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Burnout in Cybersecurity Incident Responders: Exploring the Factors that Light the Fire

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As concerns about employee burnout and skilled staff shortages in cybersecurity grow, our study aims to better understand the contributing factors to burnout in this field. Utilizing a mixed-methods approach, we analyze self-reported job and personal characteristics, along with digital activity data from 35 incident responders, identifying several factors such as high workload, time pressure, and lack of support from management. Our findings reveal that over half of the participants experience burnout (N=19), which is linked to increased workload, limited control, poor teamwork, and inadequate recognition. Burned-out responders often work more than 40 hours per week, have poor sleep quality, and engage in more email activities, meetings, and after-hour collaborations. Through our research, we also identify coping strategies individuals use to mitigate these stressors. Based on our findings, we provide practical recommendations to help organizations better support their cybersecurity incident response teams. While our study acknowledges limitations and suggests future research directions, it contributes significantly to understanding the challenges faced by cybersecurity incident responders. Our insights offer a comprehensive understanding of burnout factors in this domain and have broader implications for other high-stress work environments consistent with the interdisciplinary nature of CSCW.

CCS Concepts: • **Human-centered computing** → **Empirical studies in HCI**; *User studies*; *Empirical studies in collaborative and social computing*; *Empirical studies in ubiquitous and mobile computing*.

Additional Key Words and Phrases: Burnout, Stress, Work exhaustion, Cybersecurity, Incident response, Security responders, Activity patterns, Workplace behavior, Job Demands-Resources, Digital activity

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1 INTRODUCTION

Cyber threats are not only growing in number but also becoming more sophisticated and pervasive [54, 56]. This landscape has fueled a massive demand for frontline security defenders, also known as security incident responders [17]. These specialized security professionals are responsible for uncovering vulnerabilities, preventing, detecting, and responding to an ever-evolving threat landscape [87]. The cybersecurity field encompasses various roles and responsibilities, ranging from building secure systems to leadership and everything in between. However, security incident responders possess a unique skill set that makes them highly sought after. Organizations often establish dedicated teams for handling incidents, commonly referred to as Cyber Security Incident Response Teams (CSIRT), Security Operation Center (SOC) analysts, or Cyber Emergency Response Teams (CERT). Despite the critical role of security incident responders in an organization's operations, many entities struggle to fill positions on their security teams due to a significant shortage of skilled professionals. Estimates indicate that millions of cybersecurity positions worldwide remain unfilled, including the essential role of security incident responders [55]. The crux of this issue lies not only in the scarcity of qualified candidates but also in the challenge of retaining skilled and experienced employees [58].

Security incident response is a high-stress, high-demand job [55, 58]. The security incident responders have to act with speed and accuracy to thwart the cyber attacks. Faster response time results in quicker mitigation of attacks minimizing the damage that the incident can cause [54, 56]. That means the security responders must be constantly vigilant about new and upcoming threats. Threat actors are continuously active; they can be in any part of the world and can potentially compromise systems at any moment, requiring that the incident responders be available 24x7, even during off-hours and holidays, to ensure constant coverage [54–56, 58]. In addition, the incidents have to be handled in an exceptionally effective manner. Any failure in doing so can be highly visible, publicized and can have a costly impact in terms of money, the reputation of the organization, and the privacy of customers' data. Along with all these responsibilities, security responders often work on multiple overlapping incidents simultaneously because of the growing volume of cyberattacks, despite the limited number of skilled professionals. Handling multiple incidents amidst the increasing cyberattacks and limited professionals adds more pressure on the workers, exacerbating their work stress. Unlike occasional occupational stress that one can recover from, the constant high demand on the job can hinder recovery, pushing the incident workers to the far end of the stress continuum, resulting in burnout. Data shows that almost two-thirds of security operations center (SOC) staffers leave their jobs due to stress and burnout [53, 57]. As the threats worsen, resources are constrained and more loaded, and security professionals have to deal with the tasks urgently and effectively. Such a scenario leads to a vicious cycle of burnout/attrition and an increased workload for the remaining personnel.

In this study, we undertake an important first step to understand and characterize burnout in security incident responders. Burnout can be defined as a, “*work-related state of exhaustion that occurs among employees, characterized by extreme tiredness, reduced ability to regulate cognitive and emotional processes and mental distancing*” [104], and can occur due to chronic interpersonal stressors on the job [75]. Specific symptoms of burnout include exhaustion, such as lacking energy, feeling tired quickly, and an inability to relax after work. When workers are exhausted all the time, they are prone to emotional and cognitive impairment, such as feeling frustrated and angry at work, poorer memory, and trouble staying focused at work. Such emotional and cognitive impairment is usually followed by detachment from work, a cynical attitude and disinterest in

work [104]. Ultimately, burnout can lead to poor performance and turnover intention [75]. In addition, burnout can have lasting harmful effects on an individual's physical and mental health, including insomnia [111], depression [107], anxiety [124] and substance use disorder [26]. At the same time, it can accrue both direct and indirect costs for organizations. For instance, security workers experiencing burnout may become detached from their jobs and are more likely to leave their positions. Such detachment and likelihood to leave means that the organization has to hire new security professionals (which there is a shortage of) and train them while enduring lost productivity as they locate replacements [64, 66, 92]. Furthermore, the lack of adequate staff or experienced or skilled security professionals increases the likelihood of security breaches [24, 112]. Hence, burnout in security professionals is a critical issue that requires more attention.

In this work, we study $N=35$ security incident responders from a large information technology company using several self-reports about their job characteristics and behavior. We categorize participants into burnout and non-burnout groups according to the recommended cut-off scores from the validated single-item burnout survey utilized to assess their burnout levels [33]. We also collect and analyze six months of retrospective digital activity data from the workers' computers. Overall, the contributions of our work are as follows:

- We assess the level of burnout and progression of burnout symptoms in a sample of $N=35$ security incident responders, discovering that many participants are burned-out and exhibit high scores in the work exhaustion dimension of burnout.
- We investigate various individual, situational and organizational factors that influence burnout, comparing and contrasting between burnout and non-burnout groups. We find that the burnout group reports working more than 40 hours a week, higher job demand, poorer sleep quality, lower workplace recognition, and less team support than the non-burnout group.
- We collect and analyze high-level telemetry data from participants' work computers to objectively validate our findings from self-reports. The digital activity data confirms that the burnout group sends more emails and works more during after-hours and on weekends.
- Through open-ended questions, we gather participants' perspectives on their stressors and coping mechanisms. We perform a thematic analysis to identify common stressors, such as high workload, and explore the various coping strategies employed, with the majority taking breaks to manage stress.
- We discuss our findings and offer potential recommendations or opportunities to help alleviate burnout in security responders.

Our study is relevant to the HCI and CSCW communities due to several key aspects. By employing a mixed-methods approach, we combine self-reported data and passively sensed telemetry data from participants' computers, showcasing the interdisciplinary nature of CSCW research. This methodology provides a comprehensive understanding of burnout factors in cybersecurity incident responders, an important but rarely explored population in the literature. Security incident responders are our first line of defense in a cyber attack, and burnout can hurt their ability to protect against threats and breaches. With this exploratory study, we seek to contribute to the burnout literature and information systems literature by emphasizing the importance of understanding the profession and its pervasive burnout phenomenon. Only then can we propose and implement practical solutions to address the issue. Our findings offer valuable insights to help inform the development of relevant strategies across various fields, guiding organizations to support their incident response teams better. The recommendations that we make, such as fostering collegiality, teamwork and monitoring workload levels, resonate with the CSCW community's interest in exploring how technology can facilitate cooperation and collaboration in diverse contexts [7, 51, 118]. Furthermore,

our study's relevance is emphasized by its connection to previously published security-related papers within the CSCW community, addressing various aspects of IT security, system administration work, and the role of Chief Information Security Officers, among other topics [10, 27, 61, 62]. By building upon these existing works, our research examines a wide range of factors influencing wellbeing and burnout, enhancing the body of knowledge on security and wellbeing in the context of the CSCW community.

The structure of the paper is as follows. We describe the related work in Section 2 and then detail our exploratory framework in Section 3. We elaborate on our study and data collection in Section 4. We discuss the different analyses we perform in Section 5. In Section 6, we go through the results; first, the burnout level of the participants and their symptoms. Second, we analyze different factors that influence burnout and compare those factors between the burnout and non-burnout groups of participants. Third, we perform thematic analysis on the open-ended questions to identify the stressors the participants face in their jobs and the coping mechanisms they use to deal with the stress. Following this, we discuss the findings of our work in Section 7. We also highlight some suggestions or recommendations to help ease burnout in Section 7. Finally, we discuss the limitations of our work in Section 8 and present some concluding remarks in Section 9.

2 RELATED WORK

In this section, we delve into existing research that forms the foundation of our investigation, concentrating on the well-being of security incident responders, their susceptibility to burnout, and the role of passive sensing in monitoring the well-being of workers.

2.1 Security Incident Responders and Burnout

Burnout has been studied extensively, and researchers generally agree that certain situational, individual, and organizational factors are responsible for it [75]. Interestingly, situational and organizational factors play a more significant role in burnout than individual ones [72, 81, 89]. These factors primarily include (but are not limited to) the workload, sense of control, reward, social support, fairness, and values associated with the job [75]. For example, when individuals are repeatedly overloaded with work and are not able to meet the demands of the job, they will likely experience burnout [13]. Similarly, a lack of positive reinforcement and social support at work has also been associated with burnout [37]. It is important to note that burnout leads to adverse outcomes for the organization and the individuals themselves. On an organizational level, burnout may lead to job withdrawal, counterproductive work behaviors, and ultimately employee turnover [75, 92, 99]. González-Morales et al. [40] report that burnout can also be contagious to colleagues and teams due to increased personal and task-related conflict. On an individual level, burnout has been shown to be associated with several mental health issues such as depression [107], anxiety [124] and sleep disorders [111]. Also, people experiencing burnout are likely to face work-family conflict as well [91]. Regarding physical health, researchers find that burnout is associated with headaches, stomach problems, palpitations, and other complaints [1, 75]. One study reports that burned-out individuals are 79% more likely to develop coronary heart disease than others [117].

Initially, burnout was only studied within the caregiving and service occupations [75]. The studies then expanded to occupations requiring casual contact with service recipients and disciplines without direct personal contact with the people [75]. Some fields where burnout has been extensively studied include teachers, healthcare and social workers, nurses, physicians, and police officers [110]. In addition, numerous studies have examined the prevalence of burnout among information workers, such as software developers and project managers [77, 109]. Prior research has also employed burnout theories to analyze cybersecurity behaviors in regular employees, frequently neglecting the experiences of security incident responders. Most of these studies investigate the concept of

privacy or security fatigue, wherein individuals feel drained and overwhelmed due to the persistent requirement to protect their online information [23, 25, 95]. Consequently, they might exhibit less care with their privacy and security, elevating their susceptibility to online threats. For instance, Cram et al. [25] delved into information security fatigue caused by the profusion of security policies and guidelines. Simultaneously, other studies have probed privacy fatigue stemming from managing online personal data [23] and cyber-fatigue resulting from an overabundance of cybersecurity demands [95]. Nevertheless, the exploration of burnout in the context of security incident responders remains largely under-investigated and under-researched. Sundaramurthy et al. [114] share how there is little contact between security practitioners and academic researchers, which may be responsible for the scarcity of research focused on security incident responders. They share a list of reasons for this gap—the sensitive environment the analysts work in, which discourages sharing information with outsiders, the intensive workload that does not give them any spare time to share information, and the fundamental difference between the two jobs, i.e., while academicians create and share knowledge, security professionals work independently without exposing their knowledge. Sundaramurthy et al. [114] also mention that most research is irrelevant or far from reality, so they receive little credibility and have little impact among security practitioners. As a result, security analysts are often cautious of researchers, “*as they are perceived to be interested in publications rather than solving real problems*” [114]. There is, however, some work that is relevant to our study. In a systematic review conducted by Agyepong et al. [3], the authors report that burnout is a significant challenge SOC analysts face. The authors list several problems that may lead to burnout in security analysts: the increasing volume of security events, false positives and negatives, sophisticated attacks, incident management, skill shortage, inadequate communications across teams, and increased workload. Some of these problems are also confirmed by Hull [52], who interviews SOC analysts regarding their experience with burnout. Ogbanufe and Spears [87] suggest that frontline cybersecurity professionals, which they consider to be those security workers who are involved in uncovering vulnerabilities—preventing, detecting, and responding to an ever-shifting threat landscape—may experience higher levels of burnout. Security incident responders have unique job demands, such as high secrecy, quick mitigation time, and round-the-clock vigilance. Therefore, the authors suggest they may be more susceptible to burnout. In a study conducted by Sundaramurthy et al. [113], the authors find that SOC analysts face constant challenges in justifying their value to management as the value of SOC goes unnoticed until there is a breach. The authors also observe that the analysts have to endure long working hours and that the rotation of shifts may be necessary to ensure that workers do not feel isolated and left behind. They highlight the need for analysts to feel motivated and excited about their jobs. Finally, Chappelle et al. [22] examine cyber warfare operators in the United States Air Force and find that 15.06% of active duty participants (N=376) are highly stressed. The authors identify high pressure, overload of cyber threats, and maintaining top-secret information as some factors that have the potential for burnout.

2.2 Passive Sensing for Worker Wellbeing

An increasing amount of work uses data collected from ubiquitous devices, such as smartphones, wearables, and computers, to study workplace behavior and wellbeing [83]. For example, the Tesseract project collected smartphone, wearable, and social media data from 700 information workers in the US to investigate the relationship between sensor data and workers’ performance, psychological traits, and wellbeing [76]. Similarly, Zakaria et al. [122] utilized location data from in-office Wi-Fi sensors to analyze movement and group interaction patterns, exploring their association with worker stress and depression. Das Swain et al. [29] present a new method to measure Person-Organization fit using routine similarity, analyzing activity patterns with Bluetooth sensing

to understand its impact on job performance, wellbeing, and stress. While numerous studies have looked into stress, anxiety, and mental wellbeing at the workplace through the lens of objective data [82–84], very few studies have examined burnout specifically. Lou et al. [69] use passively collected electronic health record (EHR)-based audit log data to predict physician burnout, obtaining an area under curve (AUC) score of 0.83. In follow-up work, the authors propose an end-to-end deep learning-based approach that uses raw activity logs in EHR to predict physician burnout [67]. Wu et al. [120] study burnout with the help of social media data collected from N=1532 Weibo users. Similarly, Grossi et al. [44] use a wearable to track the sleep duration of N=104 office workers across 14 days. Authors find that while self-reported sleep quality was predictive of burnout, the objective sleep duration collected via the wearable was not. Mendelsohn et al. [79] also report that daily sleep and daily steps tracked via a wearable did not affect resident physicians' burnout. All these studies are either conducted in the general population or among physicians; hence, we do not find any work that uses objectively sensed data to study burnout in cybersecurity workers.

In this work, we study the factors contributing to burnout among cybersecurity incident responders and suggest possible prevention and mitigation approaches. While numerous studies have investigated burnout in various professional domains, our research uniquely focuses on a critical yet understudied population that faces distinct challenges. Frontline cybersecurity workers encounter specific stressors, such as rapidly evolving threat landscapes, high stakes of potential data breaches, round-the-clock vigilance, and skill shortages, which set them apart from other high-stress jobs, such as live support teams. These unique stressors highlight the importance of studying burnout in this context to develop tailored interventions and support mechanisms. Moreover, our study employs a mixed-methods approach, combining self-report measures of personal and job characteristics with passively sensed telemetry data from participants' computers (referred to as 'digital activity') to provide a more comprehensive understanding of burnout factors and their relationships. This methodological approach enables us to investigate the complementary value of these data sources, offering additional insights beyond those obtained through traditional self-report measures alone. Lastly, our qualitative study on security incident responders' stressors and stress coping mechanisms provides a deeper understanding of the unique experiences of this population, further informing the development of targeted interventions and support strategies. By addressing these specific aspects, our study contributes valuable knowledge to the existing literature on burnout, particularly in the context of cybersecurity incident responders.

3 EXPLORATORY FRAMEWORK

Although various conceptual models have been suggested about burnout and its subsequent impacts [75], it is generally agreed upon that certain factors are associated with it (as antecedents as well as outcomes) [75]. To help identify potential burnout factors, we follow an iterative design process in which we review prior work and interview professionals working in the space. We decided on five factors for this study: wellbeing, job demands, personal resources, social resources, and job content resources. Our work heavily borrows from the widely confirmed Job Demands-Resources (JDR) model [31], which seeks to elucidate the factors contributing to job strain and work engagement, along with their potential consequences on employees' wellbeing and job performance. According to the JDR model, individuals experience burnout when they face persistent job demands without adequate resources to address and alleviate those demands [31]. The model postulates two main categories of job characteristics:

Job Demands: These encompass a job's physical, psychological, social, or organizational aspects that necessitate sustained physical or mental effort and entail certain physiological or psychological

costs. Job demands, such as work pressure, emotional demands, and work-home interference, can lead to negative outcomes like exhaustion, burnout, and decreased job satisfaction.

Job Resources: These comprise the physical, psychological, social, or organizational aspects of a job that assist employees in achieving work goals, reducing job demands and associated costs, as well as promoting personal growth, learning, and development. Examples include job autonomy, social support, feedback, and opportunities for skill development. Job resources contribute to positive outcomes like work engagement, job satisfaction, and improved job performance.

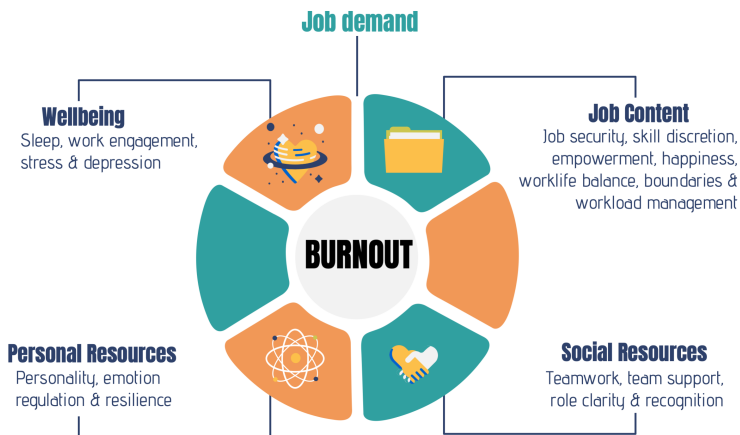


Fig. 1. Factors influencing burnout. In this study, we consider five factors that influence burnout: job demand, wellbeing, personal resources, job content resources, and social resources.

As part of our work, we evaluate participants' job demands. The greater the job demands, the more physical and psychological effort employees must expend to maintain performance, avoid exhaustion, and achieve their goals [75]. Consequently, unrelenting job demands can result in long-lasting physical and psychological costs, ultimately culminating in burnout. Regarding job resources that better equip individuals to handle job demands, we gather information on three distinct types of resources: personal, organizational, and social. Personal resources refer to individual variables or characteristics that enable a person to effectively control and influence their environment [12, 106]. Some examples of personal resources we consider are personality, emotion regulation, and resilience. We also explore two situational or organizational variables: social work resources and job content resources. Both job aspects protect against the negative impact of job demand and play a role in achieving occupational goals, personal growth, and professional development [31, 100]. Regarding social resources, we assess teamwork, team support, role clarity, and recognition. For job content, we evaluate job security, happiness, skill discretion, empowerment, worklife balance, boundaries, and workload management. Furthermore, the JDR model posits that high job demands and insufficient job resources contribute to burnout and strain, leading to adverse health outcomes and diminished job performance over time. Therefore, we also assess participants' wellbeing. For wellbeing, we specifically analyze sleep, stress, depression, physical activity, and work engagement. Although

work engagement can be defined as a separate outcome altogether, it is also considered a state of wellbeing [101, 105]. Wellbeing can directly affect burnout, but symptoms of burnout can also negatively impact wellbeing, making it essential to assess participant wellbeing.

In this exploratory study, we avoided having predefined hypotheses for the relationships between burnout and all the variables we mentioned earlier. Since burnout in cybersecurity incident responders remains relatively unexplored, our study aims to uncover new insights and trends that could inform future hypothesis-driven research in this area. By examining these factors and their interrelationships, we hope to understand the complex dynamics underlying burnout and its consequences within this population. The understanding gained from our study could then be used to develop targeted interventions and strategies for reducing burnout risk, as well as promoting employee wellbeing among cybersecurity incident responders.

4 METHODOLOGY

In this section, we outline the methodology of our study, which encompasses the study design, demographic profile of participants, methods for assessing burnout, and the factors that may influence burnout among security incident responders.

4.1 Study Design

We recruit security incident responders from a well-established, global information technology corporation with diverse products and services, including software, hardware, cloud computing, and cybersecurity solutions. With a long-standing presence in the industry, the company serves a broad clientele, including individual consumers, small businesses, and large enterprises across various sectors. Security workers in the company are sent emails inviting them to take part in the study. As part of the requirements, participants must reside in the US, be working in the company for 1.5 years, and, importantly, be primarily working in a security incident responding role. The 1.5 years experience is deemed a necessary limit to abstain from potential participant bias; prior literature suggests that the first initial months could basically be the ‘honeymoon phase,’ i.e., the transition phase where the employees are learning, building their network, and could be more engaged in their work solely as a result of the change in environment [36]. We recruited a total of 35 responders for the study—participants are required to answer multiple surveys and allow access to their anonymized telemetry data for the past six months. We collect high-level metadata on participants’ meetings, emails, calendars, calls, and weekend work habits through Microsoft’s Viva Insights¹. Viva Insights captures de-identified activity aggregates in 30-minute windows for Microsoft tools across all devices associated with an individual’s account. The total expected duration of our study is under an hour, and participants are compensated with a \$200 gift card for their time and data. This amount is selected to help lower the perceived burden of an already significantly stressed population. Participants are also allowed to complete the survey over multiple sessions as needed. The study is approved by the company’s internal institutional review board (IRB).

4.2 Demographics

Table 1 shows the demographics of our participants. The majority of our participants identify as men (68.6%, N=24). In terms of age group, most participants are in the 26-35 (37.1%, N=13) and 36-45 (28.6%, N=10) age range. The majority of the participants worked remotely (57.1%, N=20) during the six months before the study. With respect to their years of experience at the current company, 34.3% (N=12) have been working in the company for under 3 years (but more than 1.5

¹<https://learn.microsoft.com/en-us/viva/insights/Use/Metric-definitions>

years), 20% (N=7) have been working for the last 4 to 6 years, 14.3% (N=5) have been working since 7 to 9 years, and 31.4% (N=11) have been working for 10 or more years.

Table 1. Demographics of the participants. The table below lists the demographic composition of the participants in our study.

Category	Count	Percentage
<i>Gender</i>		
Woman	10	28.6%
Man	24	68.6%
Prefer not to answer	1	2.8%
<i>Age</i>		
18-25	2	5.7%
26-35	13	37.1%
36-45	10	28.6%
46-55	4	11.4%
56-65	5	14.3%
Prefer not to say	1	2.9%
<i>Working situation in past six months</i>		
Hybrid	12	34.3%
Remote	20	57.1%
Onsite	3	8.6%
<i>Years of experience at current company</i>		
1.5-3	12	34.3%
4-6	7	20.0%
7-9	5	14.3%
10 and above	11	31.4%

4.3 Measuring Burnout

We assess the burnout level of participants using validated surveys (i.e., surveys that have been tested for reliability and validity through previous research studies). The Burnout Assessment Tool (BAT) [104] is a self-reported instrument that asks questions about the work situation and how individuals experience these situations. In particular, participants have to answer 23 questions on a scale from 1-5, where 1 indicates that they never experience such a situation, whereas 5 indicates that the participants always experience it. The final score is obtained by adding the scores on all items and dividing them by 23 (i.e., taking an average). In addition to the total burnout score, BAT also captures four core dimensions of burnout: 1) exhaustion, characterized by severe loss of energy resulting in both physical and mental tiredness; 2) emotional impairment, referring to reduced ability to regulate emotional processes and a sense of being overwhelmed by one's emotions; 3) cognitive impairment, which includes having issues in remembering information, paying attention, and poor cognitive performance in general; and finally, 4) mental distance, characterized by psychological detachment and mental withdrawal from work. BAT allows us to assess how far along participants are in each of these four burnout symptoms or dimensions, in addition to their overall burnout level. We also use a different validated, single-item burnout (SIB) [33] inventory that is a simpler method to capture the perceived burnout level of the participants. It simply asks, "Overall, based on your definition of burnout, how would you rate your level of burnout?". To which, the participant can answer from 1 to 5. Options 1 and 2 suggest that they enjoy their work and might occasionally be stressed but not feel burned-out. However, 3 and above options are reflective of burnout severity.

For instance, option 3 says, “*I am definitely burning out and have one or more symptoms of burnout, such as physical and emotional exhaustion*”. Option 4 and 5 indicate higher severity; 4 inquires how their symptoms of burnout would not go away and if they are frustrated a lot at work, and 5 asks when they feel completely burned-out and need some change in their life.

4.4 Measuring Factors Influencing Burnout

We measure all the factors mentioned in Section 3 with the help of self-reports obtained from the participants. We list all the factors and associated attributes we study in Table 2. We cite the validated surveys that we use in the table, and in case of self-constructed single-item questions, we list the question as-is. Note that all the single-item questions are answered on a Likert scale from 1 to 5 (1: *strongly disagree* and 5: *strongly agree*). The following are the different attributes/variables we collect from the participants:

Sleep: Sleep improves the capacity to regulate emotions, making it easier to manage or let go of stress [119]. Prior research finds that “too little sleep” is the main risk factor for burnout development [111]. As listed in Table 2, in this study, we use the Pittsburgh Sleep Quality Index (PSQI) [21] (with 18 items) to gather sleep-related information from the participants. PSQI groups responses into seven components: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbance, use of sleep medication, and daytime dysfunction.

Depression and stress: Depression and stress in the workplace have been explored in previous studies [108], and people who suffer from burnout often exhibit symptoms for both [107, 124]. We use 7-items of Depression, Anxiety, Stress Scale (DASS) [47] and 10-items of Perceived Stress Scale (PSS) [116] to assess participants’ depression and stress, respectively.

Physical activity: We assess how physically active the participants are with the help of the Nordic Physical Activity Questionnaire (NPAQ) [28], which has 4 items. Studies find that physical activity moderates individuals’ burnout and mental health [38, 39]. The NPAQ asks participants to report the amount of time in minutes that the participants spend doing moderate and vigorous physical activities on a typical week, both during their leisure time as well as while they are on the job. The current Public Health Guidelines for Physical Activity recommends that adults accumulate at least 150 minutes each week of moderate-intensity activity or 75 minutes of vigorous activity [88].

Work engagement: We finally look at work engagement, which is often considered to be the positive antipode of burnout and the general literature shows that there is a negative relation between these factors [14]. Whereas burnout refers to a state of exhaustion, cynicism, and impairment, engagement is characterized by a high level of energy and mental resilience while working (i.e., vigor), strong enthusiasm and identification with one’s work (i.e., dedication), and full concentration and engrossment in one’s work (i.e., absorption) [102]. We use the 9-item Utrecht Work Engagement Scale (UWES) [102] to assess all three dimensions of work engagement.

Job demand: Job demand refers to physical or psychological demands at work such as long working hours, high time pressure, and excessive work [121]. When the demands of the job increase and exceed a person’s ability to face their work, it may be perceived as a threat [16]. It is important to note that excessive job demand does not necessarily lead to burnout if the workers have the time to recover. Chronic excessive job demands and little to no recovery time are when the stressor increases burnout. We sum up 6 items from the Job Content Questionnaire (JCQ) [60] to assess Job demands.

Personality: Since personality influences how an individual interacts and deals with the world and copes with stressful situations, it plays a role in the development of burnout as well [6, 90]. We assess participants’ personalities using the 10-item version of the Big Five Inventory (BFI) [94].

Emotion regulation: Emotion regulation can be defined as, “*the process by which individuals*

influence which emotions they have, when they have them, and how they experience and express these emotions” [42]. Prior work finds that the ability to modulate emotions to achieve desirable emotional outcomes can influence burnout [18, 71]. In this study, we measure responders’ tendency to regulate their emotions in two ways: (1) Cognitive Reappraisal and (2) Expressive Suppression through the 10-item Emotion Regulation Questionnaire (ERQ) [43]. Cognitive reappraisal refers to changing the way one thinks about a situation in order to change its emotional impact. In contrast, expressive suppression is an attempt to hide or inhibit behavioral expression of emotion [42].

Resilience: We measure resilience at work using a single-item question mentioned in Table 2. Resilience refers to an individual’s ability to be resilient and cope with stress levels, strain, and burnout. Prior research, mostly in the healthcare sector, finds that resilience inhibits burnout symptoms [8].

Teamwork and team support: Teamwork and team support are related concepts. Whereas teamwork refers to an individual’s sense of the level of cooperation among team members on the same team (i.e., working in the same direction to be successful), team support is the assessment of the support they get. Due to the interdependence of workers on each other, prior studies show that quality teamwork and team support could protect workers against burnout [68, 80]. We measure teamwork and team support using a single-item question mentioned in Table 2.

Role clarity: Role clarity can be defined as the individual’s level of understanding of what is expected (goals, behavior and performance) of them. Role clarity offers workers certainty about their roles and responsibilities and gives them a sense of direction. When workers know what is expected of them, they are less likely to experience burnout [74, 78]. We measure role clarity with a single-item question.

Recognition: Recognition is the individual’s level of satisfaction with formal and informal acknowledgment and the appreciation given for their efforts and accomplishments. Insufficient or inconsistent recognition or reward can increase people’s vulnerability to burnout, making them feel that their work is unimportant or undervalued [75]. Recognition is also measured with single-item questions, as mentioned in Table 2

Job security and skill discretion: We collect job security (single-item) and skill discretion (6-items) scores via the Job Content Questionnaire (JCQ) [60]. Job security is simply the probability that the individual is unlikely to be dismissed from the job, and skill discretion, “*defines the degree to which the job involves the variety, advancement, and use of an individual’s special abilities*”. If the job is too repetitive and boring, such that individuals do not get to learn new things while on the job, then there is little to no skill discretion on the job. Both are common sources of work-related stress and play a significant role in burnout [11, 93].

Empowerment and happiness at work: Empowerment is an individual’s sense of authority and autonomy for decision-making and accomplishing job expectations. When employees perceive that they have the capacity and authority to take actions to influence decisions that affect their work, it leads to better job engagement and lower levels of burnout [46, 75]. Similarly, happiness refers to an individual’s overall satisfaction with working at the company. Prior research finds that job happiness functions as a buffer of burnout symptoms [99]. Scores for both empowerment and happiness at work are obtained via single-item questions.

Workload management, worklife balance, and boundaries: Workload management refers to the individual’s sense that the amount of work assigned is reasonable and not overwhelming. Worklife balance deals with an individual’s sense of balance between work and personal life/home life demands. Quite similarly, boundaries refer to the individual’s ability to manage the boundaries between work and other aspects of their life to allow for a mental and emotional break from work. Workers struggle with workload management when the job demands are beyond the workers’ capabilities (for example, several tasks to be completed within a short period). When this is a

Table 2. Collected personal and job characteristics. The table below lists the categories of attributes we collect and the associated survey or feature.

Category	Attribute	Survey/Feature
Wellbeing	Sleep	Pittsburgh Sleep Quality Index (PSQI) [21]
	Stress	Perceived Stress Scale (PSS) [116]
	Depression	Depression, Anxiety, Stress Scale (DASS) [47]
	Physical activity	Nordic Physical Activity Questionnaire (NPAQ) [28]
	Work engagement	Utrecht Work Engagement Scale (UWES) [102]
Job demand	Job demand	Job Content Questionnaire (JCQ) [60]
Personal resources	Personality	Big Five Inventory (BFI) [94]
	Emotion regulation	Emotion Regulation Questionnaire (ERQ) [43]
	Resilience	<i>I am able to cope effectively with work-related stress</i>
Social resources	Teamwork	<i>Where I work, we feel part of a team that works together</i>
	Team support	<i>I can get the help I need from my teammates and colleagues</i>
	Role clarity	<i>I clearly understand what is expected of me in my role</i>
	Recognition	<i>I feel satisfied with the recognition or praise I receive for my work</i>
Job content	Job security	Job Content Questionnaire (JCQ)
	Skill discretion	Job Content Questionnaire (JCQ)
	Empowerment	<i>I feel empowered to make decisions regarding my work</i>
	Happiness	<i>I am happy working at my company</i>
	worklife balance	<i>I am able to successfully balance my work and personal life</i>
	Boundaries	<i>I am able to disconnect from work during non-work time</i>
	Workload management	<i>In general, I feel that my workload is manageable</i>
Digital Activity	Calendar	Conflicting hours with booked focus duration, meetings organized, time delay in joining meetings, no. of meetings joined late, no. of meetings marked private, no. of meeting invitations not replied to, no. of meeting invitations tentatively accepted
	Mails & Messages	Total emails sent and received, emails sent after hours, emails sent duration, emails sent and calls made during work hours
	Weekend work	Non-quiet days, weekend recharge time

chronic job condition, it leaves workers with little opportunity to rest, recover, and restore balance. The chronic nature of these excessive demands negatively impacts their ability to set boundaries and their worklife balance [9, 75]. All three constructs are based on single-item questions.

5 ANALYSIS

In this section, we present our analysis, organizing participants by burnout levels, comparing these groups, and performing a qualitative review to uncover the factors and experiences linked to burnout among security incident responders.

5.1 Grouping participants into Burnout and Non-burnout Categories

One of the key goals of our study is to understand the differences between security incident responders who experience burnout and those who do not. While BAT recommends cut-offs that can be used to divide people into such categories, the cut-offs are generated based on a population sample belonging to Belgium and Netherlands [103]. However, our study participants are all working in the United States, and we know from prior studies that there are regional differences in occupational burnout levels [30]. Therefore, instead of relying on the cut-offs generated from an unrelated population sample, we categorize participants into two distinct groups using the Single Item Burnout Inventory (SIB): a burnout group (with scores greater than or equal to 3 on a scale from 1 to 5) and a non-burnout group (with scores less than 3). We selected the cut-off of 3 based on three rationales. First, it signifies the midpoint of the burnout scale, effectively distinguishing between participants exhibiting burnout or no burnout. Second, this cut-off is the first point on the scale that explicitly identifies the participant as experiencing burnout with one or more symptoms.

In contrast, the preceding item (score of 2) indicates occasional stress without the feeling of burnout. Lastly, previous research utilizing the same survey has consistently defined burnout as a score of 3 or higher [33]. Adopting this established cut-off point ensures our study remains aligned with prior research and facilitates meaningful comparisons across different studies within the field. Thus, the two groups are generated with an SIB score-based categorization for all the analysis that compares the burnout and non-burnout groups. The BAT score is used to assess relationships of burnout (and its symptoms) with several other job and personal characteristics, but it is not used to group the participants.

5.2 Analyzing Differences Between the Groups

We compare the burnout and non-burnout participant groups across various self-reported and digitally captured characteristics. Given our small sample size, we opt for less complex methods to analyze data while considering multiple variables. For self-reported comparisons, we employ the Kruskal-Wallis (KW) test due to the non-normal distribution of self-reports, as determined by the Shapiro-Wilk test. Furthermore, we visually inspect box plots to evaluate our data's shape and confirm that most responses in our study are measured on an ordinal scale. In addition to the KW test, since our data is non-normally distributed and of an ordinal nature, we report the Spearman rank-order correlation between different self-reported characteristics and overall burnout scores (based on both SIB and BAT scores). The non-parametric methods of Kruskal-Wallis and Spearman correlation are more robust to small sample sizes and assumption violations, making them suitable for our study. It is important to note that all correlation and test results we present in the following sections are statistically significant with a p-value of less than 0.10 after adjusting for multiple comparisons using the Benjamini-Hochberg procedure [15]. As our study is exploratory, we adopt a slightly more lenient threshold for significance, enabling us to identify trends and associations warranting further investigation in future research without prematurely dismissing potentially essential factors.

In analyzing digital activity data, we employ mixed-effects modeling to account for the repeated nature of measurements (spanning six months) and to control for time-based effects. We consider the group to which the participant belongs (i.e., burnout or non-burnout, hence as a binary variable) as a fixed effect while treating the unique participant identifier and month as random effects. The dependent variable in our analysis is the associated digital activity. As the primary objective of our study is to uncover distinguishable differences in digital activity patterns between the two groups rather than predicting burnout based on passive measures, we focus on the associated digital activity as the dependent variable. This approach enables us to examine the variations in digital activity patterns between burnout and non-burnout groups, potentially assisting us in identifying passive markers of burnout. The results pertaining to the digital activity are presented in Table 4.

5.3 Qualitative Analysis

In addition to the self-reports and retrospective telemetry data, we also collect participants' responses to two open-ended questions – “*What contributes to your feelings of stress as it relates to the incidents you address?*” and “*What are some of the specific ways in which you cope with stress related to work?*” With these questions, we aim to tap into the stress-inducing factors and the coping mechanisms participants may have in place. Note that all these open-ended questions were optional to answer. We perform a thematic analysis and identify common themes across participants' responses. We then discuss some of the common stressors and coping mechanisms mentioned by the participants.

6 RESULTS

In this section, we explore the prevalence of burnout, highlight the key differences between the burnout and non-burnout groups, and delve into the stressors and coping mechanisms identified by security incident responders.

6.1 Prevalence of Burnout

Based on the single-item burnout (SIB) assessment grouping, we find that 19 people in our study fall in the burnout category, whereas 16 fall into the non-burnout category. Of the 19 in the burnout category, 14 participants responded that they are burned-out and have one or more symptoms of burnout; 4 participants said that their burnout symptoms would not go away and they think about frustration at work a lot, and 1 participant responded that they feel completely burned-out and often wonder if they can go on, indicating that they are at a point where they need some change (i.e., severely burned-out). When we look at the four dimensions or symptoms of burnout (based on BAT) – exhaustion, mental distance, cognitive impairment, and emotional impairment – we find that most participants (N=18) score highly on the exhaustion component. We present this result in Figure 2. The average exhaustion score we obtain in our population (i.e., 3.06) is the suggested cut-off in the BAT manual for ‘high exhaustion.’ In addition, 15 participants scored higher than the recommended ‘severe exhaustion’ threshold. After exhaustion, cognitive impairment is the most common symptom, with 11 participants scoring higher than the cut-off, followed by mental distance (N=9) and emotional impairment (N=8). The prevalence of high scores in the exhaustion dimension shows that exhaustion is the most prominent burnout dimension for the security incident responders in our study.

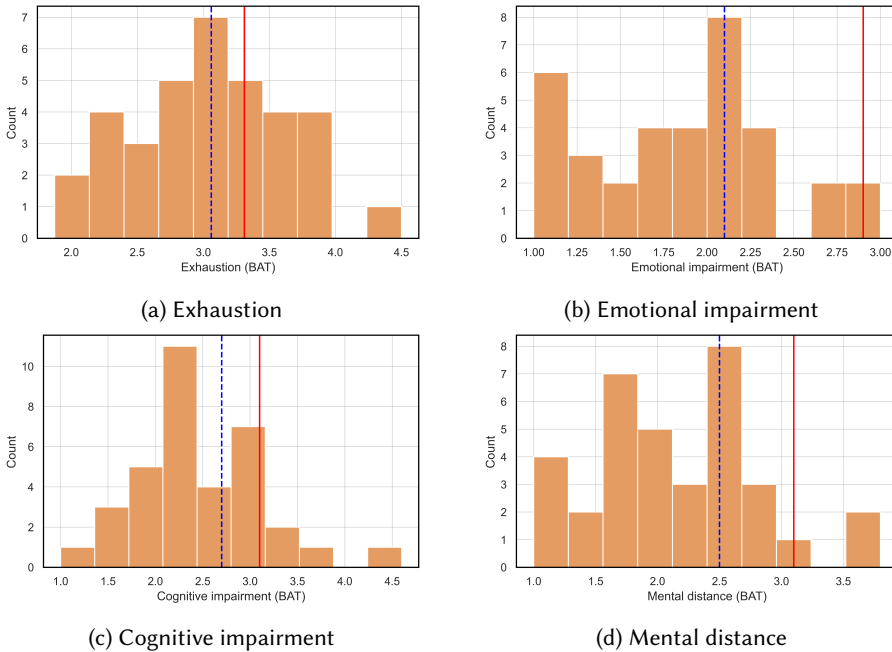


Fig. 2. Burnout dimensions: the four different dimensions or symptoms of burnout as captured by the BAT. The blue dashed vertical line indicates the cut-off score for ‘high score’ on a particular dimension, whereas the red solid vertical line indicates ‘severe’ symptom occurrence.

Note that the 11 participants who reported not being burned-out still score high in at least one of the four symptom dimensions, which could indicate that they are on the verge of being burned-out. At the same time, it is crucial to restate that the cut-offs are based on studies conducted on a non-U.S.-based population sample, so it may not be completely accurate. However, it does allow us to compare and contrast the scores obtained across the four symptom dimensions. To this point, the SIB and overall BAT scores highly align with each other in our data. They are moderate to strongly correlated with a score of 0.536 (p -value <0.01 ; Spearman correlation). SIB's correlation with the different BAT components varies – 0.535 with mental distance (p -value <0.01), 0.438 with exhaustion (p -value <0.05), and 0.342 with emotional impairment (p -value <0.10). However, SIB does not have a statistically significant correlation with the cognitive impairment component of BAT.

6.2 Differences Between the Burnout and Non-burnout Group

In this section, we showcase the results of our analysis, which examine the differences between the burnout and non-burnout groups across various attributes outlined in Table 2. We have organized the results according to the categories these attributes belong to, including wellbeing, job demand, personal resources, social resources, and job content. Some key statistics are presented in Table 3; however, please refer to the supplement for a comprehensive view of the statistical results.

6.2.1 Wellbeing

We consider five factors relevant to participants' wellbeing: sleep, stress, depression, physical activity, and work engagement.

Sleep. PSQI groups responses into seven components: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbance, use of sleep medication, and daytime dysfunction. All of the scores on these components are combined to make an overall sleep score. We find that the overall sleep score is positively correlated with the overall burnout score (SIB $\rho=0.505$; BAT $\rho=0.498$) along with two dimensions of burnout: exhaustion ($\rho=0.441$) and emotional impairment ($\rho=0.462$). In addition, the sleep components that are significantly correlated with overall burnout include day dysfunction (SIB $\rho=0.372$; BAT $\rho=0.516$), (negated sleep) duration (SIB $\rho=0.373$), latency (SIB $\rho=0.404$; BAT $\rho=0.368$), and habitual sleep efficiency (SIB $\rho = 0.420$; BAT $\rho=0.402$). Note that higher scores mean worse sleep quality; the burnout group reports higher scores within our data. Therefore, a positive relationship here suggests that worse sleep quality, a higher amount of daily dysfunction, latency, sleep inefficiency, and lower sleep duration are associated with increased burnout. In addition to the sleep questions, we also ask participants to report the number of hours they work in a week in general. Figure 3 shows the overall sleep score (labeled as 'poor sleep' as scoring high indicates worse sleep quality) and the self-reported total number of weekly working hours of the participants based on their group (burnout vs. non-burnout). The orange circles indicate the burnout group, and the grey triangles indicate the non-burnout group. The vertical dashed line is drawn to indicate the separation between the majority of the burnout participants and the non-burnout participants. We can see that burnout participants report a higher overall sleep score (meaning they have poorer sleep quality). In addition, they are also working for comparatively longer periods; almost all of them report doing 40+ hours of work (94.7%, $N=18$), some even up to 60 hours and beyond (26.3%, $N=5$). It is interesting to note that a few participants belonging to the non-burnout group mention that they work for a longer period but reportedly have better sleep quality than the burnout group. It is possible that for these individuals, higher working hours may be accompanied by higher levels of job satisfaction and engagement, which could contribute to better overall wellbeing and sleep quality.

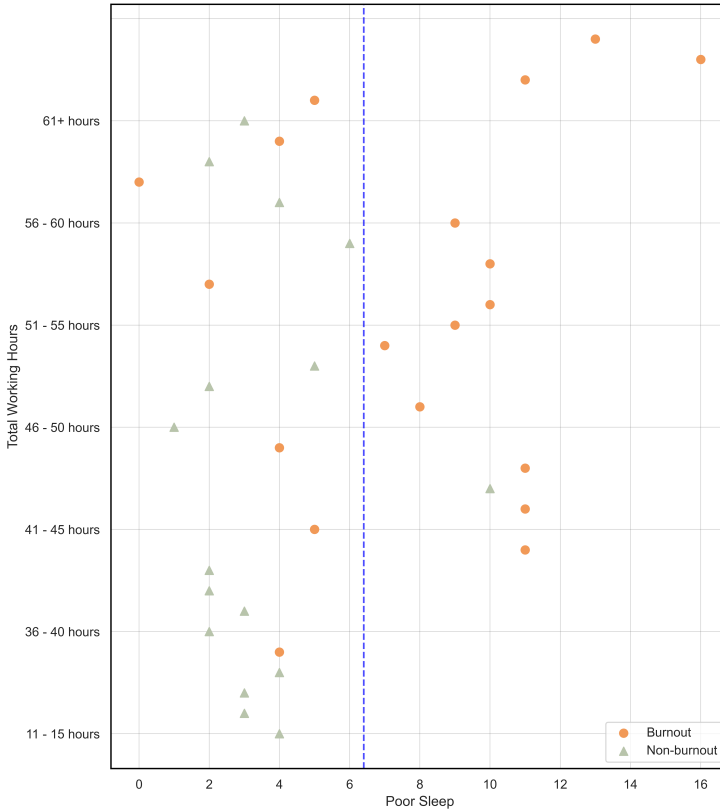


Fig. 3. Sleep vs. total working hours: the total working hours of participants alongside their associated sleep score. Note that the y-label says poor sleep, indicating a higher score reflects worse sleep quality. Orange circles indicate participants in the burnout group, and grey triangles indicate participants in the non-burnout group.

Depression and stress. The median score of the burnout group ($\tilde{B}O$) for stress is 22, and the median score for the non-burnout group ($\tilde{N}B\tilde{O}$) is 18. Similarly, for depression, $\tilde{B}O$ is 7 whereas $\tilde{N}B\tilde{O}$ is 3.5. Thus, the burnout group reports higher stress and depression; the differences are statistically significant ($p\text{-value} \leq 0.05$). We observe a positive correlation between depression and overall burnout (SIB $\rho=0.343$; BAT $\rho=0.425$) as well as exhaustion ($\rho=0.533$). Similarly, perceived stress is also positively correlated with overall burnout (SIB $\rho=0.482$; BAT $\rho=0.501$) and exhaustion ($\rho=0.551$). Emotional impairment, another component of burnout, is positively correlated but only with perceived stress ($\rho=0.398$).

Physical activity. 66% ($N=23$) of our participants report less than 150 minutes of total physical activity during leisure, and 91% ($N=32$) of them report under 150 minutes of physical activity while on the job. We do not find any statistically significant difference between the two groups about their physical activity. We also do not find any significant correlation between physical activity and burnout.

Work engagement. We find that the total work engagement score (the sum of all three dimensions – vigor, dedication, and absorption) is negatively correlated with overall burnout (BAT $\rho=-0.556$), exhaustion ($\rho=-0.416$), and mental distance ($\rho=-0.612$). Vigor is negatively correlated

with overall burnout (SIB $\rho=-0.327$; BAT $\rho=-0.613$), exhaustion ($\rho=-0.507$), mental distance ($\rho=-0.423$), and cognitive impairment ($\rho=-0.430$), whereas dedication is positively correlated with overall burnout (SIB $\rho=-0.403$; BAT $\rho=-0.704$) as well as all the components of it (exhaustion $\rho=-0.465$, mental distance $\rho=-0.707$, cognitive impairment $\rho=-0.396$, and emotional impairment $\rho=-0.362$). And finally, absorption only correlates with mental distance ($\rho=-0.466$). When we compare the engagement scores between the burnout and non-burnout groups, we obtain statistically significant differences in vigor (p-value ≤ 0.05), dedication (p-value ≤ 0.05), and the total engagement score (p-value ≤ 0.10) but not in absorption, with the burnout group reporting less engagement than the non-burnout group (\tilde{BO} 34; $N\tilde{BO}$ 37). While this may or may not be related to engagement, objective digital activity data shows that burnout participants ignore meeting invitations more often (BO $\beta=16.729$). When they respond, they mark a higher number of invitations as “tentatively accepted” (BO $\beta=16.820$). However, interestingly, the non-burnout group has a longer delay when joining the meetings (BO $\beta=-70.243$). They are also more frequent in joining meetings late (BO $\beta=-3.586$).

6.2.2 Job Demand

We find that job demand is positively correlated with overall burnout (SIB $\rho=0.416$). We also obtain a positive correlation between the exhaustion dimension of burnout and job demand ($\rho=0.409$). The positive correlation indicates that greater job demands are associated with higher exhaustion. Job demand also shows a statistically significant difference (p-value ≤ 0.05) between the two groups, with the burnout group reporting higher job demand (\tilde{BO} 17; $N\tilde{BO}$ 15.50).

The objective digital activity data also reflects high job demand in burnout participants; the burnout group reports more non-quiet days (BO $\beta=3.17$), indicating that they have more days in the week where they make at least one collaboration (i.e., meetings, emails, chats, and calls) in their after hours. In addition, they have lower weekend recharge time (BO $\beta=-45.44$). Weekend recharge time is the hourly difference between the latest collaboration performed on Friday and the earliest collaboration performed on Saturday, Sunday, or Monday before the participant’s working hours start. Lower weekend recharge time means that the burnout participants spend more time working, even during the weekends, and, as a result, they have less time to relax and recover during the weekend. We observe that the burnout group sends and receives more emails (BO $\beta=34.125$) in total. They also send more emails after hours (BO $\beta=16.233$) and consequently spend a longer time on email (BO $\beta=22.978$). Burnout participants have more meetings that conflict with their booked “focus” hours (BO $\beta=2.830$). Booked focus hours refer to a block of uninterrupted time an individual has reserved to focus on work. Setting the focus hours on the calendar lets the colleagues know that the individual should not be disturbed during that period. However, as mentioned earlier, burnout participants have more meetings that conflict with such booked focus hours. Burnout participants also organize more meetings by themselves compared to the non-burnout participants (BO $\beta=28.328$) as well as have a more significant number of meetings marked as private (BO $\beta=8.586$), which might indicate that they are handling incidents that require more privacy and may be perceived as more demanding.

6.2.3 Personal Resources

We consider three aspects related to an individual’s internal resources: personality, emotion regulation, and resilience.

Personality. We find a statistically significant correlation between the single score SIB and extroversion ($\rho=0.418$, p-value ≤ 0.10). However, we do not find any significant correlation with

Table 3. Statistical analysis of self-reports. SIB/BAT: overall burnout scores; EX, EI, CI, and MD: exhaustion, emotional/cognitive impairment, and mental distance dimensions. Test results show the median score outside the bracket and the interquartile range inside. Burnout and non-burnout correspond to the respective groups. Statistically insignificant results are greyed out. (***p*-value ≤ .01, * .01 < *p*-value ≤ .05, * .05 < *p*-value ≤ .10). Please see the supplement for full result.

Self-reports	Spearman Correlation						Kruskal Wallis Test		
	SIB	BAT	EX	EI	CI	MD	Burnout	Non-burnout	H stats
Sleep									
sleep quality	0.213	0.178	0.070	0.349*	-0.128	-0.077	2.00 (1.00)	1.00 (1.00)	2.312
sleep latency	0.404**	0.368*	0.384*	0.371*	0.015	0.039	1.00 (1.00)	1.00 (1.00)	7.287**
sleep duration	0.373*	0.316	0.229	0.339*	0.047	0.144	1.00 (2.00)	0.00 (0.00)	6.350**
sleep efficiency	0.420**	0.402**	0.400**	0.423**	0.109	0.158	1.00 (1.00)	0.00 (1.00)	7.204**
sleep medication use	0.303	0.241	0.226	0.053	0.261	0.193	0.00 (1.50)	0.00 (0.00)	4.125*
daytime dysfunction	0.372*	0.516***	0.574***	0.336*	0.339*	0.162	1.00 (1.00)	1.00 (1.00)	5.423**
overall sleep	0.505***	0.498***	0.441**	0.462**	0.143	0.189	9.00 (6.50)	3.00 (2.00)	11.119***
Physical activity									
during leisure	-0.098	-0.165	-0.293	-0.159	-0.175	0.222	70.00 (157.50)	120.00 (180.00)	0.617
while on the job	-0.260	-0.283	-0.194	-0.180	-0.159	-0.296	0.00 (5.00)	15.00 (60.00)	3.026
Work engagement									
vigor	-0.327*	-0.613***	-0.507***	-0.290	-0.430**	-0.423**	9.00 (2.00)	10.50 (2.25)	5.374**
dedication	-0.403**	-0.704***	-0.465**	-0.362*	-0.396**	-0.707***	12.00 (3.50)	14.00 (4.25)	5.853**
absorption	-0.085	-0.173	-0.120	0.017	-0.115	-0.466**	11.00 (2.50)	12.00 (4.25)	0.000
total engagement	-0.278	-0.554***	-0.416**	-0.243	-0.298	-0.612***	34.00 (9.50)	37.00 (8.75)	2.752*
Personality									
openness	-0.008	-0.080	-0.139	0.072	0.066	-0.138	6.00 (2.00)	6.5 (2.25)	0.000
conscientiousness	0.324	-0.095	-0.222	0.215	-0.266	0.040	8.00 (3.00)	7.00 (1.50)	1.313
extroversion	0.418*	0.126	0.137	0.076	0.040	0.245	7.00 (2.00)	5.00 (2.25)	4.036*
agreeableness	-0.051	-0.018	-0.092	-0.153	0.405*	-0.117	7.00 (3.50)	8.00 (2.00)	0.326
neuroticism	0.126	0.237	0.198	0.117	0.081	0.109	6.00 (2.00)	5.50 (3.00)	0.964
Emotion regulation									
cognitive reappraisal	-0.009	-0.038	-0.096	-0.007	-0.098	0.052	29.00 (6.00)	29.50 (5.25)	0.000
expressive suppression	-0.321	-0.247	-0.101	-0.022	-0.175	-0.387*	15.00 (3.00)	18.00 (4.00)	2.410
Job demand	0.416**	0.304	0.409**	0.229	0.063	0.042	17.00 (2.50)	15.50 (3.25)	6.544**
Depression	0.343*	0.425**	0.533***	0.157	0.223	0.177	7.00 (5.00)	3.50 (2.75)	6.194**
Stress	0.482***	0.501***	0.551***	0.398**	0.122	0.206	22.00 (6.00)	18.00 (5.50)	6.299**
Resilience	-0.291	-0.307	-0.338	-0.207	-0.084	-0.110	3.00 (1.50)	4.00 (1.00)	3.129**
Teamwork	-0.378*	-0.196	-0.264	-0.081	-0.025	-0.117	4.00 (1.00)	5.00 (1.00)	5.718**
Team support	-0.463**	-0.470**	-0.61***	-0.309	-0.001	-0.254	3.00 (2.00)	4.00 (1.00)	10.162***
Role clarity	-0.427**	-0.451**	-0.457**	-0.467**	-0.141	-0.048	3.00 (2.00)	4.00 (1.25)	5.529**
Recognition	-0.633**	-0.445*	-0.381	-0.262	-0.143	-0.395	3.00 (2.50)	4.00 (1.250)	6.296**
Job security	-0.344	-0.267	-0.371*	-0.274	0.203	-0.049	3.00 (1.00)	4.00 (1.00)	7.137**
Skill discretion	-0.288	-0.293	-0.085	-0.105	-0.142	-0.522***	18.00 (3.50)	20.00 (3.25)	1.916
Empowerment	-0.210	-0.290	-0.261	-0.159	-0.094	-0.228	4.00 (0.50)	4.00 (1.00)	1.677
Happiness	-0.269	-0.108	-0.039	-0.070	0.040	-0.233	4.00 (1.00)	5.00 (1.00)	1.196
Workload management	-0.470**	-0.272	-0.321	-0.332	0.067	-0.022	3.00 (2.00)	4.00 (1.00)	5.626**
Worklife balance	-0.319	-0.129	-0.317	-0.180	-0.158	-0.150	2.00 (2.00)	4.00 (1.00)	4.988**
Boundaries	-0.334	-0.260	-0.413*	-0.164	-0.009	0.035	1.00 (1.50)	3.50 (2.00)	7.139**
Working hours	0.445**	0.171	0.212	0.282	0.041	0.003	50.00 (10.00)	40.00 (31.25)	10.175***

the BAT burnout score. One possible explanation for this positive relationship is that extroverted individuals may be more prone to overextending themselves and taking on too many responsibilities or commitments, which could lead to feelings of being overwhelmed and burnout.

Emotion Regulation. The only significant result we obtain regarding emotional regulation is between the mental distance dimensions of burnout and expressive suppression, which are negatively correlated with a ρ of -0.387. However, we do not find any statistically significant difference among the emotional regulation components between the two groups. It is possible that

expressive suppression may be more difficult for individuals experiencing high levels of burnout, as they may be more emotionally taxed and less able to control their emotional responses.

Resilience. We obtain a statistically significant difference between the resilience score of the burnout group and the non-burnout group, with the non-burnout group reporting higher resilience than the burnout group (\tilde{BO} 3; $N\tilde{BO}$ 4; p -value ≤ 0.05). However, resilience is not significantly correlated with burnout (or its dimensions) in our study.

6.2.4 Social Resources

Social resources at work refers to the community and social relationships in the workplace. We assess teamwork, team support, role clarity, and recognition within it.

Teamwork and team support. Teamwork and team support are related concepts (in fact, they are positively correlated in our data with a ρ of 0.491). We find that teamwork is negatively correlated with SIB ($\rho = -0.378$), but we do not find any statistically significant correlation with BAT. Team support is negatively correlated with both burnout scores (SIB $\rho = -0.463$; BAT $\rho = -0.47$) as well as the exhaustion dimension of BAT ($\rho = -0.61$). When comparing the burnout and non-burnout groups, we find that there is a statistically significant difference – the non-burnout group reports higher teamwork (\tilde{BO} 4; $N\tilde{BO}$ 5; p -value ≤ 0.05) and better team support (\tilde{BO} 3; $N\tilde{BO}$ 4; p -value ≤ 0.01). It is also important to note that team support is associated with several other factors, such as recognition ($\rho = 0.626$), role clarity ($\rho = 0.549$), empowerment ($\rho = 0.569$), job demand ($\rho = -0.409$), and job security ($\rho = 0.506$). Analyzing the objective digital activity data, we find that the non-burnout group makes more calls and messages during their working hours than the burnout group ($\beta = -13.21$). The reduced number of interactions for the burnout group may be indicative of a lower level of teamwork and team support.

Role clarity. Role clarity is negatively correlated with both burnout scores (SIB $\rho = -0.427$; BAT $\rho = -0.451$) as well as the exhaustion ($\rho = -0.457$) and emotional impairment ($\rho = -0.467$) dimensions. The two groups are also significantly different in relation to their role clarity responses, with the non-burnout group reporting higher role clarity (\tilde{BO} 3; $N\tilde{BO}$ 4; p -value ≤ 0.05).

Recognition. We observe that higher recognition is associated with numerous factors, namely, better resilience ($\rho = 0.606$), ability to set proper work boundary ($\rho = 0.484$), higher role clarity ($\rho = 0.444$), less burnout (SIB $\rho = -0.633$), higher skill discretion ($\rho = 0.494$), better sleep ($\rho = -0.483$; higher sleep score means poorer sleep quality), and higher work engagement (dedication component $\rho = 0.464$). There is also a statistically significant difference between the groups with regard to recognition (\tilde{BO} 3; $N\tilde{BO}$ 4; p -value ≤ 0.05). In addition to the single-item recognition question in Table 2 that asks participants whether they are satisfied with the recognition or praise they receive at work, we ask participants a more specific question relating to their past six months of experience, “Have you received any rewards or recognition, like gift cards, cash bonus, etc. in the last six months?” to which the participants can answer with a ‘Yes’ or a ‘No’ response. If they answer a ‘Yes,’ they can provide us with the reward or recognition they received (optional). Most non-burnout participants respond that they have received recognition in the last six months (68.7%, $N=11$), whereas most burnout participants answer that they have not received any form of recognition (73.7%, $N=14$). Regarding the particular recognitions, responses include answers such as awards, gift cards, and positive feedback from managers.

Table 4. Relationship between digital activity streams and burnout. β : coefficient of the mixed effect model; SE: standard error; CI95%: confidence interval (95%); DF: degrees of freedom. Statistically insignificant results are greyed out. (** p -value $\leq .01$, ** $.01 < p$ -value $\leq .05$, * $.05 < p$ -value $\leq .10$).

Digital activity	Burnout Group				
	β	SE	CI95%	DF	Z-stat
Conflicting hours with booked focus duration	2.830	1.337	(0.211, 5.450)	32.318	2.118**
Meetings organized	28.328	12.516	(3.797, 52.859)	33.000	2.263**
Time delay in joining meetings	-70.243	30.116	(-129.652, -10.832)	33.000	-2.317**
Number of meetings joined late	-3.586	1.727	(-6.971, -0.202)	33.000	-2.077**
Private meetings	8.586	3.827	(1.085, 16.087)	33.000	2.243**
Meeting invitations not responded to	16.729	7.566	(1.900, 31.559)	33.000	2.211**
Meeting invitations marked as "tentatively accepted"	16.820	7.615	(1.895, 31.745)	33.000	2.209**
Total emails sent and received	34.215	18.104	(-1.268, 69.698)	32.170	1.890*
Emails after hours	16.233	9.063	(-1.530, 33.997)	32.137	1.791*
Total time spent on sending emails	22.978	12.999	(-2.500, 48.456)	32.154	1.768*
Total emails sent during working hours	226.802	124.380	(-16.978, 470.583)	32.214	1.823
Calls made during working hours	-13.209	6.839	(-26.613, 0.196)	31.814	-1.931*
Non-quiet days	3.176	1.707	(-0.170, 6.522)	33.000	1.861*
Weekend recharge time	-45.441	20.011	(-84.661, -6.221)	33.000	-2.271**

6.2.5 Job Content

Job content resources are all non-social aspects of one's job that contribute to personal growth, professional development, and attainment of occupation goals. In this study, we tap into several aspects of job content (as listed in Table 2), beginning with job security.

Job security and skill discretion. We obtain a negative correlation between the exhaustion dimension of burnout and job security ($\rho=-0.371$). The negative correlation suggests that higher job security is related to lower exhaustion. We also observe a negative correlation between skill discretion and mental distance ($\rho=-0.522$). However, only job security shows a statistically significant difference between the two groups, with the burnout group reporting lower job security ($\tilde{B}O$ 3; $\tilde{N}\tilde{B}O$ 4; p -value ≤ 0.05).

Empowerment and happiness at work. We do not find any statistically significant relationship between burnout (or its dimensions) and empowerment or happiness.

Workload management, worklife balance, and boundaries. We find that workload management is positively correlated with the concepts of worklife balance ($\rho=0.457$) and boundaries ($\rho=0.377$). Also, only workload management correlates significantly with overall burnout (SIB $\rho=-0.47$). Boundaries are negatively correlated but only with the exhaustion dimension of burnout ($\rho=-0.413$). However, there is a statistically significant difference between the burnout and non-burnout groups in all three concepts. The burnout group scores poorly in managing workload ($\tilde{B}O$ 3; $\tilde{N}\tilde{B}O$ 4; p -value ≤ 0.05) and maintaining worklife balance ($\tilde{B}O$ 2; $\tilde{N}\tilde{B}O$ 4; p -value ≤ 0.05). A stronger difference is observed in the boundaries score between the two groups ($\tilde{B}O$ 1; $\tilde{N}\tilde{B}O$ 3.5; p -value ≤ 0.05). It is also important to recall that the objective data confirms that burnout participants are working more after-hours and during weekends – they are sending more emails after-hours (BO $\beta=16.233$), they have more non-quiet days i.e., the number of days in the week where the participants have at least one collaboration in their after hours (BO $\beta=3.176$), and less weekend recharge time (BO $\beta=-44.441$).

6.3 Stressors and Coping Mechanisms

Of all the participants, 33 (94.3%) report some form of stressor related to the job when we present them with the question, *"What contributes to your feelings of stress as it relates to the incidents you address?"*. We list the interpretation of these responses as structured descriptions in Table 5. We perform a thematic analysis, identify common themes across these responses, and group them into workload, timing, communication, training, priorities, support, documentation, and other miscellaneous categories.

The majority of the participants mention high workload and long working hours as the main contributing factors to their stress. One participant states, *"When I arrive home from work, it takes an hour or so to unwind, leaving little time to be excited about 'off duty' activities. This creates frustration within the family 'You are always working' is a common theme. Can you be too tired to exercise? I feel that way often. I am always on the clock!"*. Participants also report that false positives are stressful, i.e., when security incidents do not lead to serious threats but they have already spent hours or days working on them. Lack of adequate staffing is also a source of stressors for participants. Not having adequate staff means that the workload has to be distributed across the existing staff, which increases the workload for everyone involved. In addition, participants mention that there is an unrealistic expectation of them, which makes it stressful to work: *"People have unrealistic expectations of our effort. Some think we work 24x7x365, some think we do not sleep or have any sort of life outside of work. We understand they are typically in difficult situations and if they have not been involved in a security incident, they may think that 'working' 20 hours/day endlessly is the thing to do, but it really falls apart after a couple of days."*

The timing of the security incidents is another major stressor after workload. Because security incidents can occur at any time, participants mention that they add uncertainty to their day and disrupt their lives after work hours. One of the participants responds, *"The largest aspect of stress in my life is the uncertainty of the day in relation to raising a family. Some days are fine, but other days are not, especially when you are forced to cancel planned events with your children because of an escalated case that has come in"*. Similarly, working across different time zones and the pressure or expectation of faster response time and immediate mitigation/clean-up of issues adds to the stress. The other theme we identify in the participant's response is communication. Communication stressors are mostly centered on lacking synergy across teams. Participants mention that cross-team communication is ineffective, which results in resolution lag as some teams may not be responsive to take actions immediately. Also, security workers frequently get roped into events that do not concern them. Other teams desire reassurance from the security team that things are alright with their product/services, and as a result, they ask for their advice or request them to investigate. One of the participants perceives this communication gap as the greatest stress inducer: *"Lack of knowledge about which team is responsible for what is a big gap I have noticed. Especially while working on incidents involving members from various engineering teams. We often get questions that were meant for another team and hence we are always in the loop of the incident even though our work is not directly concerned"*.

The next two main types of stressors are training and priorities. A few participants mention a lack of training opportunities and that they do not get to take days off during the week to research and train themselves. One participant responds that the constant need to be updated with the threat landscape in itself is stressful. Similarly, several participants state that there are issues around the prioritization of incidents, that they do not get any help from management in prioritizing, the incidents are sometimes assigned incorrect priority, and that there are conflicting priorities. We also identify a general theme around support, where participants state that they do not receive assistance from their colleagues and managers in resolving incidents. In fact, one of the participants responds

Table 5. Stressors around incidents: different themes identified from participants' responses to our open-ended question on stressors that participants face in the workplace.

Theme	Structured Response
Workload	High workload and long working hours
	False positives
	Lack of adequate staff
	Unrealistic expectations
Timing	Random timing of events leading to uncertainty to the day
	Having to work across timezones
	Critical mitigation time
Communication	Frustrating cross-teams communication process
	Requests from other teams for security investigation
	Resolution lag as the teams are not responsive enough
	Looped into events that are not of concern
Training	Need to learn
	Lack of training
	No day off to research and train
Priorities	Lack of prioritization from management
	Conflicting priorities
	Incorrect priority
Support	Lack of assistance
	Pressure from managers to be a 'team player'
Documentation	Documentation of resolution steps
	Writing report to the exact requirements of the report writing guidelines
Miscellaneous	Lack of stress management skills
	Imposter syndrome
	Repetition of task
	Working remotely
	Tools and processes that do not work as expected
	No recognition

that there is pressure from managers, *to take on the additional workload and be a 'team player'*. Two participants state that documenting the resolution steps and writing the report is stressful for them. The other stressors we identify in participants' responses include lack of recognition, lack of stress management skills, majority of events belonging to one particular category, and, as such, being too repetitive, and tools and processes that are too frustrating to work with. One of the participants states that working remotely is also stressful compared to being on-site because they do not know what their team is doing throughout the day, as they are detached from them for hours. Another participant mentions that they struggle with the imposter syndrome and that they *"feel like always playing catch up to be as useless as possible on engagements."*

Following the stressors, we ask, *"What are some of the specific ways in which you cope with stress related to work?"*. Like the stressor question, 33 participants (94.3%) responded to this inquiry. Based on the responses, we find that almost all the participants in the study are knowledgeable of different coping mechanisms. In particular, 48% of the participants mention that they take a break in order to cope with the stress at work, 45% report that they either go on a short walk, meditate, or exercise, and 18% respond that they indulge in their hobbies to cope with the work stress. Some hobbies include playing with pets, watching TV shows, dining out, and shopping. Note that the percentage does not add up to a perfect 100% because these response categories are not mutually

exclusive (i.e., meditating, walking, and hobbies may all be termed as taking a break). Regarding breaks, several participants state that they take their entire lunch hour to step away from work, avoid email clients or messaging apps on the phone, and listen to music they enjoy. One participant states, "Heading out for a nice lunch, disengaging from work after the day ends". Another responds, "I have been trying to set more boundaries about time so I can go to sleep earlier and be well rested". It is interesting to note that working from home could be a double-edged sword, as one participant mentions that working remotely adds to their stress, as described above, but, another participant states that working from home actually helps them focus better. In addition, some participants mention that better clarity about the tasks or better focus allows them to cope with the stress. For instance, one participant says, "I try to clearly understand the threat in order to try to predict how much work it will end up being". While other responds, "I try to ignore as much noise as possible and focus on what I need to do so that at the review period, I can illustrate positive impact". The majority of participants report healthy coping strategies, but some appear to be struggling with them. One participant states, "I don't have a time schedule that is consistent enough to get into anything that I want to" and other mentions, "I scream into my pillow at night in frustration so people can't hear me."

7 DISCUSSION

In this section, we synthesize our key findings and offer actionable recommendations, aiming to address burnout among security incident responders and improve their overall well-being.

7.1 Summary of findings

In this work, we examine the factors contributing to the burnout of security incident responders. We present our most prominent findings in Figure 4. Summarily, we find that:

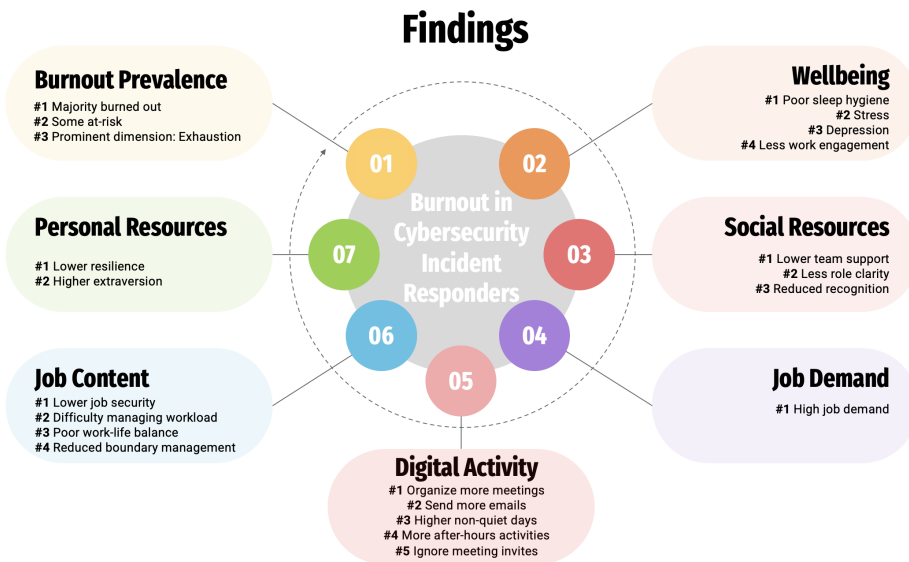


Fig. 4. Findings: a summary of our prominent findings, categorized by the factors we assessed.

- The majority of participants in our study cohort are already burned-out, and some are at risk of being burned-out. The burnout dimension that they score most highly on is exhaustion.

- Participants who experience burnout show signs of poor wellbeing. They have poor sleep hygiene, stress, depression, and less work engagement compared to participants who are not burned-out.
- Burned-out participants report higher job demands than non-burned-out participants.
- In terms of personal resources, burned-out participants have lower resilience and have the personality trait of being more outgoing, lively, and sociable (i.e., extroversion).
- The burnout group also lacks social resources at work – they report lower teamwork, team support, role clarity, and recognition than the non-burnout group.
- Job content resources also show a similar trend, with the burnout group reporting lower job security, difficulty managing workload, poor worklife balance, and a reduced ability to manage proper boundaries between work and other aspects of life.
- Digital activity data reveal that non-burned-out participants are more delayed in joining meetings and frequently join meetings late. Burned-out participants, on the other hand, organize more meetings but ignore meeting invitations more often. Similarly, they send more emails (in total as well as after hours) but spend less time on calls during their working hours. Burnout participants also have a higher number of non-quiet days and lower weekend recharge time, indicating that they are working more during weekends as well as after hours.
- Most participants report that the high workload and the random timing of events are the most significant stressors they are facing at work.

We note that our findings corroborate observations made in prior burnout research. The field, in general, is not certain of the causal assumptions about burnout, its symptoms, and effects, but there is enough evidence that specific factors are in some way related to burnout [75]. A large body of research provides support that burned-out workers manifest depression, stress, and poor sleep quality [4, 35], and our findings align with this result. Similarly, work engagement is proposed as the opposite of burnout state [98], indicating that engaged employees tend to experience positive affect (such as enthusiasm and enjoyment), enabling them to manage the demands at their work effectively [97]. Our finding supports this; we observe that engagement negatively correlates with burnout scores, and the burnout group reports less engagement overall than the non-burnout group. Job demands are positively correlated with the burnout score in our work, and the burnout group reports higher job demands than their counterparts. High job demands are also evident from their working hours; 94.7% (N=18) participants in the burnout group report that, on average, they work for more than 40 hours a week, whereas 50% (N=8) of the non-burnout group report having to work as long. We primarily consider three categories of resources available to individuals to protect against the job demands and thereby, burnout: personal resources, social resources at work, and job content resources. These may also be termed as variables or factors that influence burnout. Personal resources are an important factor because they enable workers to be more flexible, sensitive to change, open to learning, and they also promote wellbeing [5, 49]. We find that the burnout group scores higher in the extroversion component of the Big 5 personality traits. Individuals with this personality trait are friendly and outgoing and seek stimulation through conversations with others. Our finding is in contrast to the general consensus in the burnout literature, where extroversion is considered to be related to lower burnout syndrome [32, 96, 115]. A plausible explanation for our finding comes from Buhler and Land [19], who suggest that as extroverted individuals are highly motivated and ambitious, they have a greater tendency to be emotionally exhausted, as they are more likely to give more of themselves than is actually sustainable. While it may be possible that burnout symptoms would be more noticeable in extroverts, more comprehensive research would be needed to indicate the potential relationships clearly. In addition, much of the prior work exploring personality and its association with burnout has focused on healthcare, teaching, or

the administrative domain; therefore, we argue that this finding may be related to the nature of the job itself—i.e., extroversion may not offer the same advantage to security responders that it offers in the case of other jobs. It is also important to note that personality may influence burnout indirectly. For example, Lykourantzou et al. [70] find that balancing team personality significantly improves collaborative task performance, reduces conflict, and increases satisfaction and acceptance, demonstrating a straightforward matching strategy for enhancing team effectiveness. As teamwork, team support, and conflict influence burnout, it is plausible that personality plays a mediating role here, but more research is needed to elucidate the particular relationships. Resiliency-wise, however, our finding is aligned with the general literature; the burnout group in our study scores lower on resiliency compared to the non-burnout group. Since resiliency enables individuals to adapt and thrive in the face of adversity and stress, it is logical that burned-out individuals report less resiliency [8].

However, burnout can also be more of a systemic issue rather than a resiliency deficiency problem. Studies report that organizational factors such as high workload and lack of control are stronger predictors of burnout than individual factors such as resiliency and personality [81, 89]. As such, we focus on the work variables more: social resources and job content resources. We observe that the burnout group struggles with a shared sense of community, as they score low in all the social variables we consider – teamwork, team support, role clarity, and recognition. Prior studies show that a lack of support, trust, clarity, and appreciation for work are all recipes for workplace conflicts and burnout [68, 74, 75, 78, 80]. Since security analysts rely heavily on team collaboration, team cooperation, and on how information is shared and used in teams [45], the perceived lack of team support may negatively affect their work and wellbeing. We notice that perceived recognition at work is particularly worse for the burnout group, as almost 70% of the burned-out participants report that they have not received any form of recognition in the past six months, compared to 24% of non-burned-out participants reporting the same. Burned-out participants report high job demands, poor work life balance, and longer working hours compared to non-burned-out participants. Objective data collected through digital activity even confirms that they work more after hours and on the weekend. Since they report longer working hours and higher job demands, it may be possible that the reward or recognition policy in place is inconsistent or insufficient and contributes towards the workers' burnout, as shown by studies in the past [37, 59]. It could also be that the burnout group has to work longer because they are working less efficiently and making poor judgment calls due to stress.

In terms of job content resources, we observe that burned-out participants perceive more threats to their jobs as they score lower for job security. Studies report several pathways for job insecurity to cause stress and burnout [20, 41]. For instance, the uncertainty surrounding the job itself could be stressful. Or, job insecurity could threaten aspects of work that are important for one's mental wellbeing, such as income, social status, etc. Also, researchers propose that job security is a part of the psychological contract between the employee and the employer – employees make an effort to fulfill their obligations in exchange for the pay, recognition, and other outcomes offered by the employer. As a result, when employees perceive job insecurity, they may experience a breach in their psychological contract, which in turn may lead to burnout [65]. At the same time, it is also important to note that a reciprocal relationship exists between job security and mental wellbeing. While job insecurity can lead to stress and burnout, issues such as burnout in turn can result in absenteeism, poor performance, and reduced work engagement, leading to perceptions of job insecurity [41]. Our findings also indicate that the burnout group struggles with workload management as they score significantly lower than the non-burnout group. It is also of note that among all the self-reports collected, worklife balance and boundaries are the two attributes where there is the largest discrepancy in the scores of the burnout and non-burnout groups. There is a

40% difference between the two groups' median score of worklife balance and 50% difference in the median score of work boundaries. These self-reports paint one picture: the majority of the security incident responders in our study have chronic excessive workloads that are contributing to their burnout by preventing them from having the opportunity to rest and recover. The objective digital activity data also provides some validity to this. In particular, we find that burned-out participants organize more meetings, they send more emails after hours, have a higher number of non-quiet days, and have a lower weekend recharge time, all of which indicate that they work on most days after hours and across weekends. It should be noted that the findings based on self-reported survey instruments are also confirmed from the responses received to the open-ended stressors question. For instance, the majority of participants responded that they have a high workload, long working hours, and uncertainty in their workday due to randomly occurring incidents. Several stressors we obtained from the participants have shown up in prior studies that explore the challenges faced by SOC analysts [63]. For instance, stressors like high workload, communication issues, false positives, and repetitive processes are highlighted in a review conducted by Agyepong et al. [3]. We also observe that most of the participants in our study are aware of healthy coping mechanisms, but a few struggle with deploying them. Overall, while some of our findings may not be entirely novel, we believe they still contribute to a deeper understanding of the specific challenges faced by cybersecurity incident responders.

7.2 Recommendations

Based on our findings, we identify eight potential opportunities to help ease burnout in security responders. In our recommendations below, we focus on practical, actionable solutions that can be applied by both individuals and organizations to address burnout in security responders. While individual-level strategies, such as training workers to modify their work behavior or build up their internal resources, may help reduce exhaustion [72], it is also important to consider organizational-level interventions that address the underlying causes of burnout. Both approaches can potentially support the wellbeing and effectiveness of security responders [73].

- (1) **Dynamic prioritization strategies:** By developing adaptive prioritization strategies that consider not only the worker's expertise but also their emotional state and previous workload, organizations can help cybersecurity responders focus on tasks more effectively. Such strategies can reduce the stress they experience from juggling multiple tasks simultaneously.
- (2) **Targeted appreciation strategies:** Implement transparent, equitable recognition strategies that are tailored to the preferences and values of cybersecurity responders. This can include non-monetary rewards such as flexible work schedules, professional development opportunities, and positive reinforcement through personalized acknowledgments.
- (3) **Fostering a supportive work environment:** Encourage a culture of collaboration, mentorship, and shared learning among cybersecurity responders. Such an environment can include initiatives such as regular team-building activities, peer mentoring programs, and training on recognizing and supporting colleagues in distress.
- (4) **Resilience-focused onboarding:** Integrate resilience training and stress-coping strategies into onboarding programs for new hires. Teach employees practical self-care tools, mindfulness techniques, and other methods to help them manage work stress and prevent burnout from the outset.
- (5) **Proactive workload monitoring:** Implement a balanced approach to workload monitoring that allows managers to identify and address potential issues without making employees feel

overly surveilled. This can include regular check-ins, offering tailored support, and providing opportunities for employees to recharge after periods of high workload.

- (6) **Flexible work arrangements:** Encourage and support flexible work arrangements that enable cybersecurity responders to maintain better worklife boundaries. Such an approach can include remote work options, adjustable work hours, and clear expectations around availability outside of work hours.
- (7) **Adequate staffing and skill development:** Address understaffing by hiring and appropriately dispersing workload among employees. Invest in ongoing skill development and training for both new hires and existing staff to ensure they are well-equipped to handle their roles.
- (8) **Human-factors initiatives:** Establish human-factors programs that focus on optimizing human behavior, performance, and cognition in the cybersecurity domain [50, 85]. Such programs can include integrating burnout prevention measures, analyzing security tasks from a human-centered perspective, and learning from successful human-factors initiatives in other domains such as medicine, aviation, and industrial safety [86].

Note there is no one-size-fits-all approach to preventing burnout; therefore, intervention strategies must be tailored to the context of a given organization. As a start, organizations need to conduct an assessment to understand the factors or primary drivers of burnout that should be targeted. Research on interventions for dealing with burnout has been relatively limited, primarily because of difficulties in designing these studies along with the challenges associated with implementing the interventions, as well as conducting longitudinal follow-up studies for this area [72]. As a result, it is necessary to work across silos and have buy-in from leadership before implementing intervention strategies. Gaining this buy-in from leadership would allow for long-term commitment and ethical monitoring mechanisms. Also, as security responders spend the majority of their working time on a computer, digital activity data could be used as proxies to assess impact over time, reducing the burden on workers when performing evaluations of the strategies (for example, the time they spend working during weekends, whether the meetings attended are unreasonably numerous, indicating excessive work, etc.).

In addition, it is necessary to be aware of the ethical concerns associated with using passive sensing in the workplace. Such technologies that observe human behavior and workplace activity have to be safeguarded against abuse and bias of employees. Some of the recommendations we make may require workers' data to be shared with their managers so that they can identify potential problems early on and help avoid burnout from taking place. However, this requires further scrutiny as it may have several discomforts. For instance, while the digital activity data helps reduce the burden of evaluating intervention strategies, it can add burden and pressure on the workers' privacy. In a study conducted by Adler et al. [2] among resident physicians, the authors report that there are primarily three tensions surrounding the use of sensing interventions for stress and burnout: accurate measurement of burnout and wellbeing, how to hold upper management (or residency programs) accountable to improve wellbeing after having the knowledge of burnout among the workers, and maintaining privacy while sharing data with the workplace. We believe these concerns are critical within the cyber security domain as well. In this regard, Hernandez et al. [48] propose some ethical guidelines for technologies that use emotion recognition, which we believe are helpful to the broader passive sensing field. Thus, using passive sensing in the workplace can potentially exacerbate harm and proper guardrails must be put in place before implementing passive sensing or using interventions based on it.

8 LIMITATIONS AND FUTURE WORK

Our work has several limitations that also open up opportunities for future researchers. We mainly use self-report measures to assess different variables, which means that the results are subject to potential biases such as social desirability, common method, and recall bias. First, social desirability bias may have affected participants' self-reported responses, as they might have provided answers that reflect well on them or align with societal expectations. To address this bias, we ensured participants' confidentiality and encouraged them to answer honestly. Second, common method bias might have influenced our results since we collected self-report measures for different variables from the same participants. To mitigate this bias, we designed our survey with clear and distinct sections for each variable, minimizing the likelihood of participants' responses to one variable influencing their answers to others. Participants were also given the opportunity to take breaks and complete the survey over multiple sessions. Third, recall bias could have been present, as participants might have struggled to accurately remember specific events or feelings when responding to the self-report measures. To address this, we used a shorter recall period in our study, asking participants about their experiences within the past few weeks or months rather than over a longer time frame. Additionally, we included objective digital activity data in our study, which helped alleviate some of the concerns around self-reports. By incorporating this data, we could triangulate our findings with both subjective and objective measurements, enhancing the validity and robustness of our results.

While this study analyzes many burnout factors, they are not exhaustive as we had to exclude some other variables in order to protect the privacy of the workers. Some examples include but are not limited to psychosomatic symptoms, job satisfaction, supervisor support, turnover intention, number of dependents in the family to care for, etc. Future research should consider as many factors as possible (probably through objective means) in a privacy-preserving manner. Next, our sample population came from a single organization. The influence of this specific company's characteristics may limit the generalizability of our findings, as the nature of the work, organizational culture, and employee demographics may be unique to this particular organization. Therefore, our results may be more applicable to organizations with similar features, such as those operating in the same industry or having comparable organizational structures and employee demographics. Caution should be exercised when applying our findings to other organizations that differ significantly in terms of their work environment, employee composition, or other relevant factors. For instance, the results may not directly apply to organizations in different industries, those with predominantly part-time or contract-based employees, or companies with vastly different organizational cultures. In order to enhance the generalizability of the findings, future research could involve collecting data from multiple organizations across various industries and locations. Such a multi-organizational approach would allow for a more comprehensive understanding of the relationships between the variables of interest and help to identify consistent patterns across different organizational contexts. Individuals also voluntarily signed up for the study, which could represent a possible selection bias; however, this is the most common procedure in this type of research. In addition, because we have a small sample size, our analyses are exploratory. Further studies should be conducted in different organizations to validate or contrast with the results obtained herein. We acknowledge that there may be other sophisticated analyses that could provide additional insights into the relationships between multiple dependent and independent constructs. However, considering the nature of our data, the study objectives, and the small sample size, we opted for a more simplistic and straightforward approach in this study to initiate the discussion. In future research, we aim to explore more complex analytical methods to enhance our understanding of these relationships further. It is also important to note that recruiting security professionals can be quite challenging, a

realization we came to during our study. Security incident responders operate in a highly demanding environment under significant pressure and may have limited time to devote to tasks they perceive as unrelated to their work. Dykstra and Paul [34] find that security practitioners are overburdened, stressed, and difficult to access, which could contribute to the lack of scientific research focusing on this community. Furthermore, due to their nature, security professionals are trained to scrutinize everything they encounter, which may make them less receptive to research examining their behavior or work practices. Sundaramurthy et al. [112] report that they had to establish an element of trust before the security analysts at a SOC were comfortable with their research. As security workers are handling sensitive tasks day in and day out, they are hesitant to trust someone they would consider an “outsider” [114]. Getting full buy-in and support from leadership is, therefore, a necessity. They may feel more comfortable sharing their views if the suggestion to participate in the study comes from “one-of-their-own”. Another limitation of our study is using a single-item measure to separate participants into groups based on their burnout levels. While this approach is suitable for exploratory research, future studies should consider using more robust multi-item measures of burnout to ensure a more accurate and nuanced understanding of the participants’ experiences. A multi-item measure would allow for a more comprehensive assessment of burnout, capturing its various dimensions and providing greater insight into its effects on cybersecurity incident responders.

Another limitation is with regards to our study design which does not allow making causal inferences between the different variables and burnout. Despite this, the analyses reveal important associations among the study variables. We recommend that future studies take a longitudinal approach to this, which is crucial to understand how different variable influence stress, burnout, and various dimensions of burnout across time, as well as explore potential reverse and reciprocal effects. In this work, we categorize participants into two groups based on their burnout scores and analyze how they differ. This variable-oriented approach ignores people who may not follow specific patterns as it lumps everyone together based on a cut-off score (for example, someone who scores high in a particular dimension of burnout but not in others may be put together with someone who scores medium in all dimensions, but the dimension itself is not explored further). Future work may instead follow a person-oriented approach by exploring different burnout profiles based on the dimensions [123]. Such approach may help detect hidden profiles as well as help identify individuals who are at risk of burnout based on certain profile characteristics. Finally, we recognize that the relatively high payment for participation might have influenced our findings. While we intended to fairly compensate participants for their time and effort, given the demanding nature of their job and to foster trust and openness in their responses, it is possible that this payment amount could have attracted more economically motivated individuals. However, we made efforts to ensure participant attention and engagement during the study, such as conducting the survey during work hours, allowing breaks and multiple sessions, emphasizing the importance of thoughtful responses, and being available for questions or concerns. It is worth noting that the median response time for the survey was 22 minutes, suggesting that participants took the survey seriously and that the majority of them completed the survey in a single session. The impact of the payment amount on our findings remains uncertain and warrants further investigation in future studies. Considering all the limitations, our study should be viewed as an early approximation of the burnout factors experienced by security incident responders and a necessary analysis to consider when conducting further studies or developing a burnout mitigation program focused on security workers.

9 CONCLUSION

Security incident responders have the complex and demanding job of protecting resources from cyber threats and attacks. Against the backdrop of severe skill shortages in cybersecurity, these security professionals are experiencing increased work exhaustion and burnout and are leaving the workforce. In this study of 35 security incident responders, we found that the majority of participants experienced burnout. Some main contributing factors to burnout were high job demands, poor sleep quality, lack of recognition, and limited social support at work. In addition, the random timing of security incidents was perceived as a significant stressor for the responders. Our work extends the understanding of burnout in security incident responders. It adds to the body of knowledge regarding burnout and stress in security professionals and other highly stressful job categories in general. We hope that our work is a step towards supporting future efforts or solutions to understand the underpinnings of burnout better and subsequently prevent it.

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