solution was added to each well. Finally, the plate rotator was used for an additional three minutes at 500 rpm, the bottom of the plate was wiped dry, and the plate was entered into a plate reader at 450 nm.

All samples were analyzed for salivary cortisol in accordance with the ELISA kit manufacturer's instructions (Salivary cortisol enzyme immunoassay kit, Salimetrics, State College, PA, USA). After raw data collection from ELISA tests, the following calculations were used to determine cortisol levels from each sample. Average optical density (OD) was calculated for duplicate wells. The average OD for the non-specific binding wells were subtracted from the average OD of all other wells. The percent bound (B/B0) was then calculated for each standard,

control, and saliva sample by dividing the average OD of each well by the average OD of the zero wells. Finally, the µg/dL concentration of each standard and the resulting B/B0 for each were used to construct a 4-parameter non-linear regression curve fit. Once completed, the averaged B/B0 value for each sample was applied to the equation provided from this model which facilitated cortisol value determinations.

Statistical Analysis

Two-way ANOVA was completed to determine correlations between the time of day when a sample was taken versus the cortisol concentration, and linear regression was performed to determine correlations between the cortisol level of a given sample with the self-reported stress level of the nearest preceding stressor event logged in the diary. Regression models were first constructed for each participant, then pooled together to include all data in a single regression. Time of day was segregated into three categories, first, second, and third sample, which would have equated to morning, midday, and afternoon for many of the participants. Levels of statistical significance were set at $p \leq 0.05$. Statistical analyses were performed within SigmaPlot 14.0 (Inpixon, Palo Alto, CA, USA). Lastly, a qualitative analysis and summary of stressor events and subjective stress levels was completed.

RESULTS

Study Demographics

Participants ranged from numerous careers including: R&D scientist for a multinational consumer goods corporation, work-from-home (WFH) supervisor for a Fortune 500 health insurance company, WFH college admissions advisor, marketing, WFH project manager for luxury vacation rentals, WFH internet marketer, WFH information security manager for a

healthcare system, a master's level graduate student, weight loss specialist/health center manager, wastewater treatment biologist, accounting specialist, and four nurses. Of the fifteen, nurses made up 26.7% of the population, those in a WFH capacity made up 33.3%, and the rest accounted for 6.6% each (i.e., one graduate student, one biologist, etc.). Of the nurses, one was a respiratory therapist, and another worked partly in a HHCW capacity. Four participants were men (26.7%), eleven were women (73.3%), and ages ranged from twenty-eight to sixty-two. All participants worked day shifts typically of either five eight-hour shifts, four ten-hour shifts, or three twelve-hour shifts except for the respiratory therapist who worked three twelve-hour overnight shifts per week.

Correlation between Sampling Time and Cortisol Level

The two-way ANOVA results found the difference in mean values among the levels of salivary cortisol from study subjects was greater than would have been expected by chance regarding effects from the time of shift when a sample was taken ($p < 0.001$, study subject, $F = 11.462$). Here, although some increased during the day, cortisol tended to wane throughout the working day, following typical circadian rhythm. Sampling error for the dataset with a confidence level at 0.05 was found to be 1.387. As not all participants worked identical shifts based on time of day, sampling time was defined as sample one, two, and three, during each shift (time of day, $F = 3.642$, $p < 0.030$). So, while not all samples were taken at the same time of day between participants, they were statistically different from one another when comparing the samples based on the order collected.

Correlation between Cortisol Level and Self-Reported Stressor

The linear regression analysis tested the relationship between self-reported levels of stress occurring most closely to the nearest sample provided. Only two individuals' regression models were found to be significant in addition to the pooled model. The pooled model contained all 135 samples and was found statistically significant ($p = 0.042$). The constant variance test, Spearman rank correlation, passed and had a power of 0.53, but had an R-squared value of only 0.0308.

Differences within Shift

Most samples followed a trend of highest in the morning and tapering downward during the day, similar to typical circadian rhythm. Figure 2-1 compares cortisol levels and participant, separated by the daily sample average for first, second, and third daily samples. The second participant's third daily mean and the tenth's participant's second and third daily mean concentration were all below 0.01 µg/dL on the graph as they were nearly a concentration of 0 µg/dL. Participants six, eleven, twelve, thirteen, fourteen, and fifteen showed increased average concentrations of the final daily samples in their sampling period compared to their second daily samples and sometimes even their first daily samples.

Stress Diary Information

One of the two participants with statistically significant correlations between the self-reported stress levels and their corresponding cortisol levels included a WFH information security manager for a healthcare system. This person experienced self-reported stress levels ranging from 1 to 3 out of 5 on day one and levels of either 1 or 2 on the second and third day of the study period. The stressors given a level of 3 involved unexpected spreadsheet formatting changes in a collaborative file and running late for a dentist appointment due to a work meeting

running over schedule. The lesser occupational stressors predominantly dealt with prepping for the day at hand, a slight overburden involving work tasks (i.e., ticket queues, unread emails, and review processes), and stress over homelife related factors as this individual worked from home.

The second participant with statistically significant correlations between their self-reported stress levels experienced and their cortisol levels was a registered nurse who worked partially in a HHCW capacity. This participant noted higher levels of stress over the course of their three-day participation overall ranging from 2–4 out of 5. On day one of the participants study period, the individual noted a stress level of 4 when preparing for the day as they had accidentally slept a little too long. Closer to noon, this individual then noted a stress level of 3 due to a home patient's family needing their visit moved so the participant was stressed over juggling patient times. On the second day of the study period, the nurse expressed stress levels of 3 and 2 due to others working from home so many calls came to her, interrupting her work, and bad traffic, respectively. Finally, the third day of the study period saw the participant experience a stress level of 2 when getting prepared for a clinic followed by a stress level of 4 in the afternoon when a patient passed away very unexpectedly, and she experienced guilt from this.

Table 2-1, outlines and summarizes any of the occupational stressors ranked three or higher experienced by the fifteen participants over the course of the study period. Many of these stressors dealt with keeping up with work tasks and an overburdened workload/schedule. When focused on the stressors given a three or higher, of the 59 total stressors listed, 25 of these were from participants who worked in healthcare, either the four nurses or the weight loss specialist. Of the 15 participants, everyone experienced at least one occupational stressor level three or higher over the course of their three-day study period. The two individuals who experienced the fewest higher stressors included the internet marketer who had experienced one level three event

involving an unforeseen problem at work and one of the nurses who had experienced one level three event due to lab results coming back wrong which made her anxious. On the other hand, the individual who experienced the most amount of higher-level stressor events was one of the other nurses who reported experiencing three level threes, three level fours, and three level fives within the three-day period. Nearly all of these stressor events involved understaffing issues at the hospital such as a lack of help for the patients, being overburdened with tasks, and caring for sick patients.

Many of the diary entries reported the study days were typical, but a few had abnormalities during their day. The accounting specialist was newer to her job and was learning how to complete payroll for employees and navigate a new reporting system. The project manager had to work on what was typically one of her days off. The person in marketing had a team meeting and an evening activity with work. One of the nurses worked in a home healthcare capacity during one of her three study days although this was fairly regular. Finally, the health center office manager dealt with a missing employee during the second day of the study period to the point where police needed to be involved.

Table 2-2 shows the frequencies with which various emotional descriptors were written within the emotional behavioral reaction column of each diary entry. Although a total of 128 stressor events were inscribed within all fifteen participants' diaries, the emotional behavioral reaction column was not completed for all entries and a total of 121 emotional reactions were recorded. With 16 uses of "stressed" or "stress", this appeared to be the most popular emotional behavioral reaction provided at 13.22%. Closely behind "Stressed" came various feelings of upset at work situations the participants experienced including: "Frustrated" at 12.40%, "Angry/Mad/Pissed" at 11.57%, "Anxious/Unease/Restless" at 10.74%, and

"Overwhelmed/Pressured" at 8.26%. All diary entries related to the aforementioned frequent behavioral reactions dealt with feelings due to situations at work, such as an overbearing workload, but no conflicts with co-workers or supervisors were noted associated with any of these emotions. In that regard, examples of emotional reactions which dealt with co-workers or supervisors included being frustrated and mad over writing up an employee due to a policy that the participant did not believe in, worry, anxiety, and stress over having to replace an employee who received a promotion, and nervous/overwhelmed over firing an employee. Of the emotional reactions written least frequently, the following all had an occurrence of two each: "Shame/Guilt", "Confused/Surprised", "Tired", "Frazzled", "Dread/Fear", and "Impatient".

DISCUSSION

Correlation between Sampling Time and Cortisol Level

Following the data analysis of all fifteen participants after the conclusion of the ELISA analyses, it was determined there was a statistically significant relationship between a given cortisol level and the time of day it was taken utilizing the two-way ANOVA. This trend was to be expected as cortisol levels tend to follow a circadian rhythm with the highest levels typically occurring upon waking each day (Thau et al., 2022; Šušoliaková et al., 2018). Further, the importance of documenting the time of sampling towards sound statistical analysis has been outlined in previous literature, due to fluctuations over the course of the day (Hansen et al., 2009). Time of day was segregated into three categories: first sample, second sample, and third sample. For most participants, this would have equated to the morning, midday, and afternoon sample. However, the rapid response team nurse worked overnight shifts, but her cortisol levels

followed the same trend as the analysis presented with levels declining from first to third sample per day, although she worked from the evening into the morning.

Correlation between Cortisol Level and Self-Reported Stressor

Of the fifteen participants included in this study, only two individuals' datasets were deemed statistically significant regarding their relationship between stress levels and corresponding cortisol levels. However, when pooling the data from the entire study population, this was determined to be statistically significant, demonstrating there was a notable relationship between one's subjective stress level assigned to an occupational stressor event and their physiological response of cortisol release. Unfortunately, the R-squared value with this relationship was only 0.031. Nevertheless, while the model presents the idea only 3.1% of the variation is accounted for, there could have been a variety of confounders contributing to one's cortisol levels. Stressors not accounted for in a participant's diary, such as occupational stressors a participant may not have deemed of adequate magnitude to include in the diary, personal/familial stressors which one may not have wanted to include, or simply forgetting to document a stressor, could have been somewhat responsible for the poor predictive value provided. Additional confounders could include aspects such as smoking habits, time of awakening, alcohol consumption, body mass index, and medication, of which smoking and alcohol consumption were both controlled for through exclusion criteria and participant instructions (Al'Absi et al., 2004; Federenko et al., 2004; Edwards et al., 2001; Kudielka & Kirschbaum, 2003; Alderling et al., 2006).

Additionally, if the only point of the linear regression model was prediction, the model would indeed poorly predict one's cortisol level following an occupational stressor. Yet, the

purpose was to determine if there was a small, but reliable relationship between the two factors, which was the case. Admittedly, the ability to potentially reduce one's occupational stress exposure by 3% through minimizing the exposures noted in the diaries would not seem to legitimately reduce one's cortisol levels, sampling a larger participant pool would potentially increase the statistical validity of the present study, ideally improving the associated R-squared and power level. Another tactic to improve the validity may be to simply increase the longevity of the study period compared to three consecutive days for each participant if a smaller study population is used. This holds true to previous literature which found seemingly poor covariance between perceived stress and salivary cortisol to be typical due to the complex interplay of the neurobiological events linking perceived stress with HPA axis activation (Hellhammer et al., 2009). The ability to collect total cortisol in blood, salivary cortisol, and adrenocorticotropic hormone levels would paint the clearest picture of cortisol levels within the individual, although impractical in a community-based study where multiple samples per day are necessary. For this reason, the recommended methodology would still be the sampling of saliva following a standard cadence (Hellhammer et al., 2009; Jessop & Turner-Cobb, 2008).

Temporal Difference

While nearly two-thirds of the participants cortisol trends tended to follow the typical pattern of being greatest in the morning and declining throughout the day, there were a handful who tended to have greater cortisol levels in their third sample each day. This would infer something stressful may have been experienced by each of these individuals. Upon consulting the work diaries submitted for each of the participants who had these trends, participants 6, 11, 12, 13, 14, and 15, experienced atypical stress in their work shift during their sampling days. Participant 6, for example, worked from home while caring for their toddler. In the healthcare

realm, participant 11 was the health center manager whose employee went missing, participant 12 was a nurse who found out one of her patients had passed away, and participant 13 appeared to be in a short-staffed work setting based on many of her diary entries. Participant 14, the wastewater biologist, expressed feelings of frustration towards the afternoon one day when a supervisor left work early and expected him to fix an unplanned outage. Finally, participant 15 was recently hired in an accounting capacity and was learning how to process payroll during the week of the study. Fortunately, none of the participants worked irregular shift work (i.e., alternating work schedules) which has been found to increase cortisol excretion upon waking in the morning and a slower regression over the course of the working day (Šušoliaková et al., 2018).

Stress Diary Information

Regarding the more intense stressors experienced by the participants, nearly half of the 59 events which were described as a stress level of 3, 4, or 5 out of 5 were experienced by those in healthcare, demonstrating the trend in healthcare occupations typically consisting of a great level of stress. Further, three of the seven level-five stressors were experienced by one individual in healthcare. What might be considered a silver lining, nearly all these greater stressors experienced by the healthcare participants involved stress over providing care for their patients as opposed to stress involving their superior or workplace conflict with co-workers. In fact, the only events logged in the diaries of the healthcare participants that involved co-workers involved a couple working from home and one who went missing. This individual was eventually located by authorities, but then terminated their employment within the same week.

Although all participants experienced a stressor event they described as at least a 3 out of 5, it was natural for all participants to experience varying amounts of stressor events and various degrees of stress during the three working day period they had participated in the study. This was largely dependent on if the study period were considered typical working days for the individual or if abnormal stressors were experienced. For example, one of the nurses had a typical week according to her diary and listed a total of seven stressor events, with only one level three event. On the other hand, while the wastewater biologist listed only four stressor events over the course of the three days, two were level four and one was level three, appearing that his days were more sporadically stressful although he listed each day as typical. Worse yet, although one of the nurses listed her days as typical, she also documented nine stressor events level three or greater (3 = 3, 4 = 3, 5 = 3) which gives her job the appearance that she is typically very stressed even on what would be considered a normal day.

Lastly, the 121 emotional behavioral reactions given for any of the diary entries were quantified into a frequency table. The most frequent emotional behavioral reactions documented included: “Stressed” at 13.22%, “Frustrated” at 12.40%, “Angry/Mad/Pissed” at 11.57%, “Anxious/Unease/Restless” at 10.74%, and “Overwhelmed/Pressured” at 8.26%. Many of the associated stressor events with these emotional reactions involved issues with their work or their job, but fortunately nearly no issues were noted involving workplace conflict with others. Common issues involve stress over one’s job typically consisted of feeling overwhelmed with a workload, being short-staffed, or poor opinions of workplace policies.

Limitations

The participants were recruited using convenience sampling in a large, midwestern metropolitan area up until fifteen individuals were recruited. For this reason, the findings of this study may not completely reflect occupational stressors experienced by workers in general, but does provide insight regarding common stressors in the workplace. For example, the qualitative results showed healthcare appeared to be a commonly stressed career field.

Second, the work stress diary entries were based on the perceptions of the individuals, especially the intensity of the stress experienced. Subjective perceptions about the level of stress experienced, if the day was typical, etc. have the potential be biased as what one may consider a stressor event of 5, someone else may describe the same event as a 3. Further, there may have been events that occurred which a participant deemed not appropriate to enter into the work diary (i.e., if they felt the need to concentrate specifically on occupational stressors, but something familial caused them stress at work, or if someone had a physiological stress response, but did not think the event severe enough to log the occurrence). For this reason, bias may exist to the extent of participants underestimating the breadth or depth of stressors experienced while working. Future work could be carried out following the end of the pandemic and investigate how well one's subjective sense of severity of stress correlates with physiological responses, measuring salivary cortisol as well as salivary alpha-amylase, an enzyme whose presence has been found to increase following exposure to external stress (Šušoliaková et al., 2018).

Finally, due to budgetary constraints and the goal of methodology validation, only fifteen participants were recruited for this study and only a total of nine saliva samples were collected over the course of three consecutive working days. Future work hopes to collect for a longer study period using a larger population pool which would potentially increase the statistical validity of the study and improve the foundation of knowledge. Ideally, a greater depth and

breadth of knowledge will lead towards the prevention of illnesses associated with chronic stress so as to reduce workplace absenteeism or economic repercussions (Reale et al., 2020). Further, we hope to collect data on alpha-amylase fluctuations in addition to changes in salivary cortisol levels. Studying targeted industries, such as home healthcare workers or those that work from home may also help to understand the stressors experienced by growing work sectors.

CONCLUSIONS

The results from this study illustrate a variety of common stressors experienced by a variety of workers: healthcare, WFH, information technology, scientists, and a few other white-collar workers. Levels of salivary cortisol levels tended to follow typical trends due to circadian rhythm although there were some individuals who experienced increased cortisol levels towards the end of their work shift, potentially due to exposure to occupational stress. Although the correlation between cortisol levels and the levels of self-reported stress occurring most closely to respective sampling times was determined to be statistically significant, the low R-squared value could have been due to the various confounders associated with stress. Expanding the participant pool and the sampling period could aid in allocating for greater validity. Qualitatively, it was shown that although participants who worked in healthcare accounted for one-third of all participants, they documented 25 of the 59 intense stressors reported. Based on the emotional behavioral reaction frequencies, it was common for participants to feel emotions involving stress, frustration, anger, anxiety, and being overwhelmed. In addition to minimizing the risk of occupational illness or injury, workplaces should allocate greater resources for mental health awareness and intervention. Besides a reduction in the triggers which may spike one's cortisol levels, minimizing occupational stress could also improve workplace retention, productivity, and the interpersonal relationships between co-workers.

CHAPTER 3. EXAMINING WORK STRESS AND AIR POLLUTANTS EXPOSURE OF HOME HEALTHCARE WORKERS

INTRODUCTION

Occupational stress, linked to a variety of adverse health outcomes, is associated with an estimated 120,000 deaths annually in the U.S. (Aro, 1984, Malamardi et al., 2015, Kang et al., 2015, Sun et al., 2011, Soori et al., 2008, Wieclaw et al., 2005, Goh et al., 2015). The World Health Organization (WHO) reports that 83% of U.S. workers experience work-related stress, with over half admitting it impacts their home life (World Health Organization, n.d.). Furthermore, Nelson et al. (2022) established a link between occupational stress and disturbed sleep patterns. Workplace stress has been shown to impact workers' health, absenteeism rates, and earning potential. A Gallup poll revealed that employees who rated their mental health as "fair" or "poor" missed an average of 11.8 workdays per year, contributing to an annual loss of USD 47.6 billion due to reduced productivity. This equates to roughly USD 340 per day of lost work for a full-time worker (Witters D. & Agrawal S., 2022). The poll also showed higher rates of mental health issues among women compared to men (23% vs. 15%) experiencing workplace stressors, with the majority unable to confirm the presence of easily accessible mental health support services in their workplaces.

Physiological responses to stress involve the activation of the hypothalamic–pituitary–adrenal (HPA) and sympathetic–adrenal–medullary (SAM) axes (Li et al., 2017). Exposures to stressors can trigger fluctuations in hormonal regulations, potentially indicating stress severity.

For instance, frontline police officers were found to have higher diurnal cortisol levels than the general population (Planche et al., 2019). Deviation from typical diurnal cortisol patterns may imply exposure to stress, with both chronic highs and lows presenting potential health risks (Hellhammer et al., 2009). Chronic lows may signal adrenal insufficiency, while chronic highs could indicate Cushing's disease or overexposure to stress (Mayo Clinic, n.d., Oregon Health & Science University, n.d.). Such high levels may alter immune responses or suppress digestive functions (Bauer et al., 2009). While stress is a significant health concern, environmental exposures, such as ambient air pollution, also have measurable effects on health. For example, asthmatic children showed decreased physical activity and increased sedentary behaviors when exposed to higher air pollution levels (Aguilera et al., 2023). Higher particulate matter (PM) exposure has been linked to increased levels of stress hormones and other health markers, especially particles less than 2.5 microns (PM2.5) (Li et al., 2017). Home healthcare workers (HHCWs) tend to experience stressful and precarious work arrangements, typically for low wages in poor working conditions (Zoeckler, 2018, Markkanen et al., 2014, Quinn et al., 2016). Access to personal resources and job satisfaction have been correlated with reductions in emotional labor and job stress seen by HHCWs (Park & Han, 2013). This working population may also be exposed to noticeable levels of air pollutants due to commuting between patients, and also activities within the home, such as VOCs from disinfectants used; tobacco smoke; poor ventilation; and bioaerosols, like mold and pet dander (Quinn et al., 2016, Benjamin, 2019, Hittle et al., 2016). Combined, these airborne exposures could have a synergistic effect on poor cardiovascular outcomes and, when combined with chronic cortisol dysfunction, the likelihood of physical and mental disease increases (Mallach et al., 2023, Hajat et al., 2019). This study aimed to assess the association between occupational stress and salivary cortisol levels among

HHCWs and the influence of personal air pollution exposure on cortisol fluctuations. Previous research has utilized cortisol monitoring, yet its use in occupational stress exposure monitoring remains limited (Sanger et al., 2014). Recent work by the study team followed a general working population for three consecutive working days to determine a relationship between work stress exposure documented through the use of daily stress diaries and salivary cortisol from the provision of multiple saliva samples throughout each workday (Gerding & Wang, 2022). The results showed both a relationship in the diurnal trends of the highest average levels in the morning and tapering off throughout the day as well as statistically significant correlations between exposure to stressors from the diaries and increases in cortisol following these events. The authors of the present study hoped to build off this literature and expand in terms of relating changes in cortisol with exposures to ambient airborne pollutants through the use of personal air quality monitors.

MATERIALS & METHODS

Saliva Sampling Strategy

Twelve participants were recruited for this University of Cincinnati Institutional Review Board-approved study (protocol #2022-0782) through convenience sampling via phone and email directed at local home healthcare agencies. The study team previously positively validated the study methodology using a general working population consisting of fifteen individuals over the course of three days each, with a total of 135 samples (Gerding & Wang, 2022). In this work, typical diurnal trends were documented as well as increases in cortisol levels following documented exposures to stress through work stress diaries (Gerding & Wang, 2022). For this reason, the recruitment of twelve participants followed for at least a four-day work week would yield 144 total samples. In this study, we wished to examine the feasibility of taking these

measurements in a specific occupational group. Participants were excluded if they reported a positive smoking status (nicotine and marijuana products), a lack of employment in the home healthcare field, they did not work day shift, or a diagnosis of Cushing's Syndrome.

Each participant received a work stress diary, a sampling log, a study protocol, saliva sampling vials (Salimetrics, State College, PA, USA), and a cryostorage box (Salimetrics, State College, PA, USA) inside a Styrofoam cooler with two moisture-resistant ice packs. During their work week, participants were asked to record any stress-inducing incidents in the diary. The diary entries included the date, day of the week, time, stress intensity (0–10 scale; none to highest), stress duration, situation description, triggering event (if applicable), any emotional or behavioral reactions, and an assessment of whether the day was typical of their job. Besides increasing the specificity of the stress intensity from a 5-point scale to a 10-point scale, the diary remained identical to the previous methodology validation study.

The participants were asked to provide three saliva samples per day: at the beginning of their shift, the start of their lunch break, and the end of their shift. However, as they did not have designated lunch breaks and often ate while traveling to a patient's home, they were asked to provide the second sample approximately halfway through their shift. It was emphasized that they should avoid eating or drinking anything other than water for twenty minutes before each sample collection. The participants were instructed to keep the samples cold in the provided cooler during the workday and to freeze them after work. Sampling logs documented the time and vial used for each sample collection. This study was conducted from January to March 2023, with the principal investigator collecting materials at the end of the week for enzyme-linked immunosorbent assay (ELISA) analysis in the laboratory. Upon collection at the end of each study week, all samples underwent an enzyme-linked immunosorbent assay (ELISA) analysis.

This process was performed identically to a previous salivary cortisol study conducted by the research team (Gerding & Wang, 2022) and followed the guidelines provided in the ELISA kit (Salivary Cortisol Enzyme Immunoassay Kit, Salimetrics, State College, PA, USA). Following the raw data collection, calculations were performed to determine the cortisol levels in each sample.

Personal Exposure Monitoring

Along with the cortisol collection, the participants were also given a personal air quality monitor (Flow-2, Plume Labs Inc., Paris, France). This monitor recorded levels of PM10, PM2.5, PM1, NO2, and volatile organic compounds (VOCs) at one-minute intervals. The participants were instructed to attach this monitor to their backpacks or laptop bags during work hours. The data from each pollutant were extracted and averaged for each hour preceding saliva collection. The daily cortisol values were then averaged to give a single daily value, and a standard deviation was calculated for each of these averages. This standard deviation was divided by the corresponding averaged cortisol level to derive a coefficient of variation, referred to in this study as the "Relative Cortisol Index" or "RCI". The RCI was then compared to the daily averaged pollutant levels using Pearson correlation coefficients.

Statistical Analysis

This study employed two-way ANOVA, Pearson correlations, and linear regression models to probe the relationships between occupational stressors, air pollution exposure, and cortisol levels. Finally, a qualitative summary details the types of occupational stress experienced by the participants. Statistical analyses were conducted using SigmaPlot 15.0 (Inpixon, Palo Alto, CA, USA) and Excel (Microsoft, Redmond, WA, USA). A two-way ANOVA was performed to assess the correlations between the time of day when a sample was taken and the

corresponding cortisol concentration. Pearson correlations were utilized to analyze the relationships between the cortisol levels in a given sample and the selfreported stress levels of the nearest stressor event logged in the diary, as well as the air pollutants. The time of day was categorized into three groups: start of shift, mid-shift, and end of shift. The threshold for statistical significance was set at $p < 0.05$.

Additionally, a qualitative analysis and summary of the stressor events and subjective stress levels were completed. Lastly, the relationship between air pollution exposure and cortisol levels was examined by averaging the three daily cortisol samples, calculating the standard deviation of these averages, and dividing this by the average value to determine the coefficient of variation, or the RCI. A higher RCI indicates a greater dispersion between cortisol levels. The RCI was then compared to the average pollutant level the participant was exposed to during the corresponding times using a Pearson correlation model.

RESULTS

Study Demographics and Differences within Work Shifts

The study demographic information recorded in the enrollment surveys is outlined below in Table 3-1. All the study participants were female, falling within an age range of "30–39" to "60–69" and represented a broad spectrum of disciplines within the home healthcare field. The participants' experience in home healthcare varied from "less than 5 years" (41.7%) to "26–35 years" (16.7%) and most worked for their present employer "less than 5 years" (66.7%). All the participants worked during the day shift, with schedules of mostly five eight-hour shifts or four ten-hour shifts. One participant had an alternating day shift schedule, consisting of two to three eleven-hour shifts supplemented by one to two additional shifts that ranged from 4 to 7 h in length. This participant also worked every other weekend. The participants' commute times to

clients' homes ranged from 5 to 75 min. With regard to exposure to poor air quality (including cigarette smoke, poor ventilation, allergens, or strong disinfectant chemicals), the participant responses varied: 8.3% stated they experienced this rarely, 33.3% sometimes, 50% often, and 8.3% always. Notably, 33.3% of the participants reported having some form of respiratory disease, with two of these individuals attributing their conditions to occupational exposures.

Due to interpersonal differences associated with cortisol, to compare the values, the samples were log-transformed and averaged so each participant had three bars displayed in Figure 3-1. The first bar was the average of the start-of-shift samples provided, the second bar was the averaged mid-shift samples, and the third bar was the averaged end-of-shift samples. Surprisingly, none of the samples followed typical diurnal patterns, and Figure 1 shows that every participant's cortisol levels appeared to either increase toward the end of their shift or, in the case of participants eleven and twelve, increase during their shift prior to slightly declining before it concluded. Participant one's second daily mean was well below the lower limit of the graph as these samples were determined to be nearly a concentration of 0 μg/dL.

Correlation Between Cortisol Level, Sampling Time, and Self-Reported Stressor

The results from the two-way ANOVA indicated that the differences in the mean salivary cortisol levels were not statistically significant based on the time of day the sample was collected ($p = 0.86$). However, the analysis did show statistically significant differences in the cortisol levels between the participants ($p < 0.001$). While some participants' cortisol levels demonstrated typical diurnal patterns, decreasing throughout the day, many either increased or fell below the detection limit of 1.0 ng/mL. As nearly all the participants did not have a prescribed lunch break, they were instructed to provide saliva samples at the start of their shift, the middle of their shift, and at the end of their shift. While differences between individuals were

observed, no significant variation was detected based on the time of day. A further analysis was conducted using a linear regression model that pooled all the participant data points (n = 169) to determine the relationship between the self-reported stressor levels from the participants' diaries and the cortisol levels in the saliva samples collected immediately after the reported stressor event. However, this relationship was not found to be statistically significant ($p = 0.754$). The constant variance test, the Spearman rank correlation, passed, but it only had a power of 0.05 and an R-squared value of less than 0.1, indicating a very weak association.

Personal Exposure to Air Pollutants

The Pearson correlation coefficient was calculated for each type of airborne pollutant compared with the Relative Cortisol Index (RCI) values. This comparison did not reveal a statistically significant relationship between the pollutants and the RCI values. The Pearson correlation coefficients ranged from 0.16 (PM10) to 0.31 (VOC), as outlined in Table 3-2 (see below). At best, only two air pollutants (PM1 and VOC) showed a weak relationship, with a correlation coefficient above 0.25. Table 3-3 shows the average levels of the air pollutants to which each participant was exposed.

These averages varied markedly between the participants. For instance, participants 4 and 5 experienced similar exposure levels across all pollutants, as did the pairs of participants 9 and 11, and 10 and 12. However, when comparing the exposure levels across all twelve participants, the range of exposure to each pollutant varied considerably. The smallest variation was a 60% increase (comparing VOC values between participant 9 and 8), while the largest variation was more than a tripling of the exposure levels (comparing NO2 values between participant 3 and 4).

Stress Diary Record

Despite the lack of a statistically significant relationship between the cortisol levels and reported stress levels, the diary entries revealed a broad spectrum of stressors and emotional reactions. While the home healthcare professionals frequently acknowledged the stresses associated with their occupations, the number of stressor events reported in their diaries varied widely. For instance, one participant recorded multiple daily entries, many linked to their stressors outside of work and concerns about their patients. This participant recorded one level 4 stressor, two level 5 stressors, four level 6 stressors, five level 7s, and nine level 9s. In contrast, another participant reported only one level 3 stressor and one level 4 stressor across two days.

Variability in the diary entries was common among the participants. The first physical therapist recorded entries associated with commuting stress, while one of the other participant's stressors revolved around social issues arising from working with a developmentally disabled client. The first occupational therapist reported non-work-related stressors, like managing her children's schedules and navigating inclement weather. Similarly, the second occupational therapist reported stressors on only three of her four workdays, while the medical social worker listed 14 stressors, primarily work related, across a four-day work week.

One of the two registered nurses and one of the four physical therapists experienced 10 stressors over a five-day work week, with a mix of personal and work-related issues. Further disparities were noted between the second registered nurse and two of the four physical therapists. The third physical therapist experienced 16 stressor events, primarily work related, while one of the registered nurses reported mostly positive or neutral events and 5 minor stressors. The fourth physical therapist reported 13 stressors, mainly work related and tied to scheduling or patient issues.

Table 3-4 summarizes the high-level occupational stressors (ranked six or above) experienced by the participants (https://doi.org/10.6084/m9 .figshare.23717106.v2, accessed on 9 February 2023). The most frequently reported stressors were related to personal issues, commuting, or patient concerns (see Table 3-5). Among the stressors ranked six or above (n = 51), 22 were reported by a speech-language pathologist, 16 by the physical therapists, 7 by the medical social worker, 4 by the specialist for the developmentally disabled, and 2 by one of the registered nurses. Table 3- shows the frequency of emotional descriptors used in the diary entries. Frustration/aggravation/anger were the most commonly reported emotions, accounting for 22.4% of the total emotions expressed. This was followed by feelings of overwhelmed/inadequacy/exhaustion (15.7%), irritation/annoyance (9.7%), and nervousness/anxiety/uncomfortableness/drained (7.5%). The least reported emotions included feelings of shame/being unheard (two occurrences) and distraction (one occurrence). These emotions were typically associated with common stressors, such as personal issues, commuting, and patient care.

DISCUSSION

Correlation Between Cortisol Level, Sampling Time, and Self-Reported Stressor

The results from this study suggest that there was no significant relationship between the cortisol levels and the sampling time. Despite expecting a diurnal trend, no consistent decrease in the cortisol levels was observed throughout the day. The participants were instructed to collect the samples in the middle of their shift due to the lack of defined lunch breaks, which may have contributed to these findings. Further, there was no statistically significant relationship found between the cortisol levels and stress levels documented in the stress diaries for any of the twelve participants ($p = 0.754$, R-squared = 0.000587). We could not establish that there was a statistical

relationship between the subjective stress levels reported during a stressor event and the physiological response, as indicated by the release of cortisol. This might be due to several factors, such as the difficulty in quantifying stress levels, the lack of statistical power due to the small sample size, or potential issues with the saliva sample collection and preservation methods, in that HHCWs have rigorous schedules of commuting from patient to patient, and therefore saliva collection adhered to their schedule. Additionally, the practice of storing saliva samples in a Styrofoam cooler with an ice pack was less than ideal compared to using a freezer.

Interestingly, one participant had a detailed stress diary with eleven stressors recorded over five days; her average cortisol levels were lower compared to the others. This discrepancy might be due to the duration of the study and the type of events that the participants experienced, both of which might have contributed to the poor model variance. To improve this, the study could be extended or the reason why some participants reported fewer and less intense stressor events could be further investigated. Given the known high levels of stress in healthcare professions, the number and intensity of the stress events reported was surprisingly low. Including more participants in the study could help determine if the observed pattern was representative.

Five of the healthcare workers had higher average cortisol levels at the end of their shifts compared to the beginning. Two others had the highest cortisol levels in the middle of their shifts, which might indicate exposure to stressors, even if they were not related to their work or documented in their stress diaries. Regardless, none of the participants showed the typical diurnal pattern of cortisol levels being highest at the start of the shift and declining as the shift progresses. This suggests that the occupational stresses experienced by home healthcare workers may not align with typical cortisol patterns and deserves further investigation. Due to the small

sample size, we were not able to stratify the participants by sources of chronic stress in their lives.

Personal Exposure to Air Pollutants

Compared to the WHO's guidance on recommended air quality levels, the participants' average air pollutant data were all below these thresholds (World Health Organization, 2021). Of the listed pollutants, the WHO recommends average maximum exposure levels of 10 µg/m3 of PM2.5, 20 µg/m3 of PM10, and 40 µg/m3 of NO2, annually. Our data also fall within the ranges of various air pollutants measured in many other works of literature on indoor air exposure, with levels ranging from 1.7 to 428.6 PM2.5, 11.0 to 1275 PM10, and 3.4 to 1210 for NO2 (Vardoulakis et al., 2020). However, when comparing these levels of indoor air quality with various areas in a hospital, the VOC (156.7 ± 31.6 ppb) concentrations were comparable to what was monitored at on-campus locations, including a reception area, an orthopediatric area, and an otorhinolaryngology area (VOCs = 0.110–0.312 ppm) (Lee et al., 2020). On the other hand, the data collected by the home healthcare population had lower levels of PM2.5 exposure (4.4 ± 1.5 µg/m3) than the on-campus settings (20.0–49.6 µg/m3) (Lee et al., 2020).

The correlations observed in this study between the Relative Cortisol Index (RCI) and the levels of volatile organic compounds (VOC) and PM1 were weak. Several factors could contribute to these results. First, there were gaps in the data collected by the low-cost air pollution sensors. The sensors were designed to record data every minute; however, there were multiple gaps in the data that ranged from ten minutes to a few hours. These gaps would have affected the average pollutant values, thereby impacting the observed correlations. Imputation was not conducted because, in some cases, there were too many data missing.

Second, the frequency of the saliva sample collection might have affected the findings. In this study, the saliva samples were collected only three times per day. Increasing the frequency of saliva collection could provide higher resolution in the measurement of cortisol levels and potentially enhance the accuracy and specificity of the summary statistics used to calculate the RCI values. Lastly, in our study, we did not find a statistically significant association between the air pollution levels and the cortisol levels. Future studies should address our aforementioned concerns regarding air pollution sensor data reliability and the frequency of biological sample collection. The relationship between air pollution and cortisol levels remains a relevant topic that could be explored further in future research.

Stress Diary Record

This study sheds light on the intensity and frequency of stressful events experienced by HHCWs and the associated emotional responses. The most intense stressors, those rated as six or higher on a nine-point scale, accounted for more than 40% of the total 122 events documented. This indicates a significant level of high-intensity stressors within the HHCW population. Moreover, the type of worker experiencing these high-intensity stressors varied; occupational therapists reported none, while a speech-language pathologist reported multiple, including nine level 8 stressors and four level 9 stressors.

The emotional responses associated with these stressors provide additional insights. The most frequently reported emotions were frustration, aggravation, and anger, accounting for 22.4% of all responses. Emotions associated with burnout such as overwhelmed, depletion, fatigue, exhaustion, inadequacy, and insufficiency accounted for 15.7%. This suggests a high level of emotional strain among HHCWs. The source of these stressors also blurs the line between personal and professional life, as seen in previous studies by our group (Gerding et al.,

2021, Gerding, et al., 2022). This suggests that the stress experienced by HHCWs is not only related to job tasks but also to the unique challenges of managing a work–life balance for home healthcare workers. This observation warrants further investigation, as it could have implications for stress management strategies in this field.

LIMITATIONS

One limitation of this study arises from its recruitment process, which employed a convenience sampling methodology within a large, midwestern metropolitan area. This study population was finalized upon reaching the target number of participants. With many participants coming from specific healthcare fields such as occupational or physical therapy, this study may not accurately represent the variety of occupational stressors that the broader home healthcare workforce faces, particularly those in different geographic areas or those serving distinct patient demographics. This may have also led to the small sample size related to not many stressors documented by some of the participants.

The data collected from the stress diaries are subjective as they represent individual perceptions of stress. This subjectivity could mean that an event classified as a level 5 stressor by one individual might only be considered a level 3 stressor by another. Additionally, some stressful events might not have been recorded in the diaries due to their personal nature or if the participant simply forgot to document them when time allowed. Some participants logged numerous stressors daily, whereas others recorded a few over the entire work week which made determining relationships between stress exposure and increases in cortisol difficult.

The final limitation pertains to the quality of the air monitors used in this study. A higher-grade air monitor could provide more reliable data on the exposed pollutants. However, this would incur a higher cost and these higher-precision sensors tend to have a bulkier design than

the model utilized in the current study. A bulkier design may put additional burden on participants.

CONCLUSION

This study explores the various stressors encountered by a group of home healthcare workers during typical work weeks, with representation from healthcare sectors, such as developmental disability care, occupational therapy, physical therapy, speech-language pathology, medical social work, and registered nursing. Unexpectedly, the levels of salivary cortisol did not conform to the expected diurnal patterns. Neither did they correlate with exposure to occupational stressor events, the primary hypothesis of this study. Further, the air pollutant exposures poorly compared with other air quality studies.

Forty percent of the stressor events documented were classified as major stressors, rated level 6 or higher out of 10. There were notable variations in the reported stressors by occupation, with no reports of stressor events coming from occupational therapists, whereas multiple reports came from speech-language pathology. In the future, a more robust study would include a larger sample size with a longer duration to provide adequate statistical power to detect these associations. Additionally, the inclusion of more robust air quality monitors would most likely provide better quality data associated with the participants' exposures, though a larger research budget would be necessitated. Providing training to participants to "level set" their perceptions of stress and intentionally recruiting a representative sample of home healthcare occupations would improve the external validity. Studies, including ours, demonstrate relatively high levels of stress in home healthcare workers; future work could also examine interventions that could help to reduce these stressors.

OVERALL CONCLUSIONS

In this dissertation, the relationship between occupational stress and various factors were examined including: salivary cortisol, air pollution exposure, emotional reactions, and how the pandemic affected the work stress seen in multiple sectors. Firstly, it was found that while some occupational stress trends were seen in all sectors examined during the pandemic, such as experiencing changes in employment and fear of COVID exposure, some sectors had unique experiences. Healthcare saw increased workloads to the greatest degree, it was common for those who worked from home to experience web conference burnout, and it was more difficult due to the pandemic for those in a manual labor or business / office service role to juggle childcare and work. All investigated industries struggled with time management which was also seen, to some extent, in the successive two studies. This study allowed the researchers 1) to assert it would be beneficial for organizations, private and public entities alike, to incorporate the possibility of future pandemics into their EAP and 2) to determine which sector(s) to target for recruitment in Study B.

Next, Study B was able to serve as a methodology validation aim while simultaneously presenting a variety of stressors experienced by a general working population. The study population, composed of individuals working in healthcare, WFH, information technology, scientists, and a few other white-collar positions, provided salivary cortisol samples which overall followed typical diurnal patterns associated with cortisol when the data was pooled together. However, individuals did have cortisol levels which were elevated following exposure to occupational stressor events in a statistically significant relationship. Unfortunately, due to the

small R-squared value, the team hoped following a specific work sector (i.e., home healthcare) might help mitigate this issue to some degree. One of the reasons healthcare was the focus in Study C was due to the fact that while they only account for one-third of the participants in Study B, they documented nearly half of the intense stressors (3, 4, or 5 out of 5) reported from the diaries.

Finally, Study C had hoped to expand upon the success of Study B, as well as include an aspect of air pollution exposure, while examining HHCWs specifically. Following statistical analysis, no relationship could be determined between documented stressor events and fluctuations in salivary cortisol, nor was there much to report regarding fluctuations in cortisol levels with the air pollution the participants were exposed to based on the data provided by the air quality monitors. Various confounders affect cortisol levels which could have played a part in the poor models. Poor adherence to study instructions on the part of the participants as well as the use of ineffective, low-cost air quality monitors may have both played a part as well in the models. However, both Study B & Study C qualitatively determined multiple common stressors, both in a general working population and specific to HHCWs, which would be addressed within the workplace to mitigate affects of chronic stress.

LIST OF PEER-REVIEWED PUBLICATIONS

The dissertation summarizes the results obtained on the topics of 1) how occupational stress was impacted due to the COVID-19 pandemic and 2) the physiological role occupational stress plays regarding fluctuations of cortisol levels so as to determine strategies to mitigate these occupational stressors. These are presented in the peer-reviewed journal articles 1 – 3 listed below. Additionally, the findings described in this dissertation were presented at the conferences in the form of posters and platform presentations listed in Appendix A. Articles 4-6 were tangentially related to my dissertation and completed while I was at the University of Cincinnati.

PEER-REVIEWED JOURNAL ARTICLES RELATED TO DISSERTATION

1. **Gerding, T.**, Wang, J., Davis, K.G. **2022**. An Investigation into Occupational Related Stress of At-Risk Workers During COVID-19. *Annals of Work Exposures and Health,* 12;67(1):118-128. Doi: 10.1093/annweh/wxac076.
2. **Gerding, T.** & Wang, J. **2022**. Stressed at Work: Investigating the Relationship between Occupational Stress and Salivary Cortisol Fluctuations. *International Journal of Environmental Research and Public Health*, 19(19), 12311; https://doi.org/10/3390/ijerph191912311.
3. **Gerding, T.**, Wang, J., Newman, N. **2023.** Examining Work Stress and Air Pollutants Exposure of Home Healthcare Workers. *Atmosphere*, 14(9), 1393; https://doi.org/10.3390/atmos14091393.
4. **T. Gerding**, M. Syck, D. Daniel, J. Naylor, S.E. Kotowski, G.L Gillespie, A.M. Freeman, T.R. Huston, K.G. Davis. **2021**. An Assessment of Ergonomic Issues in the

Home Offices of University Employees Sent Home Due to the COVID-19 Pandemic. *Work*, 68(4):981-992.

5. Kotowski, S.E., Davis, K. G., and **Gerding T.. 2022**. Almost a Year In: Virtual Offices Remain an Ergonomic Trouble Spot. *Work*, 71(2):319-326.
6. Davis, K.G., Kotowski, S.E., Daniel, D., **Gerding, T.,** Naylor, J., Syck, S. **2020**. The Home Office: Ergonomic Lessons From the "New Normal". *Ergonomics in Design: The Quarterly of Human Factors Applications*, 28(4):4-10.

REFERENCES

Aguilera J, Jeon S, Raysoni AU, Li W, Whigham LD. (2023) Decreased moderate to vigorous physical activity levels in children with asthma are associated with increased traffic-related air pollutants. *Journal of Environmental Health.* 85(8):16-17.

Al'Absi M., Hatsukami D., Davis G.L., Wittmers L.E. Prospective examination of effects of smoking abstinence on cortisol and withdrawal symptoms as predictors of early smoking relapse. *Drug Alcohol Depend*. 2004, 73, 267–278.

Alderling M., Theorell T., de La T.B., Lundberg I. The demand control model and circadian saliva cortisol variations in a Swedish population based sample (The PART study). *BMC Public Health* 2006, 6, 288.

Aro, S. Occupational stress, health-related behavior, and blood pressure: A 5-year follow-up. *Prev. Med*. 1984, 13, 333–348.

Bauer, M.E., Jeckel, C.M.M., Luz, C. The Role of Stress Factors during Aging of the Immune System. *Ann. N.Y. Acad. Sci*. 2009, 1153, 139–152.

Beaton R.D., Murphy S.A. Sources of occupational stress among firefighter/EMTs and firefighter/paramedics and correlations with job-related outcomes. *Prehospital Disaster Med*. 1993, 8, 140–150.

Belkic K, Nedic O. (2007) Workplace stressors and lifestylerelated cancer risk factors among female physicians: assessment using the Occupational Stress Index. *J Occup Health*; 49: 61–71.

Benjamin, M. Cleaning product chemical exposures measured in a simulated home healthcare work environment. Doctoral dissertation, University of Cincinnati, Cincinnati, OH, USA, December 2019.

Bien, E., Davis, K., Gillespie, G. Home Healthcare Workers' Occupational Exposures. *Home Healthc. Now*. 2020, 38, 247–253.

Björntorp, P., Rosmond, R. Neuroendocrine abnormalities in visceral obesity. *Int. J. Obes*. 2000, 24, S80–S85.

Bruschini M, Carli A, Burla F. (2018) Burnout and work-related stress in Italian rehabilitation professionals: a comparison of physiotherapists, speech therapists and occupational therapists. *Work*; 59: 121–9.

Burn W, Mudholkar S. (2020) Impact of COVID-19 on mental health: update from the United Kingdom. *Indian J Psychiatry*; 62(Suppl 3): S365–72.

Center for the Promotion of Health in the New England Workplace. (2021) The Financial Burden of Job Stress. https://www.uml.edu/research/cph-new/worker/stress-at-work/financial-costs.aspx#burden. Accessed 20 March 2021.

Cindrich SL, Lansing JE, Brower CS, et al. (2021) Associations between change in outside time pre- and post-COVID-19 public health restrictions and mental health: brief research report. *Front. Public Health*; 9. doi: 10.3389/ fpubh.2021.619129.

Diez, J., Vigo, D.E., Lloret, S.P., Rigters, S., Role, N., Cardinali, D.P., Chada, D.P. Sleep habits, alertness, cortisol levels, and cardiac autonomic activity in short-distance bus drivers: Differences between morning and afternoon shifts. *J. Occup. Environ. Med*. 2011, 53, 806–811.

Doyle JN, Campbell MA, Gryshchuk L. (2021) Occupational stress and anger: mediating effects of resiliency in first responders. *J Police Crim Psychol*; 36: 463–72.

Edwards S., Evans P., Hucklebridge F., Clow A. Association between time of awakening and diurnal cortisol secretory activity. *Psychoneuroendocrinology* 2001, 26, 613–622.

Eller N.H., Netterstrøm B., Hansen Å.M. Psychosocial factors at home and at work and levels of salivary cortisol. *Biol. Psychol*. 2006, 73, 280–287.

Faraji A, Karimi M, Azizi SM et al. (2019) Occupational stress and its related demographic factors among Iranian CCU nurses: a cross-sectional study. *BMC Res Notes*; 12: 634.

Federenko I., Wust S., Hellhammer D.H., Dechoux R., Kumsta R., Kirschbaum C. Free cortisol awakening responses are influenced by awakening time. *Psychoneuroendocrinology* 2004, 29, 174–184.

Galanti T, Guidetti G, Mazzei E et al. (2021) Work from home during the COVID-19 outbreak. *J Occup Environ Med*; 63: e426–e432.

Gerding T, Syck M, Daniel D et al. (2021) An assessment of ergonomic issues in the home offices of university employees sent home due to the COVID-19 pandemic. *Work*; 68: 981–92.

Gerding T, Wang J. (2022) Stressed at work: investigating the relationship between occupational stress and salivary cortisol fluctuations. *Int J Environ Res Pub Health*; 19: 12311.

Gerding T, Davis KG, Wang J. (2023) An investigation into occupational related stress of at-risk workers during COVID-19. *Ann. Work Expo. Health.* 67(1):118-128.

Goh J., Pfeffer J., & Zenios SA. (2015) The relationship between workplace stressors and mortality and health costs in the United States. *Management Science*, 62(2), 608-628.

Hajat, A., Hazlehurt, M.F., Golden, S.H., Merkin, S.S., Seeman, T., Szpiro, A.A., Kaufman, J.D., Roux, A.D. (2019) The cross-sectional and longitudinal association between air pollution and salivary cortisol: Evidence from the multi-ethnic study of Atherosclerosis. *Environ. Int.* 2019, 131, 105062.

Hasan AA, Elsayed S, Tumah H. (2018) Occupational stress, coping strategies, and psychological-related outcomes of nurses working in psychiatric hospitals. *Perspect Psychiatr Care*; 54: 514–22.

Hansen AM, Garde AH, Persson R. (2009) Sources of biological and methodological variation in salivary cortisol and their impact on measurement among healthy adults: a review. *Scand. J. Clin. Lab. Invest*. 68: 6448–458.

Hansen, Å.M., Persson, R., Garde, A.H., Karlson, B., Ørbæk, P. Diurnal profiles of salivary cortisol on workdays among construction workers versus white-collar workers. *Scand. J. Work. Environ. Health* 2006, 32, 22–26.

Hellhammer, D.H., Wust, S., Kudielka, B.M. Salivary cortisol as a biomarker in stress research. *Psychoneuroendocrinology* 2009, 34, 163–171.

Hittle, B., Agbonifo, N., Suarez, R., Davis K.G., Ballard, T. (2016) Complexity of occupational exposures for home health-care workers: Nurses vs. Home health aids. *J. Nurs. Manag.* 2016, 24, 1071-1079.

Holmgren K, Hensing G, Dahlin-Ivanoff S. (2009) Development of a questionnaire assessing work-related stress in women – identifying individuals who risk being put on sick leave. *Disabil Rehabil*; 31: 284–92.

Jessop D.S., Turner-Cobb J.M. Measurement and meaning of salivary cortisol: A focus on health and disease in children. *Stress* 2008, 11, 1–14.

Jin SY, Luo XQ, Zhang JM. (2019) [Current status of occupational stress among medical staff in Shenzhen, China and related influencing factors]. *Zhonghua Lao Dong Wei Sheng Zhi Ye Bing Za Zhi*; 37: 596–601.

Jukic T, Ihan A, Strojnik V et al. (2020) The effect of active occupational stress management on psychosocial and physiological wellbeing: a pilot study. *BMC Med Inform Decis Mak*; 20: 321.

Kang S, Jo HS, Boo YJ et al. (2015) Occupational stress and related factors among surgical residents in Korea. *Ann Surg Treat Res*; 89: 268–74.

Karataş M, Pak Güre MD, Duyan V. (2022) Apparently we cannot live, we are like infectious zombies: a qualitative research on personal and familial experiences of health workers in the filiation teams in Turkey during the COVID-19 pandemic. *Soc Work Pub Health*; 37: 692–701.

Kinnunen-Amoroso M, Liira J. (2014) Finnish occupational health nurses' view of work-related stress: a cross-sectional study. *Workplace Health Saf*; 62: 105–12.

Kirschbaum, C., Hellhammer, D. Salivary cortisol in psychoneuroendocrine research: Recent developements and applications. *Psychoneuroendocrinology* 1994, 19, 313–333.

Kudielka B.M., Kirschbaum C. Awakening cortisol responses are influenced by health status and awakening time but not by menstrual cycle phase. *Psychoneuroendocrinology* 2003, 28, 35–47.

Kunz-Ebrecht, S.R., Kirschbaum, C., Steptoe, A. Work stress, socioeconomic status, and neuroendocrine activation over the working day. *Soc. Sci. Med*. 2004, 58, 1523–1530.

Lee, H.J., Lee, K.H., Kim, D.K. 2020. Evaluation and comparison of the indoor air quality in different areas of the hospital. *Medicine* 2020, 99, e23942.

Li H, Cai J, Chen R, Zhao Z, Ying Z, et al. (2017) Particulate Matter Exposure and Stress Hormone Levels. *Circulation*. 2017; 136:618-627.

Lindholm, H., Ahlberg, J., Sinisalo, J., Hublin, C., Hirvonen, A., Partinen, M., Sarna, S., Savolainen, A. Morning cortisol levels and perceived stress in irregular shift workers compared with regular daytime workers. *Sleep Disord*. 2012, 2012, 789274.

Malamardi SN, Kamath R, Tiwari R et al. (2015) Occupational stress and health-related quality of life among public sector bank employees: a cross-sectional study in Mysore, Karnataka, India. *Indian J Occup Environ Med*; 19: 134–7.

Mallach, G., Shutt, R., Thomson, E.M., Valcin, F., Kulka R., Weichenthal, S. (2023) Randomized cross-over study of in-vehicle cabin air filtration, air pollution exposure, and acute changes to heart rate variability, saliva cortisol, and cognitive function. *Environ. Sci. Technol.* 2023, 57, 3238-3247.

Markkanen, P., Quinn, M., Galligan, C., Sama, S., Brouillette, N., Okyere, D. (2014) Characterizing the nature of home care work and occupational hazards: A developmental intervention study. *Am. J. Ind. Med.* 2014, 57, 445-457.

Mayo Clinic. 2023. Addison's disease. [accessed 2023 Apr 17]. https://www.mayoclinic.org/diseases-conditions/addisons-disease/symptoms-causes/syc-20350293

Metzenthin, P., Helfricht, S., Loerbroks, A., Terris, D.D., Haug, H.J., Subramanian, S.V., Fischer, J.E. A one-item subjective work stress assessment tool is associated with cortisol secretion levels in critical care nurses. *Prev. Med*. 2009, 48, 462–466.

Nelson ME, Lee S, Allen TD, Buxton OM, Almeida DM, et al. (2022) Goldilocks at work: Just the right amount of job demands may be needed for your sleep health. *Sleep Health.* 9(1), 40-48.

NIOSH. (1999) NIOSH generic job stress questionnaire. In Department of Health and Human Services CfDC editor. Book *NIOSH Generic Job Stress Questionnaire*.

NIOSH. (2019) National occupational research agenda for healthcare and social assistance (HCSA). In Department of Health and Human Services CfDC editor. Book *National Occupatio Research Agenda for Healthcare and Social Assistance (HCSA).*

NIOSH. (2020) National occupational research agenda for health work design and well-being. Book *National Occupational Research Agenda for Health Work Design and Well-Being.*

Oakman J, Kinsman N, Stuckey R, et al. (2020) A rapid review of mental and physical health effects of working at home: how do we optimise health? *BMC Public Health*; 20: 1825.

Occupational Safety and Health Administration (OSHA). (2022) Workplace Stress. [accessed 2023 Mar 5]. https://www.osha.gov/workplace-stress

Oregon Health & Science University. 2023. Cushing disease / Cushing syndrome. [accessed 2023 Apr 17]. https://www.ohsu.edu/brain-institute/cushing-disease-cushing-syndrome

Park, M.M., Han, S.J. (2013) Relations of job satisfaction with emotional labor, job stress, and personal resources in home healthcare nurses. *J. Korean Acad. Community Health Nurs.* 2013, 24, 51-61.

Patel MK, Bergeri I, Bresee JS, et al. (2021) Evaluation of post-introduction COVID-19 vaccine effectiveness: summary of interim guidance of the World Health Organization. *Vaccine*; 39: 4013–24.

Planche K, Chan JF, Di Nota PM, Beston B, Boychuk E, et al. (2019) Diurnal cortisol variation according to high-risk occupational specialty within police. *JOEM.* 61(6):p e260-e265.

Qiao S., Li X., Zhou Y., Shen Z., Stanton B. Attitudes toward evidence-based practices, occupational stress and work-related social support among health care providers in China: A SEM analysis. *PLoS ONE* 2018, 13, e0202166.

Quick JC, Henderson DF. (2016) Occupational stress: preventing suffering, enhancing wellbeing. *Int J Environ Res Public Health*; 13: 459.

Quinn, M.M., Markkanen, P.K., Galligan, C.J., Sama S.R., Kriebel, D., Gore, R.J., Brouillette, N.M., Okyere, D., Sun, C., Punnett, L., et al., (2016) Occupational health of home care aides: Results of the safe home care survey. *Occup. Env. Med.* 2016, 73, 237-245.

Reale M., Costantini E., D'Angelo C., Coppeta L., Mangifesta R., Jagarlapoodi S., Di Nicola M., Di Giampaolo L. Network between Cytokines, Cortisol and Occupational Stress in Gas and Oilfield Workers. *Int. J. Mol. Sci*. 2020, 21, 1118.

Richman J.A. Occupational Stress, Psychological Vulnerability and Alcohol-Related Problems over Time in Future Physicians. *Alcohol. Clin. Exp. Res*. 1992, 16, 166–171.

Rocha M.C.P., de Martino M.M.F., Grassi-Kassisse D.M., de Souza A.L. Stress among nurses: An examination of salivary cortisol levels on work and day off. *Rev. Esc. Enferm. USP* 2013, 47, 1187–1194.

Sanger J., Bechtold L., Schoofs D., Blaszkewicz M., Wascher, E. The influence of acute stress on attention mechanisms and its electrophysiological correlates. *Front. Behav. Neurosci*. 2014, 8, 353.

Sarafis P, Rousaki E, Tsounis A et al. (2016) The impact of occupational stress on nurses' caring behaviors and their health related quality of life. *BMC Nurs*; 15: 56.

Smith PM, Oudyk J, Potter G et al. (2020) Labour market attachment, workplace infection control procedures and mental health: a cross-sectional survey of Canadian non-healthcare workers during the COVID-19 pandemic. *Ann Work Expo Health*; 65: 266–76.

Soori H, Rahimi M, Mohseni H. (2008) Occupational stress and work-related unintentional injuries among Iranian car manufacturing workers. *East Mediterr Health J*; 14: 697–703.

Soubelet-Fagoaga I, Arnoso-Martínez M, Guerendiain-Gabás I et al. (2021) (Tele)Work and care during lockdown: labour and socio-familial restructuring in times of COVID-19. *Int J Environ Res Public Health* :18: 12087.

Stalder T., Hucklebridge F., Evans P., Clow A. Use of a single case study design to examine state variation in the cortisol awakening response: Relationship with time of awakening. *Psychoneuroendocrinology* 2009, 34, 607–614.

Sun W, Wu H, Wang L. (2011) Occupational stress and its related factors among university teachers in China. *J Occup Health*; 53: 280–6.

Šušoliaková O., Šmejkalová J., Biˇcíková M., Hodaˇcová L., Málková A., Fiala, Z. Assessment of work-related stress by using salivary cortisol level examination among early morning shift workers. *Cent. Eur. J. Public Health* 2018, 26, 92–97.

Talkspace. (2021) Employee stress check 2021. Report Employee Stress Check 2021. https://business.talkspace.com/articles/ employee-stress-check-2021-report 2578 Broadway #607 New York, NY 10025.

Tamrakar P, Pant SB, Acharya SP. (2021) Anxiety and depression among nurses in COVID and non-COVID intensive care units. *Nursing in Critical Care*. doi: 10.1111/ nicc.12685.

Thau, L.; Gandhi, J.; Sharma, S. *Physiology, Cortisol*; StatPearls: Treasure Island, FL, USA, 2022.

The American Institute of Stress (AIS). (2020) Workplace Stress. https://www.stress.org/workplace-stress. Accessed 20 March 2021.

Thomas, C., Hertzman, C., Power, C. Night work, long working hours, psychosocial work stress and cortisol secretion in mid-life: Evidence from a British birth cohort. *Occup. Environ. Med.* 2009, 66, 824–831.

Uddin M. (2021) Addressing work-life balance challenges of working women during COVID-19 in Bangladesh. *Int Soc Sci J*; 71: 7–20.

Vardoulakis, S., Giagloglou, E., Steinle, S., Davis, A., Sleeuwenhoek, A., Galea, K.S., Dixon, K., Crawford, J.O. (2020) Indoor exposure to selected air pollutants in the home environment: A systematic review. *Int. J. Environ. Res. Public Health* 2020, 17, 8972.

Vining, R.F., McGinley, R.A., Maksvytis, J.J., Ho, K.Y. Salivary cortisol: A better measure of adrenal cortical function than serum cortisol. *Ann. Clin. Biochem*. 1983, 20, 329–335.

Wieclaw J, Agerbo E, Mortensen PB et al. (2005) Occupational risk of affective and stress-related disorders in the Danish workforce. *Scand J Work Environ Health*; 31: 343–51.

Witters D. & Agrawal S. (2022, November 3). The economic cost of poor employee mental health. Gallup.com. Retrieved April 22, 2023, from https://www.gallup.com/workplace/404174/economic-cost-poor-employee-mental-health.aspx

Wolf O.T., Fujiwara E., Luwinski G., Kirschbaum C., Markowitsch H.J. No morning cortisol response in patients with severe global amnesia. *Psychoneuroendocrinology* 2005, 30, 101–105.

World Health Organization (WHO). Air Quality Guidelines. *Global Update 2021.* Available online: https://apps.who.int/iris/handle/10665/345329 (accessed on 28 August 2023).

World Health Organization (WHO). (2023). Mental Health at Work. [accessed 2023 Mar 5]. https://www.who.int/teams/mental-health-and-substance-use/promotion-prevention/mental-health-in-the-workplace

Wright B.J. Effort-reward imbalance is associated with salivary immunoglobulin and cortisol secretion in disability workers. *J. Occup. Environ. Med*. 2011, 53, 308–312.

Zhang X, Zhao K, Zhang G et al. (2020) Occupational stress and mental health: a comparison between frontline medical staff and non-frontline medical staff during the 2019 novel coronavirus disease outbreak. *Front Psychiatry*; 11: 555703.

Zoeckler, J.M. (2018) Occupational Stress Among Home Healthcare Workers: Integrating Worker and Agency-Level Factors. *New Solut. J. Environ. Occup. Health Policy* 2018, 27, 524-542.

FIGURES

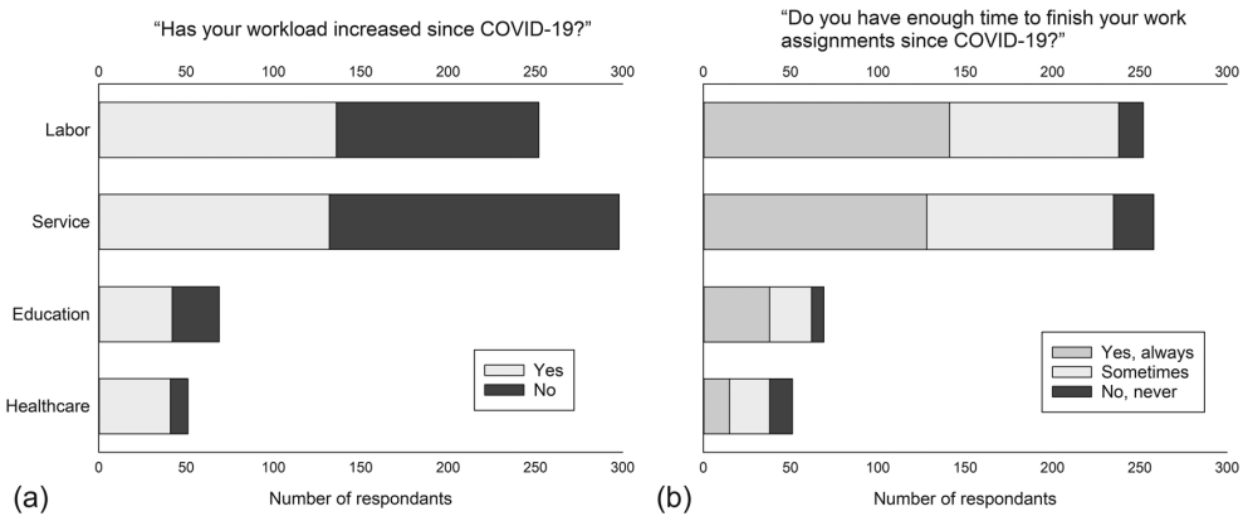


Figure 1-1. Responses to (A) "Has your workload increased since COVID-19?"; (B) "Do you have enough time to finish your work assignments since COVID-19?" as a function of industry sectors.

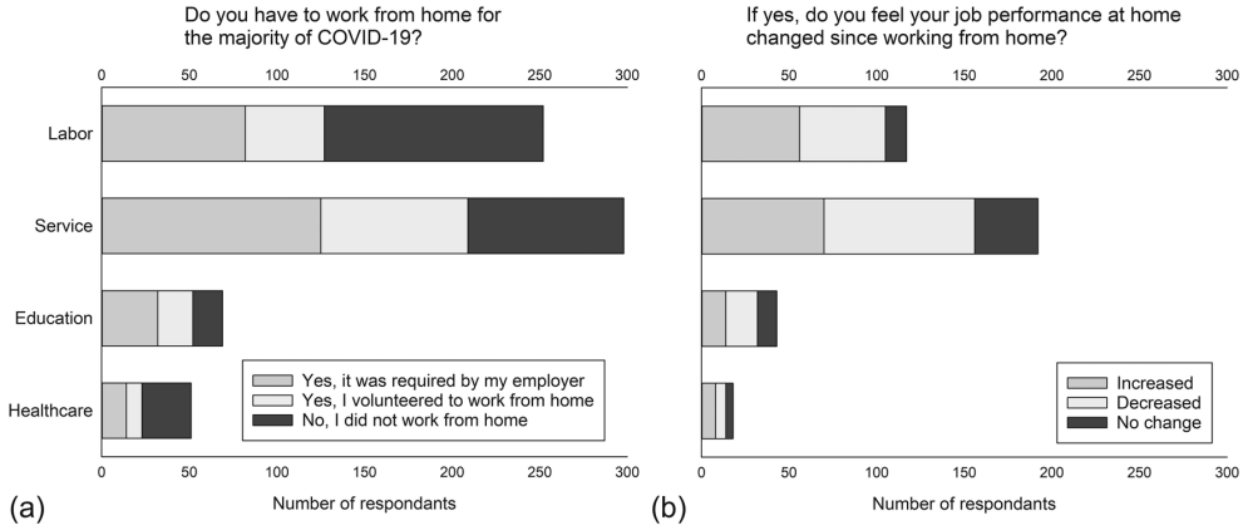


Figure 1-2. Responses to (A) "Do you have to work from home for the majority of COVID-19?"; (B) "If yes, do you feel your job performance at home has changed since WFH?" as a function of industry sectors.

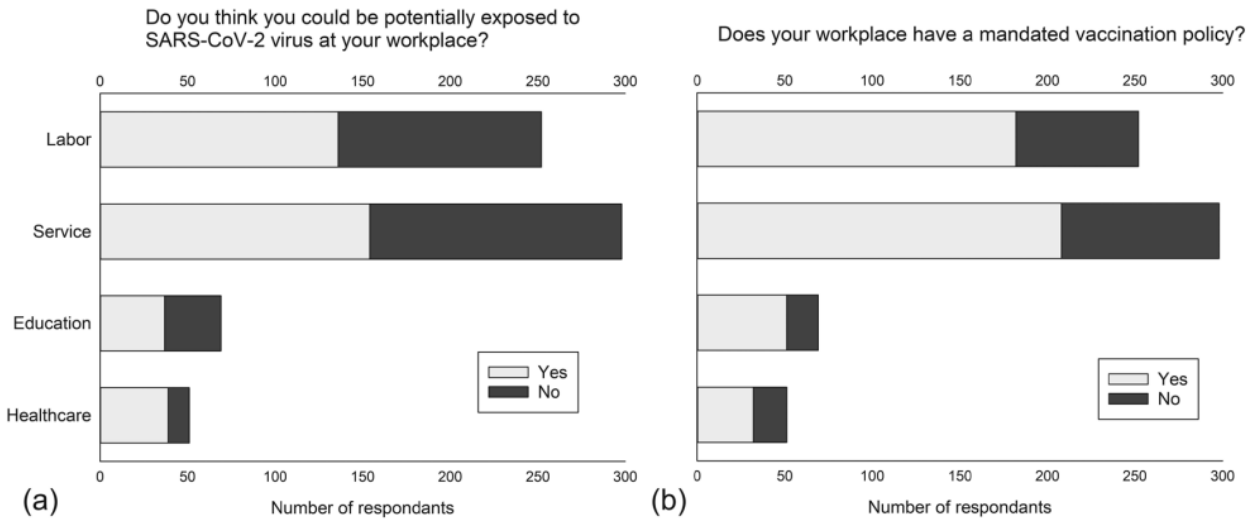


Figure 1-3. Responses to (A) "Do you think you could be potentially exposed to SARS-CoV-2 virus at your workplace?"; (B) "Does your workplace have a mandated vaccination policy?" as a function of industry sectors.

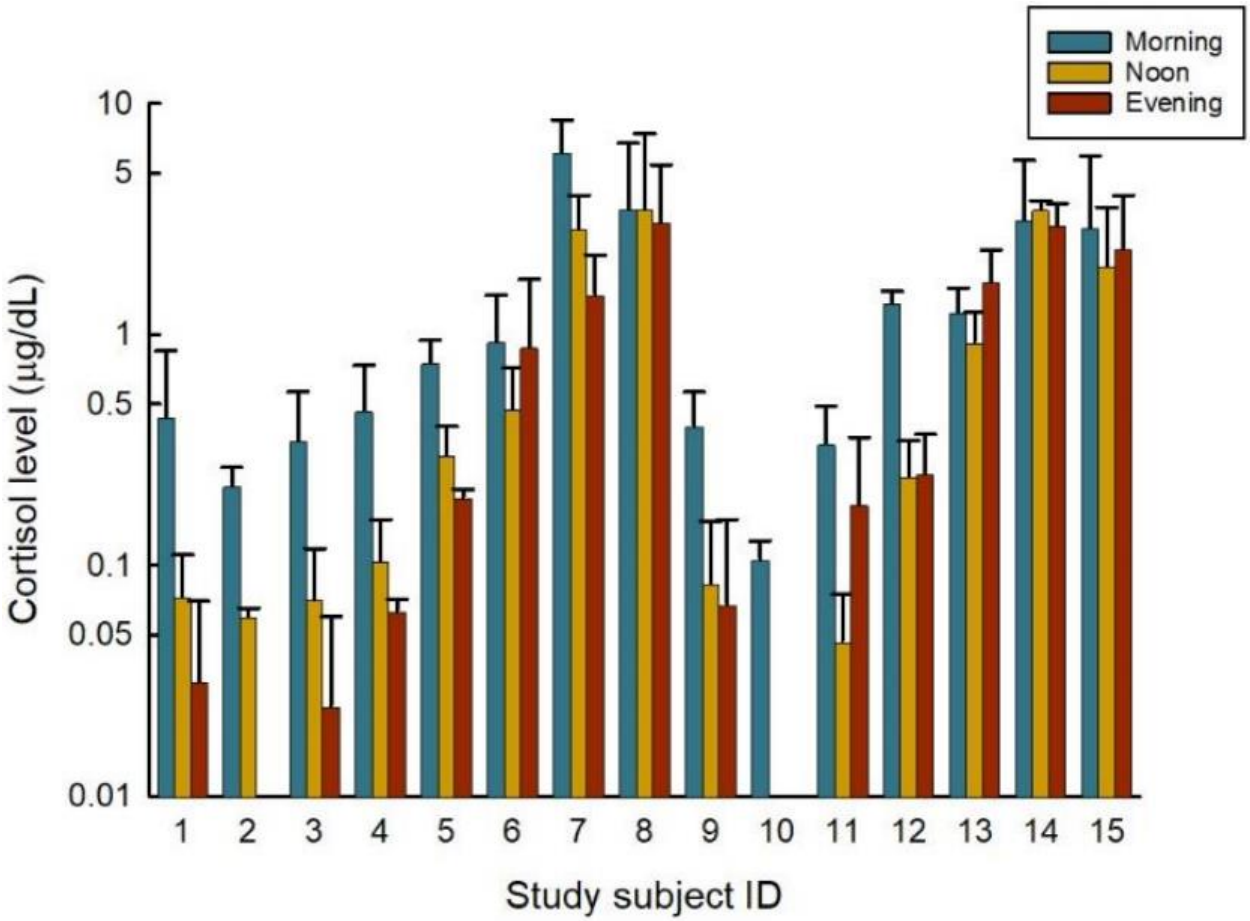


Figure 2-1. Log-transformed graph of interpersonal differences between sampling times.

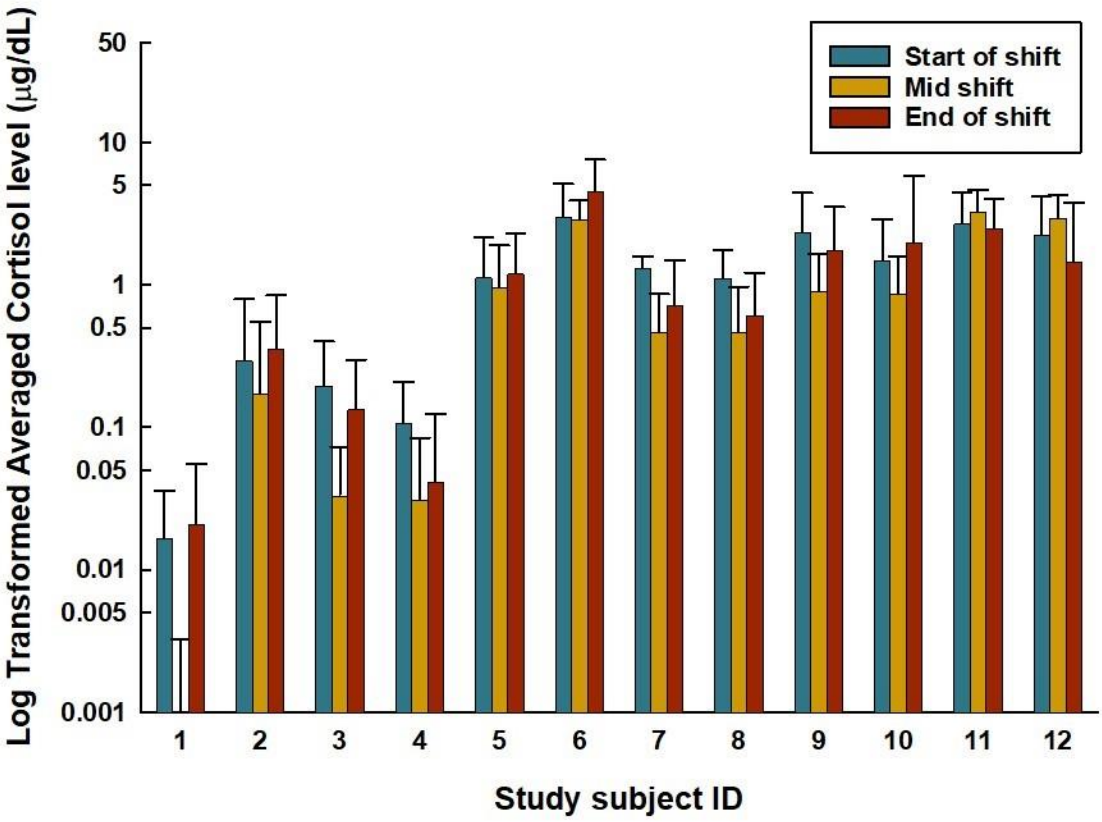


Figure 3-1. Log-transformed graph of interpersonal differences between sampling times.

TABLES

Table 1-1. Demographic information of survey respondents.

	Manual labor	Business/office service	Education	Healthcare	Overall
Total	**252**	**298**	**69**	**51**	**670**
Age					
18–29	56	95	12	13	176
30–39	151	156	40	28	375
40–49	36	34	12	6	88
50–59	7	11	1	3	22
60–69	1	2	3	1	7
70+	0	0	1	0	1
No response	1	0	0	0	1
Gender					
Male	176	194	45	30	445
Female	74	100	24	20	218
Other	1	3	0	1	5
No response	1	1	0	0	2
Race and ethnicity					
American Indian/ Alaska Native	39	23	8	8	78
Asian	6	9	8	1	24
Black or African American	23	19	5	6	53
Hispanic/Latino	13	18	2	2	35
Native Hawaiian/Pacific Islander	8	8	1	1	18
White	160	220	45	32	457
Multi-racial	2	0	0	0	2
N/A	1	1	0	1	3

Table 1-2. Statistically significant differences between industry and inquiry

Question	*p*-value	Options	Labor	Service	Education	Healthcare
Years of experience in career	0.01 $\chi2$ =12.38	Less than 5 years	82	127	22	27
		5-15 years	128	136	33	16
		16-25 years	21	24	8	4
		26-35 years	18	11	5	4
		35+ years	3	0	1	0
Does your job involve irregular working hours or night shift?	≤0.0001 $\chi2$ =30.93	Yes	130	98	14	28
		Sometimes	89	118	25	15
		No	33	82	30	8
Has your work load increased since COVID-19?	≤0.0001 $\chi2$ =29.08	Yes	130	98	14	28
		No	33	82	30	8
Are you allowed to decide your work pace on your own?	0.0008 $\chi2$ =18.87	Yes	108	122	29	12
		Sometimes	107	143	33	21
		No	37	33	7	18
Do you have enough time to finish your work assignments since COVID-19?	0.0006 $\chi2$ =19.48	Yes, always	141	128	38	15
		Sometimes	97	107	24	23
		No, never	14	23	7	13
Do you frequently use video conference software for work?	0.0005 $\chi2$ =20.17	Yes	162	212	59	26
		No	90	86	10	25
Do you have to work from home for the majority of COVID-19?	≤0.0001 $\chi2$ =24.79	Yes, it was required by my employer	82	125	32	14
		Yes, I volunteered to work from home	45	84	20	9
		No, I did not work from home	125	89	17	28
If yes, do you feel your job performance at home changed since working from home?	0.03 $\chi2$ =10.17	Yes, Increased	56	70	14	8
		Yes, Decreased	49	86	18	6
		No Change	12	36	11	4
		N/A	135	106	26	33
Do you find time/task management harder when you work from home?	0.002 $\chi2$ =17.49	Yes	80	110	25	4
		No	37	80	17	13
		N/A	135	108	27	34
Does your job directly involve dealing with COVID-19, e.g., taking care of "high-risk" patients or entering "high-risk" places?	≤0.0001 $\chi2$ =27.71	Yes	100	110	21	36
		No	152	188	48	15
Do you think you could be potentially exposed to SARS-CoV-2 virus at your workplace?	0.02 $\chi2$ =11.27	Yes	136	154	37	39
		No	116	144	32	12
Does your workplace have a mandated vaccination policy?	0.03 $\chi2$ =10.51	Yes	182	208	51	32
		No	70	90	18	19
Due to social distancing & travel restrictions, do you find it difficult to spend time with your friends & relatives?	0.02 $\chi2$ =12.10	Yes, always hard	89	101	25	30
		Sometimes	92	126	33	14
		No, not hard at all	71	71	11	7
Does taking care of children (e.g., because school is out or you voluntarily homeschool) distract you from your work?	0.01 $\chi2$ =12.81	Yes	49	49	6	5
		Somewhat	38	55	15	7
		No	17	25	8	9
		N/A	148	169	40	30

Table 1-3. Composite scores marking the degree of stress related to occupational attribute.

Aspect perceived as stressful (high to low)	Composite score (±standard deviation)
Did you experience increasing stress levels due to irregular working hours or working night shifts?	3.05 (0.73)
Did you experience increasing stress levels due to a loss or change in job?	2.59 (0.53)
Difficulty communicating and relying on coworkers	2.59 (0.71)
Involved in any conflicts at your workplace since COVID-19	2.59 (0.78)
Thinking you could potentially be exposed to SARS-CoV-2 at your workplace	2.56 (0.81)
Quarantining due to either testing positive or contact with someone who tested positive	2.55 (0.80)
Enough time to finish your work assignments since COVID-19	2.51 (0.71)
Directly involved with COVID-19, e.g. caring for "high-risk" patients/entering "high-risk" places	2.49 (0.79)
Partly/not believing work conflicts were solved in a proper manner	2.49 (0.74)
Compensated inadequately for dealing with the additional risk of COVID-19 in the workplace	2.46 (0.74)
Taking care of children distracting you from your work	2.4 (0.76)
Believing your workplace inadequately provides personal protection regarding COVID-19	2.38 (0.80)
Finding time/task management harder when you work from home	2.37 (0.74)
Experiencing a change in your body weight due to less physical activity since COVID-19	2.36 (0.78)
Increased workload since COVID-19	2.36 (0.68)
Believing your workplace has an inadequate policy regarding COVID-19	2.32 (0.78)
Caring for elderly individuals on a daily basis	2.32 (0.84)
Lacking the subjectively necessary home office supplies to support your job	2.29 (0.82)
Difficulty setting a boundary between work and family life during COVID-19	2.28 (0.69)
Difficulty finding time for your hobbies or relaxing activities	2.25 (0.76)
Difficulty spending time with friends and relatives due to social distancing and travel restrictions	2.24 (0.76)
Ability to decide on your work pace on your own	2.24 (0.73)
Working after your normal hours	2.17 (0.73)
Job performance decreased due to working from home	2.15 (0.73)
Lack of a mandated vaccination policy	2.14 (0.85)
Attending many virtual meetings	1.96 (0.65)
Presence of a mandated vaccination policy	1.89 (0.89)

Table 2-1. Summary of the intense occupational stressors experienced by participants (intensity of stress = 3, 4, or 5).

Participant's Career	Stress Level	Stressor Entry	Was this a typical day?
Principal Scientist	3	Positive stress of having many urgent things to do and limited time.	Yes
Principal Scientist	3	Positive stress. Exciting discussions & experiment planning.	Yes
Health Insurance Supervisor	3	Found out one of my associates made a big mistake and I have to write her up. But I don't think the reasoning for this policy is fair. So I don't agree w/error. Frustrated.	Yes, typical Wednesday full of meetings from 8-430pm
Health Insurance Supervisor	3	Meeting with manager about my team lead's poor communication skills. Felt stressed and overwhelmed.	Yes, a normal Thursday working from home. Usual amount of stress.
Health Insurance Supervisor	5	I had to fire one of my associates today at 3pm. At 11am I started to prepare. Nervous, overwhelmed	Yes, a normal Thursday working from home. Usual amount of stress.
Online University Admission Advisor	3	Issues w/tech – not able to have access. I feel angry at this situation.	Yes
Online University Admission Advisor	4	Continued tech issues – dog bothering me. Anger at dog, annoyed about work	Yes
Online University Admission Advisor	3	Tech issues resolved – but now dealing and trying to catch up on work. Overwhelmed	Yes
Online University Admission Advisor	3	Given reports to complete/audit I didn't know about. Frustrated	Yes
Online University Admission Advisor	3	Struggling with work-mail merge – long process – needs to be completed tomorrow. angry	Yes
Online University Admission Advisor	3	Stress about work again – about to start sorting things out – getting emails about other things. Worried & overwhelmed	Yes
Online University Admission Advisor	4	Working on project – sending lots of emails – very demanding. Stressed	Yes
Marketing	3	At work, couldn't compute a task for my leader's leader b/c I didn't have the tools necessary. Anxious, worried	No, team meeting + evening activity
Marketing	3	Team building exercise to build the tallest Lego tower w/in 30 min. w/o it falling. Friendly competition.	No, team meeting + evening activity
Marketing	3	Rushing to get work done to get to a family event I'm not looking forward to. Stressed, angry, rushed	No, team meeting + evening activity
Marketing	3	Realized I missed my mid-shift sample	Yes
Project Manager	4	Difficult chat w/co-worker. Stressed	Yes, work day, but long DR apt in middle
Project Manager	3	Last minute important request. Confused	Yes, work day, but long DR apt in middle
Project Manager	3	Going over large to-do list w/co-worker. Annoyed	Yes
Project Manager	3	Co-worker forgetting important request. Annoyed/stressed	No, I don't usually work today
Internet Marketer	3	Unforeseen problem at work.	Yes
Information Security Manager	3	Excel formula formatting date. DATEVALUE function needed	Yes
Information Security Manager	3	Dentist appt traffic, late. Next appt. July. Work meeting ran over.	Yes
Graduate Student	3	Too many assignments to do	Start of the work week
Graduate Student	5	Rework on lab reports	Yes
Graduate Student	5	Working with the reports. Stressful	Yes
Graduate Student	5	Working with the reports. Stressful	Yes
Graduate Student	3	Finally done but worried with others. Relief but worried.	Yes
Nurse	3	Lab results done wrong. Anxious	Yes

Table 2-1 Continued.

Rapid Response Team Nurse	4	Labs weren't as good as expected. Frustrated nothing was working	Yes
Rapid Response Team Nurse	3	Getting an arterial blood gas stick on a dehydrated pt. Rushed, stressed	Yes
Rapid Response Team Nurse	3	Last minute bed change due to a shit explosion (literally). Had a lot to do, don't like the smell of C. diff.	Yes
Rapid Response Team Nurse	3	Patient's whole family in room – very sick patient. Sad, empathy	Yes
Rapid Response Team Nurse	3	Transporting my ventilated pt. To MRI. MD insisted on transporting very sick pt against my advice. Stress, uneasy	Yes
Rapid Response Team Nurse	4	Setting up nitric on COVID pt. Rushed	Yes
Health Center Office Manager	4	Employee not at work and no one heard from them in 7 days. Worried.	No, missing employee
Health Center Office Manager	4	Police notified of missing employee. Unknown emotional distress – felt sick to stomach	No, missing employee
Health Center Office Manager	3.5	Appts canceled & boss asking about current policies. Boss wanting to implement new cancellation policies.	No, missing employee
Health Center Office Manager	3	Having work load doubled & having to take clients that I wasn't prepared for. Anxiety & overwhelmed at situation.	No, missing employee
Health Center Office Manager	3.5	Client arriving late. When client is late, it makes my schedule run behind.	Yes
Registered Nurse	4	I have to get up earlier than usual on Wed. I'm not a morning person.	Yes, sees home care pts. Instead of clinic
Registered Nurse	3	A family changed visit time. Stressed at having to move pt. Visit.	Yes, sees home care pts. Instead of clinic
Registered Nurse	3	2 genetic counselors on our team working from home. All calls coming to me. Can't get other work done.	Yes
Registered Nurse	4	Patient died very unexpectedly. Sad – wondering if I could have done anything differently.	Yes
Wastewater biologist	3	Training new staff. Equipment failures. Busy & high stress afternoon	Yes
Wastewater biologist	4	Boss made unnecessary changes to process and took vital equipment offline; All because they didn't follow through on scheduling ahead. Anger	Yes
Wastewater biologist	4	Above mentioned supervisor left early from work w/o resolving issues or leaving any instructions. Frustration	Yes
Accounting Specialist	3	Trying to start payroll batch on my own. Feeling frazzled trying to remember the step by step	Payroll day, we process payroll for the entire company
Accounting Specialist	3	My desk is full of paperwork and it's approaching the end of the day. It's been busy! I'm moving quickly.	Payroll day, we process payroll for the entire company
Accounting Specialist	3	In a training call for new ERP system watching co-worker navigate. I was doing a similar training before.	No, training in new ERP system.
Registered Nurse	5	Getting report on 5 patients for the day. Sick challenging patients. Worried.	Yes
Registered Nurse	5	Patient needing to use commode but RN stuck in another room with sick pt. Patient messed his pants. Family & pt. were upset. Frustrated & angry.	Yes
Registered Nurse	5	Rapid response – new nurses pt. In midst of stroke. Helping him through. Fear, worried, relief, adrenaline rush!	Yes
Registered Nurse	3	Catching up on everything. Behind because of rapid response.	Yes
Registered Nurse	4	Start of shift – a charge nurse with full team of sick pts. No help...	Yes
Registered Nurse	4	Busy sending two patients home at same time and getting everything together. Rushed	Yes

Table 2-1 Continued.

Registered Nurse	4	New admits almost as soon as beds are cleaned from old ones. Still not caught up on computer charting. No unit clerk, no pch. Trying to make pts. feel they are getting the care they deserve.	Yes
Registered Nurse	3	I scheduled appt. But know they are short sort of on call wondering if I'm needed. Anxiety.	Yes
Registered Nurse	3	Had to go into work 6 hours. Sitting for dementia patients. Not a bad afternoon	Yes

Table 2-2. Emotional behavioral reaction frequencies in the occupational stress diaries.

Emotional Behavioral Reaction	Count	Percent
Stressed	16	13.22%
Frustrated	15	12.40%
Angry/Mad/Pissed	14	11.57%
Anxious/Unease/Restless	13	10.74%
Overwhelmed/Pressured	10	8.26%
Rushed	9	7.44%
Annoyed/Aggravated/Irritated	9	7.44%
Worry	8	6.61%
Nervous/Agitated	8	6.61%
Disappointed/Bummed/Sad	4	3.31%
Concerned/Distressed	3	2.48%
Shame/Guilt	2	1.65%
Confused/Surprised	2	1.65%
Tired	2	1.65%
Frazzled	2	1.65%
Dread/Fear	2	1.65%
Impatient	2	1.65%
Total	121	100.00%

Table 3-1. Participant demographic information

Demographic	Count
Gender	
Female	12
Age	
30–39	7
40–49	2
50–59	2
60–69	1
Job Category	
Physical Therapist	4
Medical Social Worker	1
RN	2
Occupational Therapist	3
Speech Language Pathologist	1
Developmentally Disabled	1
HHCW Career Length	
Less than 5 years	4
5–15 years	3
16–25 years	2
26–35 years	3

Table 3-1. Continued

Demographic	Count
Length With Present Employer	
Less than 5 years	8
5–15 years	1
16–25 years	3
Style of Shift	
Five Day Workweek	6
Four Day Workweek	4
Three 12-h shifts	1
Complex Workweek	1
Typical Commute Times to Homes	
0–15 min	3
16–34 min	6
35–45 min	3
Experience Poor Air Quality at Work	
Rarely	1
Sometimes	4
Often	6
Always	1
Diagnosis of Respiratory Disease	
No	8
Yes	4
Respiratory Disease Affected by Job	
No	2
Yes	2

Table 3-2. Pearson correlation results

Relationship	Coefficient
RCI vs. NO_2	0.162
RCI vs. VOC	0.313
RCI vs. PM_{10}	0.155
RCI vs. $PM_{2.5}$	0.224
RCI vs. PM_1	0.269

Table 3-3. Average pollutant levels exposed to each participant

Participant	NO_2 (ppb)	VOC (ppb)	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	PM_1 ($\mu g/m^3$)	Stress Level
1	10.5	205.3	18.3	5.2	3.5	4.2
2	6.0	127.7	11.3	3.1	1.4	5.0
3	3.4	144.7	12.5	3.8	2.1	1.8
4	11.7	168.8	17.7	5.4	3.6	1.5
5	11.7	194.5	19.4	5.5	3.7	5.9
6	7.2	124.3	11.2	3.1	1.4	4.8
7	5.8	124.7	13.1	3.5	1.5	2.9
8	10.4	208.7	18.5	8.2	3.2	4.7
9	6.9	124.0	11.7	3.2	1.4	7.2
10	4.3	160.3	12.4	3.7	1.9	1.4
11	4.9	142.4	14.7	3.4	2.4	1.3
12	4.5	155.3	12.9	4.9	1.5	4.5
Average	7.3 ± 3.0	156.7 ± 31.6	14.5 ± 3.1	4.4 ± 1.5	2.3 ± 0.9	3.8 ± 1.9

Table 3-4. Summary of the intense occupational stressors experienced by participants (intensity of stress = 6, 7, 8, 9, 10)

Participant	HHCW Type	Stress Level	Stressor Entry	Was this a typical day?
1	Physical Therapist	6	Difficulty finding the house of patient due to incorrect address.	Yes
1	Physical Therapist	7	Reading work email regarding incorrect documentation on pt.	Yes
1	Physical Therapist	6	Traffic traveling to last patient visit.	Yes
1	Physical Therapist	7	During a patient visit and pt has high level of stress and pain.	Yes
1	Physical Therapist	6	Down pour of rain due to storms in the area.	Yes
2	Developmentally Disabled	7	Client A – If I can't hear what he just said, I'll say something like "What?" Instead of him repeating what he just said, he will give more details as if I don't understand what he just said.	Yes
2	Developmentally Disabled	9	Client B's mom called to tell me not to come today due to client B being very ill.	Yes and No
2	Developmentally Disabled	9	I made a call on Client A's behalf. Getting this person to give a straight answer was like pulling an alligator's teeth.	Yes and No
2	Developmentally Disabled	6	Client A gave me a hard time about cleaning his home. Helps a little bit then not and not following simple instructions. Also trying to work over me, invading my personal space. He knows I don't like my space invaded.	Yes and No
5	Medical Social Worker	8	Meeting a staff member who has limited insight.	Yes
5	Medical Social Worker	6	MRI for liver mass.	Yes

5	Medical Social Worker	7	Pt has med that is expensive. His assistance has not been approved. If he does not get his functional status, will be requiring hospital admission.	Yes
5	Medical Social Worker	8	Job interview	Yes
5	Medical Social Worker	9	Pt. Coverage for med not processed & will not process before his current Rx runs out.	Yes
5	Medical Social Worker	6	Trying to identify care manager for services to get needed supplies for pt.	Yes
5	Medical Social Worker	6	Pt. Struggling with spouse's death and lack of family support.	Yes
6	RN Clinical Educator	6	Staff meeting this morning	Yes
6	RN Clinical Educator	8	Overwhelmed by several different issues in personal life.	Yes
7	Physical Therapist	7	Car crossed center lane and I swerved out of way	Yes
8	Physical Therapist	6	Call that start of care cancelled – No time later in week to reschedule.	Yes but a typical rougher day
8	Physical Therapist	6	Email that 3:00 cancelled. Need to move visit to today to meet productivity expectations.	Yes but a typical rougher day
8	Physical Therapist	6	3:30 visit running late coming home from visiting family.	Yes but a typical rougher day
8	Physical Therapist	6	Email from boss – start of care (~2.5 hr long) assigned for me far out of my territory. Only agreeable to late afternoon.	Yes
8	Physical Therapist	6	Older 2 kids school had to close. Need to be picked up.	Yes
8	Physical Therapist	6	Youngest has fever. Needs to be picked up from preschool.	Yes
8	Physical Therapist	6	Rude, agitated patient	Yes
9	Speech Language Pathologist	8	Trying to leave patient to get to dentist appt. On time.	Yes
9	Speech Language Pathologist	8	Dealing with patient and wife with significant cognitive deficits & poor recall for meds & diabetes.	Yes

9	Speech Language Pathologist	8	At my last patient & got a call daughter was sick & needed picked up but no one to pick her up until I was done.	Yes
9	Speech Language Pathologist	7	Trying to find sitters to watch daughter tomorrow so I can work.	Yes
9	Speech Language Pathologist	8	Get work done.	Yes
9	Speech Language Pathologist	7	Left home late due to sick kid.	Yes
9	Speech Language Pathologist	7	Patient & wife both have cognitive deficits and didn't carryover simple task.	Yes
9	Speech Language Pathologist	9	Received text daughter had thrown up & thought I was going to have to call off rest of day.	Yes
9	Speech Language Pathologist	8	Step daughter of patient with poor insight into dementia and tried to do/challenge SLP.	Yes
9	Speech Language Pathologist	8	Struggling to finish all work doc due to exhaustion	Yes
9	Speech Language Pathologist	7	Sent patient to hospital 2 degrees change in neuro status & very hypotensive.	Yes
9	Speech Language Pathologist	8	Running behind. Cancelled 1 patient.	Yes
9	Speech Language Pathologist	6	In the middle of a private pay evaluation with patient & 3 family members I got a call from. & Daycare called to send daughter home.	Yes
9	Speech Language Pathologist	9	Trying to find babysitters for Thursday. Trying to get work done, up & down with daughter until 2:30AM.	Yes
9	Speech Language Pathologist	6	Late to patient post eye doctor. Preparing for a difficult conversation w/ patient & family member today. Patient isn't safe home alone. Needs assisted living, private duty in home or ST (me) would have to call adult protective services.	Yes
9	Speech Language Pathologist	6	Still working and won't be home in time for start of daughter's therapy session.	Yes
9	Speech Language Pathologist	8	Prepping daughter for bath and bed. She then dumped whole box of Cheerios on floor.	Yes
9	Speech Language Pathologist	6	Trying to find babysitter so I can work tomorrow.	Yes
9	Speech Language Pathologist	9	A lot of docs left but too tired to finish.	Yes

9	Speech Language Pathologist	9	Supposed to be at 1st patient at 9:00, but my firend was late. Had to take my daughter with me to my 1st patient for my friend to pick up daughter from there.	Shorter day – 2 patients
9	Speech Language Pathologist	8	Patient with dementia messed up meds again & husband not helpful. Patient had a hypotensive BP – had to call with her doc.	Shorter day – 2 patients
9	Speech Language Pathologist	7	Worked on week's docs.	Shorter day – 2 patients
12	Physical Therapist	6	Start of care cancelled. Will once again not meet productivity expectations for day.	Yes
12	Physical Therapist	6	Root cause analysis discussing patient of mine that passed away last week.	Yes
12	Physical Therapist	8	Hydroplaned on back roads in Independence. Van making noise.	No

Table 3-5. Emotional behavioral reaction frequencies in the work stress diaries

Emotional Behavioral Reaction	Count	Percent
Frustration / Aggravated / Mad / Anger	30	22.39%
Overwhelmed / Inadequacy / Depleted / Fatigue / Tired / Exhausted / Insufficient	21	15.67%
Irritated / Annoyed	13	9.70%
Nervous / Anxious / Uncomfortable / Drained	10	7.46%
Stress	9	6.72%
Worry	9	6.72%
Fear / Afraid / Scared / Concerned / Cautious	8	5.97%
Rushed	7	5.22%
Happy / Good / Hopeful / At Ease / Excited	6	4.48%
"Increased Heart Rate"	6	4.48%
Calm / Satisfied / Accomplishment / Relief	5	3.73%
Sad / Disappointed / Unvalued / Grief	5	3.73%
Ashamed / Unheard	2	1.49%
Tension	2	1.49%
Distracted	1	0.75%
Total	134	100%

APPENDIX A. PUBLISHED ABSTRACTS AND CONFERENCE PRESENTATIONS

The findings described in this dissertation were also presented at the conferences in the form of posters and platform presentations listed below.

POSTER

Gerding, T, AIHce American Industrial Hygiene annual conference and expo, "An Investigation into Occupational Related Stress of At-Risk Workers During COVID-19 ", Nashville, Tennessee, National, Accepted. (May 24, 2022).

Gerding, T, University of Cincinnati Pilot Research Project Symposium, "Investigation of Occupationally-Related Stress of At-Risk Workers During COVID-19", Cincinnati, Ohio, Local, Invited. (October 21, 2021).

Gerding, T, Central Appalachian Regional Education and Research Center Symposium, "An Assessment of Ergonomic Issues in the Home Offices of University Employees Sent Home Due to the COVID-19 Pandemic", Virtual, Kentucky, Regional, Accepted, 1st place. (March 12, 2021).

PRESENTATION

Gerding, T, Student Research Findings Symposium, "Investigation of Occupationally-Related Stress During COVID-19", University of Cincinnati, Cincinnati, Ohio, Invited. (January 10, 2023).

Gerding, T, Pilot Research Project Symposium, "Investigation of Occupationally-Related Stress During COVID-19", University of Cincinnati, Cincinnati, Ohio, Invited. (October 21, 2022).

Gerding, T, National Environmental Health Association's Annual Education Conference, "An Assessment of Ergonomic Office Issues Faced by University Populations Due to the COVID-19 Pandemic", Virtual, Invited. (June 1-2, 2021).

Gerding, T, Center for Occupational & Environmental Health Education and Research Centers Ergonomics Webinar Series "An Investigation of Home Ergonomic Issues Experienced by University Faculty and Students Due to COVID-19", Virtual, California, Invited. (May 19, 2021).

Gerding, T, Syck, M, Kentucky Environmental Health Association's Annual Education Conference, "An Assessment of Ergonomic Issues in the Home Offices of University Employees Sent Home Due to the COVID-19 Pandemic", Virtual, Kentucky, Invited. (February 10, 2021).

APPENDIX B. SURVEY INSTRUMENT FOR CHAPTER ONE

Work-Related Stress During COVID-19

Adult Consent Form for Research

University of Cincinnati

Department of Environmental and Public Health Sciences

Principal Investigator: Thomas Gerding, MPH

Faculty Advisor: Jun Wang, PhD

Introduction:

You are being asked to take part in a research study. This research is sponsored by the National Institute for Occupational Safety and Health through the University of Cincinnati Education and Research Center.

Who is doing this research study?

The person in charge of this research study is Thomas Gerding, MPH of the University of Cincinnati (UC) Department of Environmental and Public Health Sciences. He is being guided in this research by Jun Wang, PhD.

What is the purpose of this research study?

The purpose of this research study is to investigate the potential stressor events and stress level related to work during the COVID-19 pandemic.

What will you be asked to do in this research study, and how long will it take?

You will be asked to complete a brief survey which will take approximately 10-15 minutes to complete. The survey will take place online, it can be taken at a time convenient for you. Following the conclusion of the survey, we are also recruiting participants for the second phase of this study.

Are there any risks to being in this research study?

It is not expected that you will be exposed to any risk. The survey results are completely anouymous, de-identified and only aggregated data will be analyzed.

Are there any benefits from being in this research study?

Participate in this study may help the scientific community gain a better understanding related to how job can impact individual's stress level, especially during the ongoing COVID-19 pandemic.

What will you get because of being in this research study?

Participants in the survey will be entered into a drawing to win one of ten $25 Amazon gift cards. The gift cards will be to thank you for providing your time and being included in the study

How will your research information be kept confidential?

Federal regulations require the signed consent documents (i.e., this form) be retained for a minimum of three years upon completion of the study. Upon completion of the study, computerized records will be deleted and paper research files will be shredded. The aggregated data from this research study may be published, but you will not be identified by name or any other way to trace back to you.

Agents of the University of Cincinnati and the National Institute for Occupational Safety and Health may inspect study records for audit or quality assurance purposes. Your identity and information will be kept confidential unless the authorities have to be notified about abuse or immediate harm that may come to you or others.

What are your legal rights in this research study?

Nothing in this consent form waives any legal rights you may have. This consent form also does not release the investigator, the National Institute for Occupational Safety and Health, the institution, or its agents from liability for negligence.

What if you have questions about this research study?

If you have any questions or concerns about this research study, you should contact Thomas Gerding, MPH at gerdintr@mail.uc.edu or you may contact Jun Wang, PhD at wang6ju@ucmail.uc.edu.

The UC Institutional Review Board reviews all research projects that involve human participants to be sure the rights and welfare of participants are protected.

If you have questions about your rights as a participant, complaints and/or suggestions about the study, you may contact the UC IRB at (513) 558-5259. Or, you may call the UC Research Compliance Hotline at (800) 889-1547, or write to the IRB, 300 University Hall, ML 0567, 51 Goodman Drive, Cincinnati, OH 45221-0567, or email the IRB office at irb@ucmail.uc.edu.

Do you HAVE to take part in this research study?

No one has to be in this research study. Refusing to take part will NOT cause any penalty or loss of benefits that you would otherwise have. You may skip any questions that you don't want to answer. You may start and then change your mind and stop at any time.

What if you are an employee of the University of Cincinnati where the research study is done?

Taking part in this research study is not part of your job. Refusing to be in the study will not affect your job. You will not be offered any special work-related benefits if you take part in this study.

By click "Next Page" below, I consent to participate in this survey.

I consent to participate in this study.	◯ Yes ◯ No

Page 3

Demographics

What is your gender?	◯ Male ◯ Female ◯ Other ◯ Rather not say
What is your age?	◯ 18-29 ◯ 30-39 ◯ 40-49 ◯ 50-59 ◯ 60-69 ◯ 70+ ◯ Rather not say
Which race category best identifies you?	◯ American Indian or Alaska Native ◯ Asian ◯ Black or African American ◯ Hispanic or Latino ◯ Native Hawaiian or Other Pacific Islander ◯ White ◯ Multi-racial or Others ◯ Rather not say

Job Information

What best describes your workplace?	◯ Public sector (e.g., government or funded by government) ◯ Private sector (e.g., most businesses and individuals) ◯ Not-for-profit sector ◯ Don't know ◯ Others ◯ Rather not say
What best describes the nature of your job?	◯ Agriculture, forestry, fishing and hunting ◯ Mining ◯ Construction ◯ Manufacturing ◯ Utilities ◯ Transportation and warehousing ◯ Sales, wholesale and retail ◯ Real estate, rental and leasing ◯ Finance and insurance ◯ Software or IT service ◯ Telecommunications ◯ Broadcasting ◯ Publishing ◯ College, university, and adult education ◯ Primary/secondary (K-12) education ◯ Other education industry ◯ Health care ◯ Child care or elderly care ◯ Social assistance ◯ Arts, entertainment, and recreation ◯ Hotel and food services ◯ Government and public administration ◯ Legal services ◯ Scientific or engineering services ◯ Military ◯ Religious ◯ Other (please specify)
Please specify	_____
How many years have you worked in this career?	◯ Less than 5 years ◯ 5-15 years ◯ 16-25 years ◯ 26-35 years ◯ 35+ years
Does your job involve irregular working hours or night shift?	◯ Yes ◯ Sometimes ◯ No
Did you lose your job or have to change jobs due to COVID-19?	◯ Yes ◯ No
Did you experience increasing stress levels due to irregular working hours or working night shift?	◯ Yes, even before COVID-19 ◯ Yes, only after COVID-19 ◯ Very occasionally ◯ No

Did you experience increasing stress levels due to a loss or change in job?	◯ Yes ◯ Somewhat ◯ No

1/5 Workload and Communication	
Has your work load increased since COVID-19?	◯ Yes ◯ No
If yes, do you perceive that as stressful?	◯ Not stressful at all ◯ Somewhat stressful ◯ Stressful ◯ Very Stressful
Are you allowed to decide your work pace on your own?	◯ Yes, always ◯ Sometimes ◯ No, never
If sometimes or no, do you perceive that as stressful?	◯ Not stressful at all ◯ Somewhat stressful ◯ Stressful ◯ Very Stressful
Do you have enough time to finish your work assignments since COVID-19?	◯ Yes, always ◯ Sometimes ◯ No, never
If sometimes or no, do you perceive that as stressful?	◯ Not stressful at all ◯ Somewhat stressful ◯ Stressful ◯ Very Stressful
How easy has it been to communicate with and rely on others such as your supervisor or co-workers since COVID-19?	◯ Very easy ◯ Somewhat easy ◯ Neither easy nor hard ◯ A little difficult ◯ Very difficult
If it is difficult to communicate and rely on co-workers, do you perceive that as stressful?	◯ Not stressful at all ◯ Somewhat stressful ◯ Stressful ◯ Very Stressful
Do you frequently use video conference software (e.g., Zoom, WebEx, Teams) for work?	◯ Yes ◯ No
Does attending many virtual meetings create a stressful situation for you?	◯ Yes ◯ Sometimes ◯ No
Have you been involved in any conflicts at your workplace since COVID-19?	◯ Yes ◯ No
If yes, do you perceive that as stressful?	◯ Not stressful at all ◯ Somewhat stressful ◯ Stressful ◯ Very Stressful
Do you believe the conflict was solved in a proper manner?	◯ Yes ◯ Partly ◯ No

If partly or no, do you perceive that as stressful?	◯ Not stressful at all ◯ Somewhat stressful ◯ Stressful ◯ Very Stressful

2/5 Work From Home	
Do you have to work from home for the majority of COVID-19?	◯ Yes, it was required by my employer to work from home ◯ Yes, I volunteered to work from home ◯ No, I did not work from home
If yes, do you feel your job performance at home changed since working from home?	◯ Yes, increased ◯ Yes, decreased ◯ No change
If you feel your job performance decreased due to work from home, do you perceive that as stressful?	◯ Not stressful at all ◯ Somewhat stressful ◯ Stressful ◯ Very Stressful
Do you have to work after hours (outside of your typical schedule) at home?	◯ Yes ◯ Sometimes ◯ No
If you have to work after hours, do you perceive that as stressful	◯ Not stressful at all ◯ Somewhat stressful ◯ Stressful ◯ Very Stressful
Do you feel relaxed due to a lack of commuting?	◯ Yes ◯ Partly ◯ No
Do you feel relaxed due to a lack of dress code while working from home?	◯ Yes ◯ Partly ◯ No
Do you believe you have the necessary home office supplies (e.g., access to internet, computer, office furniture) to support your job?	◯ Yes ◯ Some ◯ No
If some or no, do you perceive this as stressful?	◯ Not stressful at all ◯ Somewhat stressful ◯ Stressful ◯ Very Stressful
Do you find time/task management harder when you work from home?	◯ Yes ◯ No
If yes, do you perceive this as stressful?	◯ Not stressful at all ◯ Somewhat stressful ◯ Stressful ◯ Very Stressful
Overall, do you find working from home an enjoyable experience?	◯ Yes, but still want to go back to work if possible ◯ Yes, would like to continue working from home if possible ◯ Neutral ◯ No

3/5 COVID Exposure and Risks	
In general, do you feel that COVID-19 pandemic made you more stressful at work?	◯ Yes ◯ No
Does your job directly involve dealing with COVID-19, e.g., taking care of "high-risk" patients or entering "high-risk" places?	◯ Yes ◯ No
If yes, do you perceive that as stressful?	◯ Not stressful at all ◯ Somewhat stressful ◯ Stressful ◯ Very Stressful
Do you think you could be potentially exposed to SARS-CoV-2 virus at your workplace?	◯ Yes ◯ No
If yes, do you perceive that as stressful?	◯ Not stressful at all ◯ Somewhat stressful ◯ Stressful ◯ Very Stressful
Have you been in quarantine due to either having a positive test yourself, or contact with people who tested positive?	◯ Yes ◯ No
If yes, do you perceive that as stressful?	◯ Not stressful at all ◯ Somewhat stressful ◯ Stressful ◯ Very Stressful
Do you feel like you are compensated enough for dealing with the additional risk of COVID-19 in the workplace?	◯ Yes ◯ Partly ◯ No
If partly or no, do you perceive that as stressful?	◯ Not stressful at all ◯ Somewhat stressful ◯ Stressful ◯ Very Stressful
Do you believe your workplace has an adequate policy regarding COVID-19 (e.g., face mask requirements, contact tracing, travel limitations)?	◯ Yes ◯ Partly ◯ No
If partly or no, do you perceive that as stressful?	◯ Not stressful at all ◯ Somewhat stressful ◯ Stressful ◯ Very Stressful
Do you believe your workplace provides adequate personal protection regarding COVID-19 (e.g., facemasks, barriers, PPE, ventilation)?	◯ Yes ◯ Partly ◯ No
If partly or no, do you perceive that as stressful?	◯ Not stressful at all ◯ Somewhat stressful ◯ Stressful ◯ Very Stressful

Does your workplace have a mandated vaccination policy?	◯ Yes ◯ No
Do you feel stressed because of the mandated vaccination policy ?	◯ Not stressful at all ◯ Somewhat stressful ◯ Stressful ◯ Very Stressful
Do you feel stressed because of the lack of mandated vaccination policy?	◯ Not stressful at all ◯ Somewhat stressful ◯ Stressful ◯ Very Stressful

4/5 Work-Life Balance

Do you find it hard to set a boundary between work and family life during COVID-19?	◯ Yes ◯ Sometimes ◯ No
If yes or sometimes, do you perceive that as stressful?	◯ Not stressful at all ◯ Somewhat stressful ◯ Stressful ◯ Very Stressful
Due to social distancing and travel restrictions, do you find it difficult to spend time with your friends and relatives?	◯ Yes, always hard ◯ Sometimes ◯ No, not hard at all
If yes or sometimes, do you perceive that as stressful?	◯ Not stressful at all ◯ Somewhat stressful ◯ Stressful ◯ Very Stressful
Due to social distancing and travel restrictions, do you find it difficult to find time for your hobbies or relaxing activities?	◯ Yes, always hard ◯ Sometimes ◯ No, not hard at all
If yes or sometimes, do you perceive that as stressful?	◯ Not stressful at all ◯ Somewhat stressful ◯ Stressful ◯ Very Stressful
Have you experienced a change in your body weight due to less physical activity since COVID-19?	◯ Yes ◯ No ◯ Rather not say
If yes, do you perceive that as stressful?	◯ Not stressful at all ◯ Somewhat stressful ◯ Stressful ◯ Very Stressful

5/5 Children and Elderly

Do you have children living with you?

- ◯ Yes
- ◯ No

How many of your children are in each of the following age groups:

	0	1	2	3 or more
Less than 5 years old	◯	◯	◯	◯
5 through 10 years old	◯	◯	◯	◯
11 through 18 years old	◯	◯	◯	◯
19 and over	◯	◯	◯	◯

If you have children, how are they taken care of while you are at work? Check all that apply.

- ☐ In school
- ☐ A childcare facility
- ☐ A nanny
- ☐ A family member
- ☐ They are old enough to care for themselves until I'm off work
- ☐ I have to take care of them by myself

Does taking care of children (e.g., because school is out or you voluntarily homeschool) distract you from your work?

- ◯ Yes
- ◯ Somewhat
- ◯ No

If yes or somewhat, do you perceive that as stressful?

- ◯ Not stressful at all
- ◯ Somewhat stressful
- ◯ Stressful
- ◯ Very Stressful

Do you have elderly individuals to care for on a daily basis?

- ◯ Yes
- ◯ No

If yes, do you perceive that as stressful?

- ◯ Not stressful at all
- ◯ Somewhat stressful
- ◯ Stressful
- ◯ Very Stressful

Emails

Thanks for participating in this survey! If you wish to enter a drawing for one of ten $25 Amazon gift cards, please leave your email address here.

The drawing will take place on Nov 15th, 2021. Digital gift cards will be automatically sent to the email address on file.

Email Address: _____

If you live in the Great Cincinnati Area (Southwest Ohio or North Kentucky), please read this:

In the second phase of this study, we are looking for volunteers to conduct a 3-day stress study. If selected for participation, we will send you a self-administered saliva sampling kit along with a daily stress diary. The goal is to correlate the work-related stressor events with salivary cortisol, a hormone released in the body when one feels stress.

All participants in the second phase will receive a $50 Amazon gift card. If you are interested in participating in this second portion, please check yes. We will contact you with more details.

◯ Yes
◯ No

Please click Finish to end the survey.

APPENDIX C. PARTICIPANT INSTRUCTIONS FOR CHAPTER TWO

Participant Instructions for:

"Investigation of Occupationally-Related Stress of At-Risk Workers During COVID-19"

A Pilot Research Project study by:

Principle Investigator: Thomas Gerding, MPH

Study Mentors: Jun Wang, PhD & Peggy Zoccola, PhD

This research study was supported by the National Institute for Occupational Safety and Health through the Pilot Research Project Training Program of the University of Cincinnati Education and Research Center Grant #T42OH008432

Study materials for this study should include the following:

- Nine (9) SalivaBio collection vials by Salimetrics – To collect saliva samples three times per day for the study duration of three days
- Daily stress diary – to log any stressors experienced while working during the three days of the study
- Pre-paid return postage – to return any study materials to the University of Cincinnati

Each of the three study days, please do the following:

- Collect a saliva sample once when you wake up, once at the start of your lunch break, and once at the end of your work shift.
- While you are working during the three days, please keep a record in the stress diary provided to you of any event you experience which causes you to feel stressed. Please also include the time of the occurrence, the severity of the stressor on the 1-5 scale, and any other pertinent details.

Prior to collecting a sample, please view this instructional video from the manufacturer for a tutorial: https://salimetrics.com/passive-drool-saliva-collection-video/

To collect a saliva sample, complete the following:

1. Open the foil pouch and remove the Saliva Collection Aid (SCA).
2. Place the ribbed-end of the SCA securely into a pre-labeled collection vial
3. Allow saliva to pool in mouth. Then, with head tilted forward, gently guide saliva through the SCA into the vial. Fill to the required volume, leaving a small amount of air space in the vial to accommodate liquid expansion during freezing.
4. Remove and discard SCA. Attach cap to collection vial and tighten.
5. Immediately after collection, place sample in a freezer as soon as possible. If freezing is not possible, refrigerate immediately at 4^{o}C and maintain at this temperature for no longer than necessary before placing in a freezer.

At the end of the third and final day of this study, please place all study materials in the pre-paid shipping container and return this to the University of Cincinnati.

Should any questions or concerns arise, please do not hesitate to contact the principal investigator:

Thomas Gerding, MPH

Phone: 859-446-1905

Email: gerdintr@mail.uc.edu

University of Cincinnati, Department of Environmental and Public Health Sciences

APPENDIX D. INFORMATION SHEET FOR

PARTICIPANTS IN CHAPTER TWO

UNIVERSITY OF CINCINNATI INFORMATION SHEET FOR RESEARCH STUDY

STUDY TITLE: **Investigation of Occupationally-Related Stress of At-Risk Workers During COVID-19**	
PRINCIPAL INVESTIGATOR NAME: **Thomas Gerding, MPH**	**PHONE NUMBER (24-hour Emergency Contact)** **(859)446-1905**
FACULTY ADVISOR (if PI is student): **Jun Wang, PhD**	**DEPARTMENT:** **Environmental and Public Health Sciences**

INTRODUCTION

You are being asked to take part in a research study. Please read this paper carefully and ask questions about anything that you do not understand.

This research is sponsored by the National Institute for Occupational Safety and Health through the Pilot Research Project Training Program of the University of Cincinnati Education and Research Center.

WHO IS DOING THIS RESEARCH STUDY?

The person in charge of this research study is Thomas Gerding, MPH of the University of Cincinnati (UC) Department of Environmental and Public Health Sciences. He is being guided in this research by Jun Wang, PhD and Peggy Zoccola, PhD.

WHAT IS THE PURPOSE OF THIS RESEARCH STUDY?

The purpose of this research study is to investigate the validity of relating daily work-related

stressor experiences with changes in salivary cortisol through self-administered sampling. Cortisol is a hormone that is released in the body when one feels stressed.

WHO WILL BE IN THIS RESEARCH STUDY?

About 15 people will take part in this study. You may be in this study if you are:

- 18 years old or older;
- Employed in the greater Cincinnati area;
- Do not have mental/physical health conditions known to affect HPA axis (i.e., Cushing's disease or major depression)
- A nonsmoker

WHAT IF YOU ARE AN EMPLOYEE WHERE THE RESEARCH STUDY IS DONE?

Taking part in this research study is not part of your job. Refusing to be in the study will not affect your job. You will not be offered any special work-related benefits if you take part in this study.

WHAT WILL YOU BE ASKED TO DO IN THIS RESEARCH STUDY AND HOW LONG WILL IT TAKE?

You will be asked to complete a brief survey which will take 15-20 minutes to complete. The survey will take place digitally, in a computer program called REDCAP where the data will be collected. As the survey will be completed online, it can be taken at a time convenient for you. Following the conclusion of the survey period, a select group of participants (15) will be asked to complete the second phase of this study.

In the second phase, should you be asked to participate, you will be provided with nine saliva sampling vials (three per day) and a daily stress diary for a period lasting three workdays. Here, you will be asked to provide a saliva sample at three times during a working day: once upon waking, once at the start of the lunch break, and once at the end of the work shift. Additionally, you will be asked to document any stressors in the provided daily stress diary including whether the stressor was work related, the severity of the stressor, and any other relevant details about the occurrence.

All activities related to phase two will be conducted at your place of employment; it will not be necessary to come to the University of Cincinnati as saliva samples will be self-administered. Upon completion of the three-day period, samples are to be mailed via pre-paid postage to the Kettering Laboratory at the University of Cincinnati.

ARE THERE ANY RISKS TO BEING IN THIS RESEARCH STUDY?

It is not expected that you will be exposed to any risk by allowing your saliva samples or subjective stress levels to be used in this research study. All samples and diaries collected will be deidentified from the individual who provided both.

ARE THERE ANY BENEFITS FROM BEING IN THIS RESEARCH STUDY?

You will probably not get any benefit because of being in this study. However, being in this study may help the scientific community gain a better understanding related to how experiencing occupational events can impact personal stress levels, especially during the ongoing pandemic.

WHAT WILL YOU GET BECAUSE OF BEING IN THIS RESEARCH STUDY?

Participants in the initial survey will be entered into a drawing to win one of four $25 Amazon gift cards. There will be four total winners from this portion.

Participants in the second phase which will include the saliva sample collections and the daily stress diary will each receive a $50 Amazon gift card upon completion of this phase and the return of all study materials. The gift cards will be to thank you for providing your time and being included in the study

DO YOU HAVE CHOICES ABOUT TAKING PART IN THIS RESEARCH STUDY?

If you do not want to take part in this research study you may simply not participate.

HOW WILL YOUR RESEARCH INFORMATION BE KEPT CONFIDENTIAL?

Information about you will be kept private by using a study ID number instead of participants' names on the research forms and keeping the master list of names and study ID numbers in a separate location from the research forms.

Your deidentified information will be kept in a locked cabinet in Dr. Jun Wang's lab within the Kettering Laboratory building at the University of Cincinnati for two years upon completion of the study. Federal regulations require the signed consent documents (i.e., this form) be retained for a minimum of three years upon completion of the study. Upon completion of the study, computerized records will be deleted, and paper research files will be shredded. The data from this research study may be published, but you will not be identified by name.

Agents of the University of Cincinnati and the National Institute for Occupational Safety and Health may inspect study records for audit or quality assurance purposes.

Your identity and information will be kept confidential unless the authorities have to be notified

about abuse or immediate harm that may come to you or others.

WHAT ARE YOUR LEGAL RIGHTS IN THIS RESEARCH STUDY?

Nothing in this consent form waives any legal rights you may have. This consent form also does not release the investigator, the National Institute for Occupational Safety and Health, the institution, or its agents from liability for negligence.

WHAT IF YOU HAVE QUESTIONS ABOUT THIS RESEARCH STUDY?

If you have any questions or concerns about this research study, you should contact Thomas Gerding, MPH at gerdintr@mail.uc.edu or you may contact Jun Wang, PhD at wang6ju@ucmail.uc.edu.

The UC Institutional Review Board reviews all research projects that involve human participants to be sure the rights and welfare of participants are protected.

If you have questions about your rights as a participant, complaints and/or suggestions about the study, you may contact the UC IRB at (513) 558-5259. Or, you may call the UC Research Compliance Hotline at (800) 889-1547, or write to the IRB, 300 University Hall, ML 0567, 51 Goodman Drive, Cincinnati, OH 45221-0567, or email the IRB office at irb@ucmail.uc.edu.

DO YOU HAVE TO TAKE PART IN THIS RESEARCH STUDY?

No one has to be in this research study. Refusing to take part will NOT cause any penalty or loss of benefits that you would otherwise have. You may skip any questions that you don't want to answer.

You may start and then change your mind and stop at any time. To stop being in the study, you should tell Thomas Gerding at gerdintr@mail.uc.edu.

BY TURNING IN YOUR COMPLETED SURVEY (or BY TAKING PART IN THESE ACTIVITIES) YOU INDICATE YOUR CONSENT FOR YOUR ANSWERS TO BE USED IN THIS RESEARCH STUDY.

PLEASE KEEP THIS INFORMATION SHEET FOR YOUR REFERENCE.

APPENDIX E. EXAMPLE STRESS DIARY USED FROM CHAPTHER TWO

SAMPLE STRESS DIARY

Name: Steve Sample Occupation: Nurse

Date: 8/25/21 Is this a typical day

(describe): Yes

CIRCLE ONE: SA M T W TH F SU

Complete the Stress Diary Below. Copy this form for additional space.

Time of Day	Intensity of Stress (0-5) 0 = no stress, 5 = most stressful	Duration of Stress	Situation (circumstance, location, people, etc.)	Triggering Event (preceding event, if applicable)	Emotional Behavioral Reaction (your feelings about the event)
9:00am	4	30 min	Woke up too late and came in late to work.	I went out last night until 2:00am the night before.	I got mad at my spouse for not waking me up soon enough.
11:30am	5	1 hour	I couldn't finish a work assignment that needed to be completed by now. It took me longer than expected to finish.	My boss set an unrealistic time frame for this assignment.	I was extremely nervous because of not being able to finish the assignment on time.
2:00pm	3	30 min	I overheard my co-worker talking about my poor performance lately with my superior.	I have been feeling overburdened between work and family needs.	I feel that I am juggling too many things in life and overwhelmed.
3:30pm	2	2 hours	I feel like I need to find a different job that will be less stressful and I will be able to better provide for my family.	Repetitive negative thinking regarding where I am at in life.	I feel inadequate.

APPENDIX F. ENROLLMENT SURVEY INSTRUMENT FOR CHAPTER THREE

Occupation-Related Stress of Home Healthcare Workers and Ambient Pollution Exposures

Adult Consent Form for Research

University of Cincinnati

Department of Environmental and Public Health Sciences

Principal Investigator: Thomas Gerding, MPH

Faculty Advisor: Jun Wang, PhD

Introduction:

You are being asked to take part in a research study. This research is sponsored by the National Institute for Occupational Safety and Health through the University of Cincinnati Education and Research Center.

Who is doing this research study?

The person in charge of this research study is Thomas Gerding, MPH of the University of Cincinnati (UC) Department of Environmental and Public Health Sciences. He is being guided in this research by Jun Wang, PhD.

What is the purpose of this research study?

The purpose of this research study is to investigate the potential stressor events and corresponding cortisol levels related to work within home healthcare.

What will you be asked to do in this research study, and how long will it take?

You will be asked to complete a brief survey which will take approximately 10-15 minutes to complete. The survey will take place online, it can be taken at a time convenient for you. Following the conclusion of the survey, we will recruit participants who match eligibility criteria.

Are there any risks to being in this research study?

It is not expected that you will be exposed to any risk.

Are there any benefits from being in this research study?

Participating in this study may help the scientific community gain a better understanding related to how a job can impact individual's stress level, speicifically within home healthcare.

What will you get because of being in this research study?

Participants who complete and return all study materials at the conclusion of their study week will receive a $50 Amazon gift card. The gift cards will be to thank you for providing your time and being included in the study.

How will your research information be kept confidential?

Federal regulations require the signed consent documents (i.e., this form) be retained for a minimum of three years upon completion of the study. Upon completion of the study, computerized records will be deleted and paper research files will be shredded. The aggregated data from this research study may be published, but you will not be identified by name or any other way to trace back to you.

Agents of the University of Cincinnati and the National Institute for Occupational Safety and Health may inspect study records for audit or quality assurance purposes. Your identity and information will be kept confidential unless the authorities have to be notified about abuse or immediate harm that may come to you or others.

What are your legal rights in this research study?

Nothing in this consent form waives any legal rights you may have. This consent form also does not release the investigator, the National Institute for Occupational Safety and Health, the institution, or its agents from liability for negligence.

What if you have questions about this research study?

If you have any questions or concerns about this research study, you should contact Thomas Gerding, MPH at gerdintr@mail.uc.edu or you may contact Jun Wang, PhD at wang6ju@ucmail.uc.edu.

The UC Institutional Review Board reviews all research projects that involve human participants to be sure the rights and welfare of participants are protected.

If you have questions about your rights as a participant, complaints and/or suggestions about the study, you may contact the UC IRB at (513) 558-5259. Or, you may call the UC Research Compliance Hotline at (800) 889-1547, or write to the IRB, 300 University Hall, ML 0567, 51 Goodman Drive, Cincinnati, OH 45221-0567, or email the IRB office at irb@ucmail.uc.edu.

Do you HAVE to take part in this research study?

No one has to be in this research study. Refusing to take part will NOT cause any penalty or loss of benefits that you would otherwise have. You may skip any questions that you don't want to answer. You may start and then change your mind and stop at any time.

What if you are an employee of the University of Cincinnati where the research study is done?

Taking part in this research study is not part of your job. Refusing to be in the study will not affect your job. You will not be offered any special work-related benefits if you take part in this study.

By click "Next Page" below, I consent to participate in this survey.

I consent to participate in this study.

◯ Yes
◯ No

Demographics (1/5)	
What is your gender?	◯ Male ◯ Female ◯ Other ◯ Rather not say
What is your age?	◯ 18-29 ◯ 30-39 ◯ 40-49 ◯ 50-59 ◯ 60-69 ◯ 70+ ◯ Rather not say
What is your marital status?	◯ Married ◯ Single, never married ◯ Single, divorced ◯ Single, widowed
Are you a non-nicotine user (i.e., you don't use cigarettes, cigars, electronic cigarettes, vapes, or pouches of any kind)? Nicotine has been found to affect diurnal fluctuations of cortisol.	◯ Correct, I do not use nicotine products and do not intend to during the week of data collection ◯ Incorrect, I use nicotine products or intend to during the week of data collection
Are you a non-marijuana user (i.e., you don't use joints, blunts, pipes, edibles, THC vapes, etc.)? Marijuana has been found to affect diurnal fluctuations of cortisol.	◯ Correct, I do not use marijuana products and do not intend to during the week of data collection ◯ Incorrect, I use marijuana products or intend to during the week of data collection
Do you have any mental or physical health condition known to affect the hypothalamic-pituitary-adrenal axis (i.e., major depression or Cushing's Syndrome)?	◯ Yes ◯ No

Job Information (2/5)

Are you employed in the Greater Cincinnati Area?	◯ Yes ◯ No
What is your current JOB TITLE?	_____
How long have you worked in the career field of home healthcare?	◯ Less than 5 years ◯ 5-15 years ◯ 16-25 years ◯ 26-35 years ◯ 35+ years
How long have you worked with your present employer?	◯ Less than 5 years ◯ 5-15 years ◯ 16-25 years ◯ 26-35 years ◯ 35+ years
Select the description that is closest to your present WORK SHIFT:	◯ Five eight-hour shifts per week ◯ Four ten-hour shifts per week ◯ Three twelve-hour shifts per week ◯ Other
If "Other," please describe.	_____
Select the description that is closest to your present WORK SHIFT:	◯ Rotating day shift ◯ Rotating evening shift ◯ Rotating night shift ◯ Permanent day shift ◯ Permanent evening shift ◯ Permanent night shift ◯ Other
If "Other," please describe:	_____
If you work on a rotating shift, what ROTATION PATTERN do you follow?	☐ Eight-Hour Shift: DAY to EVENING to NIGHT ☐ Eight-Hour Shift: NIGHT to EVENING to DAY ☐ Eight-Hour Shift: No set pattern ☐ Ten-Hour Shift: DAY to Evening to Night ☐ Ten-Hour Shift: NIGHT to EVENING to DAY ☐ Ten-Hour Shift: No set pattern ☐ Twelve-Hour Shift: DAY to NIGHT ☐ Twelve-Hour Shift: NIGHT to DAY ☐ Twelve-Hour Shift: No set pattern
How many times a week do you change shifts?	◯ 0 times (I don't change) ◯ 2 times ◯ More than 2 times ◯ On call ◯ Standby ◯ Non-standard work week ◯ Other
How long have you worked the shift you indicated above?	_____

What best describes your clients/patients?

_____

Are you issued PPE by your employer or do you need to supply your own PPE (ie., gloves, face masks, etc.)? ◯ Yes ◯ No

Air Quality Questions (3/5)

How long do you have to travel to clients' homes on average?

0 minutes 45 minutes 90 minutes

(Place a mark on the scale above)

Do you feel you experience any type of poor air quality (i.e., anything from within home visits such as cigarette smoke exposure, houses which smell bad, poor ventilation (A/C not working well or windows can't be opened for fresh air), allergens like mold & pets, using harsh disinfectant chemicals, or poor air quality while traveling from home to home)?

◯ Always
◯ Often
◯ Sometimes
◯ Rarely
◯ Never

Do you have any respiratory diseases (i.e., asthma, COPD, chronic bronchitis, etc.) ? ◯ Yes ◯ No

Do you believe those respiratory disease(s) are affected by your job (I.e., exposures within a home)? ◯ Yes ◯ No

Do you feel you are educated on poor air quality and how to address these exposures (either from information from your employer or anywhere else)? ◯ Yes ◯ No

Study Material Use Questions (4/5)

If selected, will you be willing to complete a work stress diary, documenting any event that causes you to experience stress, during your study period of one work week? ◯ Yes ◯ No

If selected, will you be willing to provide three saliva samples per day, using Salimetrics SalivaBio vials and Salimetrics passive drool method (https://salimetrics.com/wp-content/uploads/2018/02/passive-drool-saliva-collection-instructions.pdf), for the duration of your study period of one work week? ◯ Yes ◯ No

If selected, will you be willing to wear a personal air monitor (Flow 2, Plume Labs, Paris, France) either on your person (or similar, i.e., attaching this to a backpack or laptop bag if you keep one with you throughout your workday), during your study period of one work week? ◯ Yes ◯ No

Emails (5/5)

Thanks for participating in this survey! Please provide your email address here for us to contact you to deliver the study materials if you match the eligibility criteria.

We will provide you with a self-administered saliva sampling kit along with a daily stress diary. The goal is to correlate the work-related stressor events with salivary cortisol, a hormone released in the body when one feels stress.
All participants in this phase will receive a $50 Amazon gift card for each work week completed in this study.

Email Address: _____

Please click Finish to end the survey.

APPENDIX G. PARTICIPANT INSTRUCTIONS FOR CHAPTER THREE

Participant Instructions for:

"Occupation-Related Stress of Home Healthcare Workers and Ambient Pollution Exposures"

A study by:

Principle Investigator: Thomas Gerding, MPH

Study Mentor: Jun Wang, PhD

This research study was supported by the National Institute for Occupational Safety and Health through the Targeted Research Training Program of the University of Cincinnati Education and Research Center Grant #T42OH008432

Study materials for this study should include the following:

- SalivaBio collection vials by Salimetrics – To collect saliva samples three times per day for the study duration of one work week, i.e., an individual who works three twelve-hour shifts would receive nine vials while an individual who works five eight-hour shifts would receive fifteen vials;
- Saliva sampling aids equivalent to the number of sampling vials provided;
- Daily stress diary – to log any stressors experienced while working during the week of the study;
- An example stress diary;
- An ice pack to help keep samples cool during transportation;
- This set of instructions.
- A lightweight air quality monitor which is linked to a tablet also provided (Flow 2, Plume Labs, Paris, France & Tibuta Masterpad t100, Tibuta Inc., Goa, India).

Each day during the study period, please do the following:

- Collect a saliva sample once when you start your shift, once at the start of your lunch break, and once at the end of your shift.
- While you are working, please keep a record in the stress diary provided to you of any event you experience which causes you to feel stressed. Please also include the time of the occurrence, the severity of the stressor on the 1-10 scale, and any other pertinent details outlined in the diary.
- Either wear the lightweight air quality monitor on your person or keep this attached to your laptop bag or backpack to monitor air quality throughout the work day.

To collect a saliva sample, please complete the following (a more detailed explanation can be found in the video tutorial here: https://salimetrics.com/passive-drool-saliva-collection-video/#header):

1. Open the foil pouch and remove the Saliva Collection Aid (SCA).
2. Place the ribbed-end of the SCA securely into a pre-labeled collection vial
3. Allow saliva to pool in mouth. Then, with head tilted forward, gently guide saliva through the SCA into the vial. Fill to the required volume, leaving a small amount of air space in the vial to accommodate liquid expansion during freezing.
4. Remove and discard SCA. Attach cap to collection vial and tighten.
5. Place the saliva sample in a freezer immediately after collection. If immediate freezing is not possible, refrigerate the sample until it can be transferred to a freezer.

At the end of the work week, please place all study materials in the Styrofoam cooler inside the cardboard box and the PI, Thomas Gerding, will pick this box of study materials up at a place and time convenient to you.

Should any questions or concerns arise, please do not hesitate to contact the principal investigator:

Thomas Gerding, MPH Email: gerdintr@mail.uc.edu

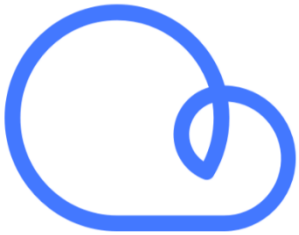
Phone: 859-446-1905 University of Cincinnati, Department of Environmental and Public Health Sciences

Flow 2 & App Instructions

Materials:

Tablet: Tibuta MasterPad T100

App: Flow



Air Monitor: Flow 2 by Plume Labs

The Tibuta MasterPad T100 already has the Flow app installed and the air monitor was previously connected to the app installed on your device.

When you open the app, the “loading” bar along the top of the screen displays how much of the data from the Flow air monitor has been imported into the app (Image 1). This may take a few minutes if it has been a few days since the app has been opened. Below the loading bar, the Flow’s battery life will be displayed and whether the monitor is successfully in sync with the app. This is displayed through the bluetooth icon appearing in blue.

In the bottom right corner, click on the image of the gear to access the settings.

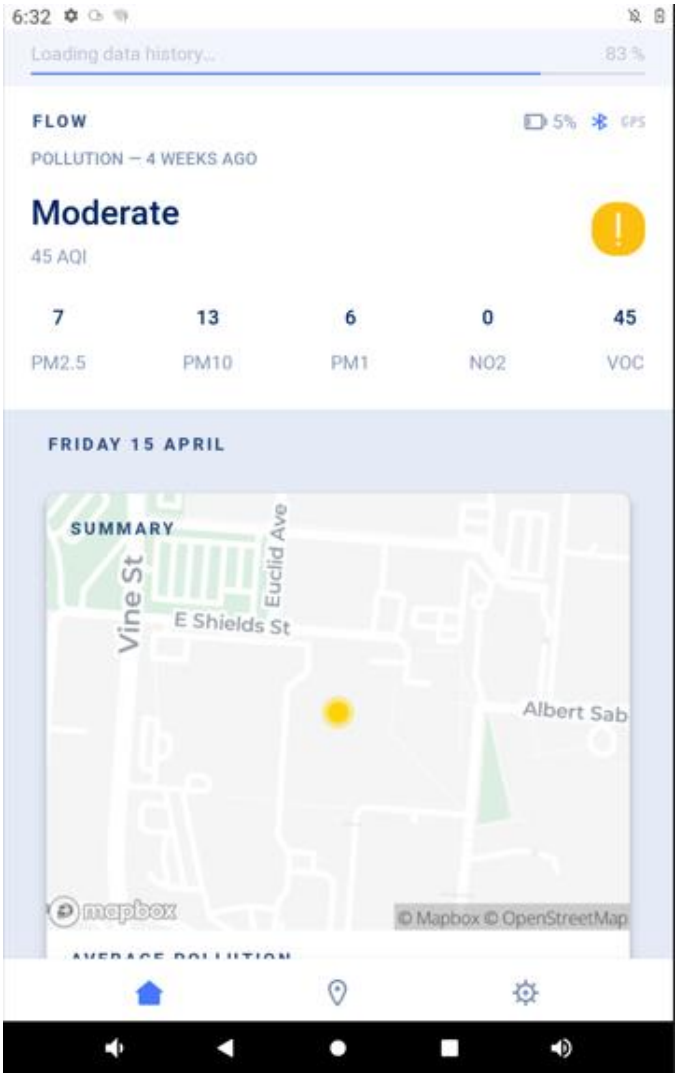


Image 1: Flow app homescreen.

Once the settings screen has been selected, you can see the email address connected with the app. When you export the data collected into the app, this information will be sent to the associated email (Image 2). It is important to remember that the data stored in the app should be exported every FOUR DAYS. The app may store data for up to a maximum of five days. For this reason, at the conclusion of the fourth day of your study period, please export the data collected from the app.

Once you click “Export my data”, the screen below will appear (Image 3). Please ensure that your device is connected to wi-fi so that no connectivity issues arrive. If you need technical support at this time, please don’t hesitate to reach out to Thomas Gerding at: 859-446-1905.

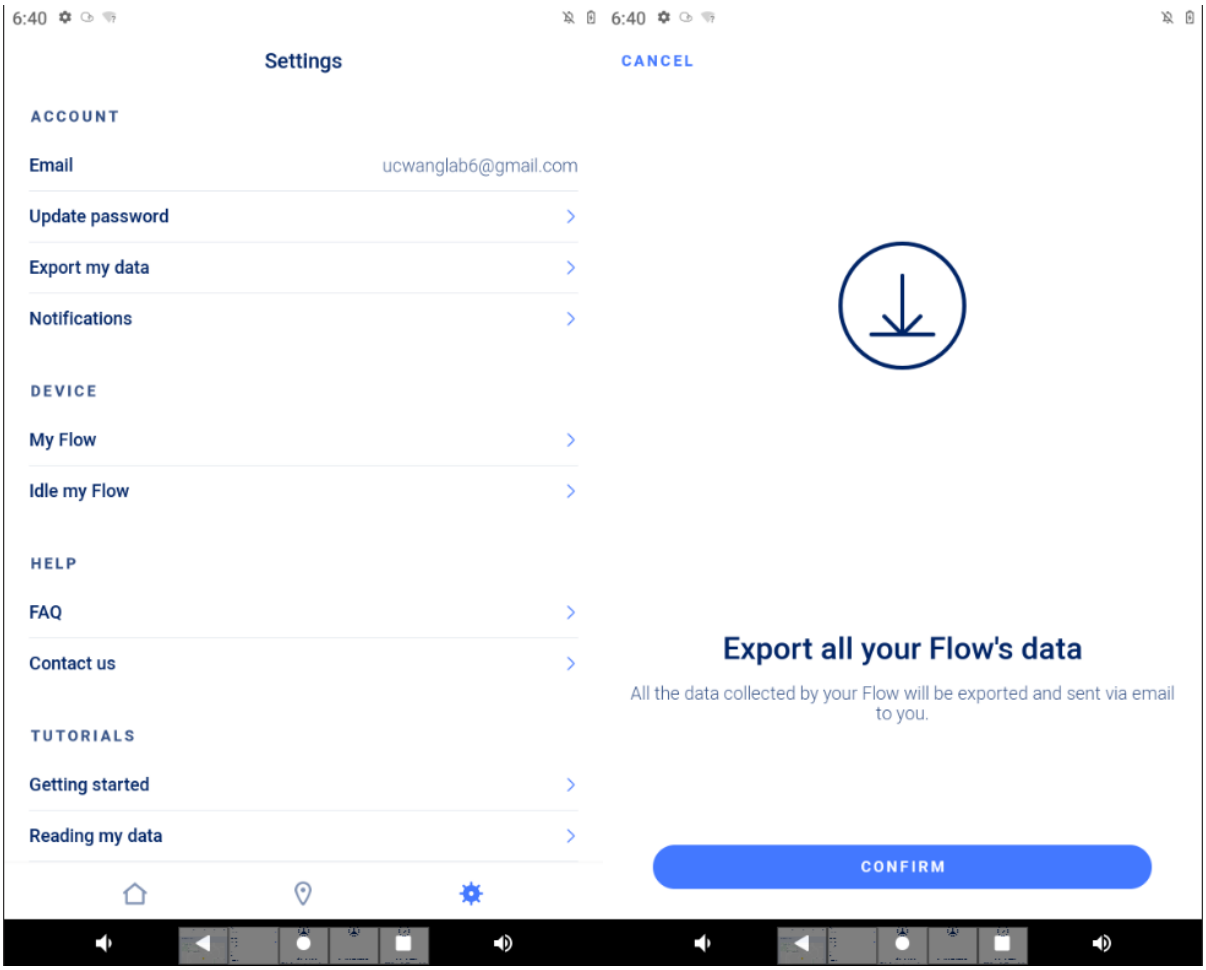


Image 2: Flow app settings screen.

Image 3: Exporting your data.

The next two screens will display “Your data is being prepared...” and “Your data is on the way!” (Image 4 & Image 5). There is nothing to do during this period as your data is being exported and emailed as a zip file. Once the screen appears that displays “Your data is on the way!”, you may then click “OK” and return to the home screen. The monitor and app will continue to collect data which will then need to be extracted again for the second half of the study week.

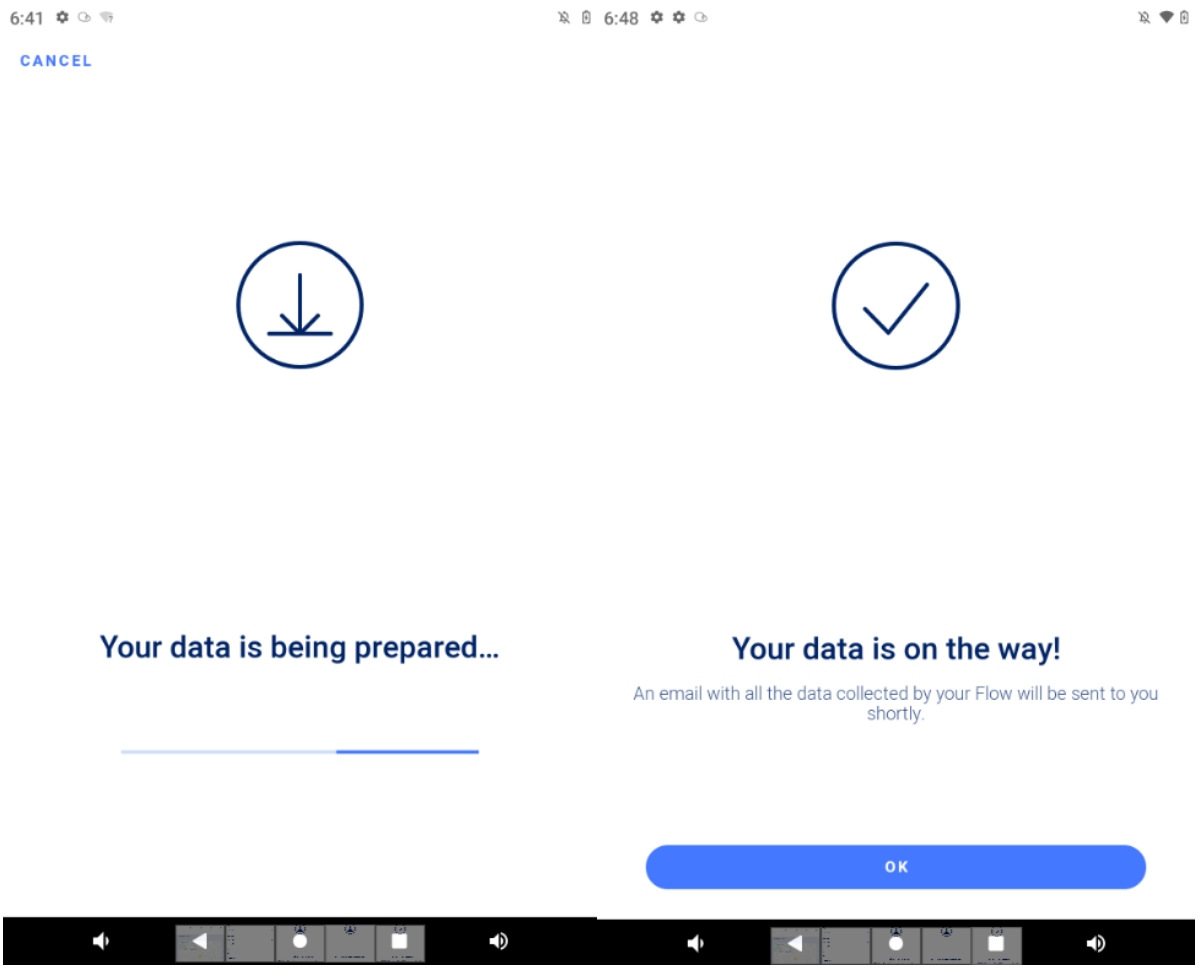


Image 4: Your data is being prepared.

Image 5: Your data is on the way.

Best practices:

- The tablet does not need to be in the vicinity of the monitor at all times. You may leave the tablet plugged in to the charger and let if continually charge at your home during the week.
- The Flow monitor has a battery life of 24+ hours. This may be charged overnight and kept on your person during the day without worrying about the battery dying. While the monitor is plugged in and charging, please ensure that the light at the bottom of the device is either flashing red, flashing yellow, or solid green. A flashing red or yellow light means that it is charging, and the battery is almost dead (if red) or partially charged (if yellow). A solid green light means that the monitor is fully charged.

APPENDIX H. INFORMATION SHEET FOR CHAPTER THREE

UNIVERSITY OF CINCINNATI INFORMATION SHEET FOR RESEARCH STUDY

STUDY TITLE: **Occupation-Related Stress of Home Healthcare Workers and Ambient Pollution Exposures**	
PRINCIPAL INVESTIGATOR NAME: **Thomas Gerding, MPH**	**PHONE NUMBER (24-hour Emergency Contact)** **(859) 446-1905**
FACULTY ADVISOR (if PI is student): **Jun Wang, PhD**	**DEPARTMENT:** **Environmental and Public Health Sciences**

INTRODUCTION

You are being asked to take part in a research study. Please read this paper carefully and ask questions about anything that you do not understand.

This research is sponsored by the National Institute for Occupational Safety and Health through the Targeted Research Training Program of the University of Cincinnati Education and Research Center.

WHO IS DOING THIS RESEARCH STUDY?

The person in charge of this research study is Thomas Gerding, MPH of the University of Cincinnati (UC) Department of Environmental and Public Health Sciences. He is being guided in this research by Jun Wang, PhD.

WHAT IS THE PURPOSE OF THIS RESEARCH STUDY?

The purpose of this research study is two-fold. The first purpose is to investigate the relationship between daily work-related stressors and changes in salivary cortisol levels using self-collected saliva sampling. Cortisol is a hormone that is released in the body when one feels stressed. The second purpose is to correlate changes in salivary cortisol levels with exposure to ambient air pollution while typical working days are completed with the use of lightweight, personal air samplers. This is an exploratory aim to determine if there is a relationship between airborne pollution exposure and cortisol levels.

WHO WILL BE IN THIS RESEARCH STUDY?

About 12 people will take part in this study. You may be in this study if you are:

- 18 years old or older;
- Employed as a home healthcare worker in the greater Cincinnati area;
- Do not have mental/physical health conditions known to affect the hypothalamic-pituitary-adrenal (HPA) axis (i.e., Cushing's disease or major depression)
- A non-nicotine user
- Fluent English speaker

WHAT IF YOU ARE AN EMPLOYEE WHERE THE RESEARCH STUDY IS DONE?

Taking part in this research study is not part of your job. Refusing to be in the study will not affect your job. You will not be offered any special work-related benefits if you take part in this study.

WHAT WILL YOU BE ASKED TO DO IN THIS RESEARCH STUDY AND HOW LONG WILL IT TAKE?

You will be asked to complete a brief enrollment survey. This survey will take approximately 5 minutes to complete. The survey will take place digitally, in a computer program called REDCap. Survey response data will be collected and stored in REDCap. As the survey will be completed online, it can be taken at a time convenient for you. Following the conclusion of the survey period, a select group of up to 12 participants will be asked to complete this study.

Should you be asked to participate, you will be provided with sufficient saliva sampling vials to provide three saliva samples per working day and a daily stress diary for a period lasting one work week. Sample vials should be stored within the Salimetrics saliva vial storage box which should be stored within a refrigerator until returned to the principle investigator (PI), Thomas Gerding. An individual who works three twelve-hour shifts would receive nine vials while an individual who works five eight-hour shifts would receive fifteen vials. The three saliva samples will be self-collected at the following times:

- once at the beginning of the work shift,
- once at the start of the lunch break,
- and once at the end of the work shift.

Additionally, you will be asked to document any stressors in the provided daily stress diary including whether the stressor was work related, the severity of the stressor, and any other relevant details about the occurrence.

Lastly, a lightweight personal air monitor (Flow 2, Plume Labs Inc., Paris, France) will be utilized to record airborne pollutant exposure over the course of the work week. The pollutants recorded by this air monitor at one-minute intervals include particulate matter ranging in sizes of 1 micron and smaller, 2.5 microns and smaller, and ten microns and smaller (PM_1, $PM_{2.5}$, and PM_{10}), NO_2, and volatile organic compounds (VOCs). The monitor may be attached to your backpack or laptop bag to keep this with you as you navigate the workday, going from house to house. The air monitor that will be assigned to you will also have an accompanying Android tablet (Tibuta MasterPad T100, Tibuta Inc., Goa, India) with which the data will be extracted through. As the monitor has the capacity to store up to five days worth of data, this extraction will need to occur on the 4th and final days of sampling. The purpose of this portion is to determine if there is a statistical relationship between air pollution exposure and cortisol levels.

All activities related to this study will be conducted at your place of employment; it will not be necessary to come to the University of Cincinnati as saliva samples will be self-collected. Upon completion of the study period, samples and diaries will be collected by the PI who will meet you at a time and place convenient for you and any materials will be stored at Kettering Laboratory at the University of Cincinnati.

ARE THERE ANY RISKS TO BEING IN THIS RESEARCH STUDY?

It is not expected that you will be exposed to any risk by allowing your saliva samples or subjective stress data to be used in this research study. Your name and any information that could be used to identify you will be removed from all saliva samples and diaries collected as part of this research study. All saliva samples and diaries will be assigned a unique code to protect your identity.

ARE THERE ANY BENEFITS FROM BEING IN THIS RESEARCH STUDY?

You will not receive any benefits by participating in the research study. However, knowledge gained through your participation in this research study may help the scientific community gain a better understanding as to how experiencing occupational events can impact personal stress levels, especially within the home healthcare sector.

WHAT WILL YOU GET BECAUSE OF BEING IN THIS RESEARCH STUDY?

Participants in this study will each receive a $50 Amazon gift card upon completion of the study and the return of all study materials.

DO YOU HAVE CHOICES ABOUT TAKING PART IN THIS RESEARCH STUDY?

If you do not want to take part in this research study, you may simply choose not to participate.

HOW WILL YOUR RESEARCH INFORMATION BE KEPT CONFIDENTIAL?

Information about you will be kept private by assigning a unique code to all saliva samples and data. A key that links the unique code to your individually identifying information will be kept in a secure location that can only be accessed by the study team.

Your information and the saliva samples collected as part of this research project will not be used or distributed for future research studies, even if identifiers are removed. Viable saliva samples will be stored within our laboratory in the Kettering Laboratory building at the University of Cincinnati will be stored no longer than six months after the conclusion of the data analysis. This is to reanalyze samples, if necessary, for quality assurance purposes. Data collected regarding air pollution exposure will be retained so as to provide if requested once the study team submits the final manuscript to a journal.

Study data will be kept in a locked cabinet in Dr. Jun Wang's lab within the Kettering Laboratory building at the University of Cincinnati for two years upon completion of the study. Federal regulations require the signed consent documents (i.e., this form) be retained for a minimum of three years upon completion of the study. Upon completion of the study, computerized records will be deleted, and paper research files will be shredded. The data from this research study may be published, but you will not be identified by name.

Agents of the University of Cincinnati and the National Institute for Occupational Safety and Health may inspect study records for audit or quality assurance purposes.

Your identity and information will be kept confidential unless the authorities have to be notified about abuse or immediate harm that may come to you or others.

WHAT ARE YOUR LEGAL RIGHTS IN THIS RESEARCH STUDY?

Nothing in this consent form waives any legal rights you may have. This consent form also does not release the investigator, the National Institute for Occupational Safety and Health, the institution, or its agents from liability for negligence.

WHAT IF YOU HAVE QUESTIONS ABOUT THIS RESEARCH STUDY?

If you have any questions or concerns about this research study, you should contact Thomas Gerding, MPH at gerdintr@mail.uc.edu or you may contact Jun Wang, PhD at wang6ju@ucmail.uc.edu.

The UC Institutional Review Board reviews all research projects that involve human participants to be sure the rights and welfare of participants are protected.

If you have questions about your rights as a participant, complaints and/or suggestions about the study, you may contact the UC IRB at (513) 558-5259. Or, you may call the UC Research Compliance Hotline at (800) 889-1547, or write to the IRB, 300 University Hall, ML 0567, 51 Goodman Drive, Cincinnati, OH 45221-0567, or email the IRB office at irb@ucmail.uc.edu.

DO YOU HAVE TO TAKE PART IN THIS RESEARCH STUDY?

You do not have to take part in this research study. Refusing to take part will not result in any penalty or loss of benefits that you would otherwise have. You may skip any questions that you don't want to answer.

You may start and then change your mind and stop at any time. To stop being in the study, please contact the study PI, Thomas Gerding, at gerdintr@mail.uc.edu.

BY TURNING IN YOUR COMPLETED SURVEY (or BY TAKING PART IN THESE ACTIVITIES) YOU INDICATE YOUR CONSENT FOR YOUR ANSWERS TO BE USED IN THIS RESEARCH STUDY.

PLEASE KEEP THIS INFORMATION SHEET FOR YOUR REFERENCE.

APPENDIX I. EXAMPLE STRESS DIARY FROM CHAPTHER THREE

SAMPLE STRESS DIARY

Name: Steve

Date: 8/25/22 Is this a typical day (describe): Yes

CIRCLE ONE: SA M T W TH F SU

Complete the Stress Diary Below. Copy this form for additional space.

Time of Day	Intensity of Stress (0-10) 0 = no stress, 10 = most stressful	Duration of Stress	Situation (circumstance, location, people, etc.)	Triggering Event (preceding event, if applicable)	Emotional Behavioral Reaction (your feelings about the event)
9:00am	4	30 min	Woke up too late and came in late to work.	I went out last night until 2:00am the night before.	I got mad at my spouse for not waking me up soon enough.
11:30am	5	1 hour	I couldn't finish a work assignment that needed to be completed by now. It took me longer than expected to finish.	My boss set an unrealistic time frame for this assignment.	I was extremely nervous because of not being able to finish the assignment on time.
2:00pm	3	30 min	I overheard my co-worker talking about my poor performance lately with my superior.	I have been feeling overburdened between work and family needs.	I feel that I am juggling too many things in life and overwhelmed.
3:30pm	2	2 hours	I feel like I need to find a different job that will be less stressful and I will be able to better provide for my family.	Repetitive negative thinking regarding where I am at in life.	I feel inadequate.