"We're Not Meant to Deal with Crisis for a Year": Supporting Frontline Healthcare Providers' Wellness During a Pandemic

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Abstract. The newly discovered respiratory disease, COVID-19, has caused significant physical and psychological strain for frontline healthcare providers (HCPs). Researchers have found higher levels of anxiety, stress, depression, and poor sleep quality in HCPs during this time. It is crucial to ensure the well-being of HCPs to secure a functioning health system amid a pandemic. This work explores how HCPs might interact with a Just-in-Time Adaptive Intervention (JITAI) system that collects their biopsychosocial metrics using off-the-shelf fitness trackers and ecological momentary assessments (EMAs) for providing actionable interventions in real-time. We found that different healthcare-related life factors influenced our participant HCPs' engagement with the technological tools in the study. HCPs also expressed the need for better tools to help them convey their emotional exhaustion from a year-long pandemic. We also observed that HCPs sometimes could not maintain their psychological well-being due to other external factors, especially workload. These findings point to important design requirements for JITAIs to support frontline providers' psychological well-being, both within healthcare and beyond.

Keywords: COVID-19 · Healthcare providers · Stress · Sleep · Psychological well-being · JITAI · Fitness tracker · EMA

A. Flis and M. Mickens—Both authors had equal contribution.

H. Lewy and R. Barkan (Eds.): PH 2021, LNICST 431, pp. 147–163, 2022.
https://doi.org/10.1007/978-3-030-99194-4_11

1 Introduction

On March 11, 2020, the outbreak of the disease caused by the novel virus SARS-CoV-2, COVID-19, was declared a global pandemic by the World Health Organization (WHO) [7]. Since that time, the pandemic has been a constant strain on healthcare systems globally. Frontline healthcare providers (HCPs) have been dealing with overwhelming stress at work due to this disease's highly contagious and lethal nature, and the increased demands on the overall healthcare system. Researchers found higher levels of anxiety, stress, depression, and poor sleep quality in HCPs [41,47] during this pandemic. COVID-19-related HCP suicides have also been reported across the world [32]. Amid a global pandemic, HCPs provide the most critical service of ensuring quality treatment for patients battling the novel disease, and the demands of the pandemic also impact their ability to maintain the broad array of normal medical services. Therefore, to ensure a functioning health system, it is critical to ensure the physical and psychological well-being of these HCPs.

A Just-in-Time Adaptive Intervention (JITAI) [27] has the potential to provide wellness resources for HCPs under unusual strain associated with a pandemic. However, designing a JITAI to provide support in this context is resource-intensive. Deploying JITAIs also requires the integration of technology in users' everyday lives, which might be especially burdensome for the HCPs who are now asked to modify their practice to accommodate the needs novel to the pandemic (e.g., wearing personal protective equipment throughout their day). Therefore, in this paper, we set out to explore how HCPs might interact with a JITAI that collects their biopsychosocial metrics using off-the-shelf fitness trackers and ecological momentary assessments (EMAs). We collected these metrics from the users every day, monitored them, and offered professional support as an intervention if the measurements were out of a normal range. Our goal was to understand how the HCPs perceive a JITAI-like system designed to provide psychological support. We asked 12 HCPs to track their sleep with an off-the-shelf fitness tracker (*Garmin Vivosmart 4*) and report their psychosocial measures with regular EMA questionnaires for seven days as a baseline period followed by a 40-day intervention period. After the baseline week, we conducted semi-structured interviews with the participants to understand their experiences with the tools.

This study found that lifestyle factors related to being HCPs influenced how the HCPs engage with the fitness tracker and the EMAs. HCPs also mentioned that the tools provided by the study did not fully capture their emotional exhaustion. We also found that even though HCPs are aware of the importance of sound psychological health, they are sometimes unable to act to support their psychological well-being due to other external factors (e.g., extensive workload, family responsibilities). Drawing from these findings, we argue that automation and context-sensing are more crucial for effective intervention delivery of a JITAI for frontline service providers. We also suggest deploying micro-interventions in a JITAI to balance the burden of HCPs amid a pandemic. We conclude our discussion with a call for alternative measurements to capture the emotional

exhaustion of HCPs, especially during periods of high demand, such as the current pandemic. We believe these opportunities will facilitate the design of supportive technology for frontline providers who dedicate their careers to supporting the well-being of others.

2 Related Work

Coronavirus disease (COVID-19) is an infectious respiratory disease caused by a newly discovered coronavirus named SARS-CoV-2 [48]. As of July 28, 2021, there have been 195,266,156 confirmed cases of COVID-19 infection globally and 4,180,161 confirmed deaths from this disease [49]. On March 11, 2020, the WHO declared the COVID-19 outbreak as a global pandemic [7]. While the entire world is fighting to end this pandemic, frontline HCPs are particularly affected because they face a range of new demands on their jobs novel to this disease.

The range of psychosocial stressors associated with the global pandemic of COVID-19 caused significant psychological distress and disturbances for the frontline HCPs. Several articles on the impact of COVID-19 on HCP wellness found that healthcare workers had elevated levels of fear, anxiety, and depression [41,47]. Liu et al. showed that 50.7%, 44.7%, 36.1%, and 73.4% of epidemiologists and healthcare workers experienced depression, anxiety, sleep disorder, and stress, respectively [24]. Many researchers have started investigating methods for supporting the psychological health of HCPs during global pandemics like COVID-19. Greenberg et al., for instance, suggested that HCPs are at risk of moral injury during a pandemic, and that their well-being should be actively monitored and they should be provided with necessary support [16]. Krystal et al. suggested that digital applications, ranging from actigraphs to mobile phone-based heart rate monitors, could be used to provide feedback on the stress levels of the HCPs [20]. Fessell et al. suggested that 'micro-practices' such as deep breathing during hand washing might help to strengthen burnout prevention of HCPs [9]. Cai et al. reported positive attitude and support from friends and family as a common coping mechanism for stress [3]. These considerations are important for supporting the wellbeing of HCPs, however they lack timely and adaptive components necessary to tailor intervention qualities at the most effective time.

Many hospitals provided their HCPs with online educational programs and online counseling to cope with this global health crisis [24]. Sasangohar et al. called out the need for feasible and practical methods to assess HCP fatigue and burnout [38]. They also mentioned the potential of wearable sensors to monitor fatigue, stress, and sleep biomarkers noninvasively and then integrate this information for timely interventions. In addition, they mentioned that mobile health (mHealth) tools might guide simple methods such as breathing exercises, biofeedback, and mindfulness to mitigate acute episodes of stress and anxiety. Furthermore, telehealth services can enable peer support and occupational counseling. However, they also caution that integration of new technologies with current workflows may present an additional burden and needs to be further examined

[38]. Among others, the benefits and burdens have been well documented in the literature examining workplace wellness programs [25,30,39]. Together, these studies collectively suggest the importance of workplace wellness programs and that mHealth technologies have clear potential to support the psychological well-being of HCPs. Accordingly, the first research question of this study is:

RQ1: How does the integration of new technologies interact with the lives, both professional and personal, of healthcare providers?

Literature suggests value in implementing tailored psychological interventions based on the needs of individual staff to mitigate the risk of deteriorated psychological health [35,36]. Since the COVID-19 pandemic is a relatively recent situation, we do not have evidence of tailored psychological interventions for supporting the needs of HCPs. However, HCI literature has focused on tailored interventions and technology to support psychological well-being in other conditions. Liang et al. found that tracking sleep behaviors with a *Fitbit* device increased users' awareness; however, it did not result in improved sleep behaviors [23]. *SleepCoacher* is a system that monitors the users' sleep behavior with mobile sensors and provides tailored recommendations to improve their sleep behaviors [8]. Levin et al. designed a skills training app that assessed users' sadness and anxiety using EMAs and automatically provided tailored skills training based on the EMA responses [22]. Similarly, other JITAIs focus on providing relevant interventions for reducing their users' stress [15,28,43]. However, assessing psychosocial measures (e.g., stress, anxiety) with EMAs requires significant effort from users. It is also unclear how the HCPs would interact with the EMAs amid a global pandemic when they already have an increased workload. Therefore, our second set of research questions includes:

RQ2a: How do HCPs interact with the burden of standard EMA questionnaires?

RQ2b: How effective are EMAs in capturing their psychosocial measures?

In addition, we also need to understand what interventions might be helpful for the HCPs. Therefore, to better understand the HCPs' current practices for coping with stress, we also explore the following research question:

RQ3: What are our participants' current approaches to stress management?

The next section describes our study, the "HCP Wellness" study, designed to answer the aforementioned research questions. We will then discuss our observations from this study and reflect on those observations.

3 Methods

We designed and deployed the "HCP Wellness" study in 2020. We recruited participants on a rolling basis from the university hospital, and the data collection for this study continued from December 2020 to March 2021. We asked participants to track their health metrics (e.g., sleep, stress, heart rate). For this purpose, participants received a *Garmin Vivosmart 4* fitness tracker from the

study team. We asked them to wear the tracker as much as possible, but most importantly, when they sleep. We also collected psychosocial measures from the participants, including perceived stress, anxiety, and burnout through EMAs. We did not collect any information that may identify the participants individually.

During recruitment, the research coordinators reviewed study procedures with participants and obtained informed consent prior to enrollment. Participants completed baseline surveys that assessed demographics, adverse childhood experiences (ACE) [26], resilience (Brief Resilience Scale; BRS) [42], work-related burnout (Copenhagen Burnout Inventory Work subscale; CBI) [18], anxiety symptoms (General Anxiety Disorder-7; GAD-7) [45], depressive symptoms (Patient Health Questionnaire-9; PHQ-9) [19], current stress (Perceived Stress Scale; PSS) [6], sleep quality (Pittsburgh Sleep Quality Index; PSQI) [2], coping resources (Brief COPE) [5], social support (Social Support Questionnaire; SSQ-6) [37], and pandemic stress (Pandemic Stress Index; PSI) [17]. Participants also completed daily EMAs using Likert scale ratings to assess perceived sleep quality and stress in addition to a daily administration of the State-Trait Anxiety Scale (STAI-S) [44]. HCPs were screened weekly for depression using the Center for Epidemiological Studies Depression Scale (CES-D) [31] and monthly for burnout and pandemic stress using the CBI and PSI. We collected data from the fitness tracker and the EMAs for seven days without any interventions to collect baseline data. After the baseline week, we collected data for 40 days where we observed the participants' biopsychosocial metrics and offered support if the metrics were outside of the normal range (see Fig. 1). Note that initially, we planned to collect data for 90 days after the baseline week; however, we had to adjust the duration to 40 days based on participant feedback. We discuss this further in Sect. 4.

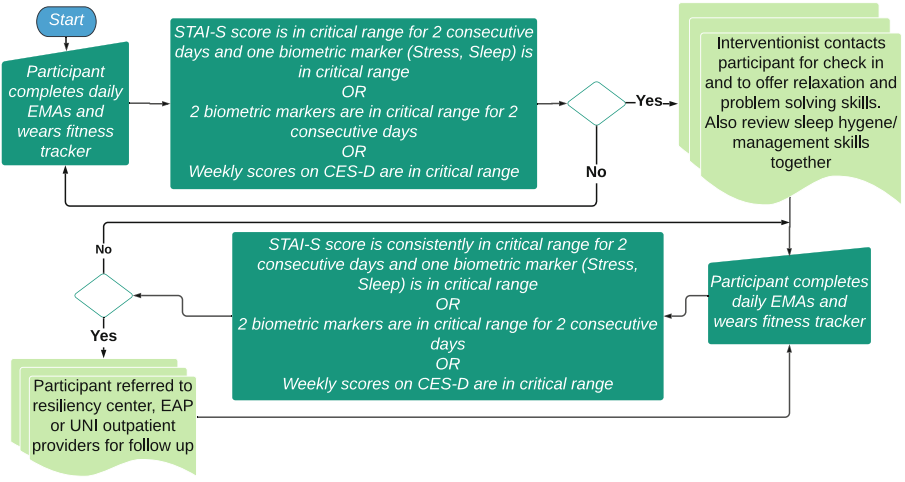

Fig. 1. Flow chart for intervention decision for the "HCP Wellness study."

After the baseline week, we conducted semi-structured interviews with participants to understand their experience with the wearable fitness tracker and EMAs. The first author conducted the interviews with the participants over video calls. The average duration of the interviews was 20 min. The interviews were recorded with the participant's consent and transcribed verbatim. The transcripts were de-identified and stored in a password-protected computer.

Table 1. A summary of participants' demographic information.

Participant	Age	Gender	Professional role	Years in current role
P1	28	F	Nurse	2
P2	30	F	Physician (resident)	2.5
P3	28	F	Physician (resident)	2.5
P4	38	F	Physician with administrative duties	1
P5	35	F	Physician (fellow)	4
P6	50	M	Physician (surgeon)	10
P7	30	F	Physician (resident)	3
P8	28	F	Physician (resident)	1.5
P9	32	M	Physician (resident)	2.5
P10	58	F	Physical therapist	15
P11	31	F	Speech pathologist	4
P12	35	F	Physician (resident)	4.5

3.1 Study Participants

The purpose of the study is to use biometric data collection via fitness trackers and psychosocial assessments to identify HCPs in need of psychological interventions during their work shifts and to utilize brief interventions designed to increase provider wellness. Therefore, we invited HCPs (e.g., residents, surgeons) working at the university hospital over email to participate in the study. Eligible participants included HCPs from a range of specialties providing care to patients in the hospital during the COVID-19 pandemic. Considering how the pandemic has caused strain across medical specialties, not simply those serving individuals infected with COVID-19, the breadth of sampling was intended to capture a range of data associated with provider wellness across medical specialties. We excluded medical staff who were not HCPs or not providing care to patients during this global pandemic of COVID-19.

We screened 16 potential participants; however, one did not meet the inclusion criteria. Two HCPs did not consent to participate. One HCP signed the informed consent form; however, they never responded to further contact attempts. Ultimately, 12 HCPs participated in the study (P1–P12); however, one participant did not participate for the entire duration of the study. The demographic information of the participants is summarized in Table 1.

We invited all the enrolled participants for the interviews after the baseline week. However, only five (P4–P6, P8, P10) agreed to participate in the interviews with the first author. Therefore, we analyzed fitness tracker data and EMA responses from 11 participants and interview responses from 5 participants. In the next section, we discuss our data collection and analysis.

3.2 Data Collection and Analysis

During the baseline week and active intervention period, participants wore *Garmin Vivosmart 4* fitness trackers to monitor their health metrics and used their personal smartphones to respond to EMA questionnaires delivered via text messages. *Garmin Vivosmart 4* data were collected using the *Fitabase* platform [10] and exported for analysis. We administered the EMA questionnaires through *RedCap* [33]. To send the *RedCap* survey links through automated text messages, we integrated *Twillio* [46] with the *RedCap* project. We then exported the EMA responses from *RedCap* for further analysis. The semi-structured interviews after the baseline week were conducted over video calls. We recorded the interviews with participants' permission and transcribed them verbatim using a paid transcription service.

We conducted a thematic analysis with the data collected from the post-baseline week interviews. The first author analyzed the transcripts of the five interviews and extracted 245 codes from them. However, we disregarded 21 codes from our analysis that were not relevant to the study's technology-related aspects (e.g., "taking melatonin for better sleep"). Therefore, we continued our analysis with the remaining 224 codes and merged similar codes. We then iteratively grouped codes to identify themes. By the end of this process, nine themes emerged, which we then carefully considered in the context of the above-mentioned research questions to identify findings and implications for designing similar interventions. In the next section, we discuss our findings based on the data we collected in this study.

4 Findings

This study revealed that the off-the-shelf fitness tracker we used was not well-suited to capture the desired health metrics of the HCPs. We also found that participants felt the standard EMA questionnaires we used did not effectively capture the accumulated emotional burden of HCPs over the previous year. We also gained insights into the different sources of stress for the HCPs amid a global pandemic and their different coping strategies.

4.1 Challenges for HCPs Integrating Technology into Daily Life

As we mentioned earlier, the HCPs were asked to wear a *Garmin Vivosmart 4* fitness tracker and responded to regular EMA questionnaires administered through automated text messages. Overall, we found that participants were interested in

interacting with their health data and found the data helpful. For instance, P5 mentioned that she looked at her heart rate variability (represented as the 'stress' measure by *Garmin Vivosmart 4*) and observed how her health behaviors impact them, which she found interesting. She said,

> "*it's looking at my heart rate variability... I just tried to calm myself down. And then I could watch my body battery increase. I was like, Oh, that's kind of cool!*"

Note that *Garmin Vivosmart 4* analyzes heart rate variability and uses that to infer the user's overall stress [13]. Users can only see their stress level from the device, not their heart rate variability. P5 had prior knowledge about the measurement process, and therefore, she mentioned looking at the heart rate variability while she was actually looking at her stress measures. P5 further mentioned that since she is an HCP and had a Ph.D., she had the background knowledge, and interacting with the health data was especially interesting to her. As found in literature [12], our participants learned about their health behaviors by tracking their behaviors with the fitness tracker.

However, participants also indicated that the integration of technology needs to consider the specific lifestyle of the HCPs. For instance, P6 is a transplant surgeon, and he is usually on-call at night. If he receives a call from the hospital, he must commute to the hospital and perform his job function. Surgeons do not stay in the hospital for the night if they are not assigned surgery or are not called. There can be situations where the surgeon goes back home in the morning and sleeps, as P6 described. In contrast, medical resident physicians may stay the entire night at the hospital and balance between sleeping and working. Residents are usually given some space to rest at the hospital. However, the duration of night shifts varies based on which year of residency they are in, as P5 and P8 explained. Overall, we observed that HCPs' sleep schedules are nuanced and can vary significantly between HCPs, and even within the same person, it varies by day. The *Garmin Vivosmart 4* we used in our study takes input from the user about their expected bedtime and starts measuring sleep metrics around that preset time. It cannot detect a sleeping session automatically. From our experience in this study, we realized that while a non-HCP population might be able to maintain a specific bedtime considering standard sleep hygiene, the professional demands of being an HCP might prevent a similar level of regularity in sleeping times. Therefore, a technology that requires a preset time might not be practical to capture their health metrics.

Similarly, participants reported that a preset time for the EMAs was not helpful since they could be on duty and, therefore, unable to respond to the EMAs when they were sent. While they could respond later, which some participants did, this may compromise the quality of the data since the responses to the assessments are no longer *'momentary'*. In the interviews, participants also mentioned that tracking their biopsychosocial metrics for 90 days seemed burdensome. As a result, we had to reduce the post-baseline duration to 40 days. We also note that when participants' EMA responses indicated they should receive an intervention, several participants were unable to schedule a meeting with the

psychologist on our team due to the participant's already overwhelmed schedule. These observations help to address RQ1. Specifically, the integration of technology needs to consider both the existing professional burden of the HCPs and the expected burden of using the integrated technological tools. For successful integration, the technology needs to be context-aware for this population.

4.2 Capturing Emotional Burden

We included EMA questionnaires in this study to capture momentary psychosocial measures of the participants. We also collected sleep metrics of the participants through the fitness tracker to observe the impact of stress on their sleep quality. However, when we spoke with participants about this data, they reported that these measures do not reflect their perceived emotional burden. For instance, P4 commented,

> "*it's emotional exhaustion. It's not physical exhaustion... I feel like I sleep great. I feel like I get up well-rested. But then it's like, once I get to work, and when stuff just keeps happening, I just feel like my bandwidth just shrinks.*"

Even when she sleeps well, P4 is emotionally exhausted due to the pandemic circumstances. In this case, the sleep metrics do not represent her emotional condition. Similarly, P4 further commented that,

> "*I don't think that the surveys measure burnout well... in my last week on service, it was exhausting. I felt terrible at the end. But none of the survey questions measure that. They basically just asked how I felt every morning and every evening. I'm like, Well, I think I'm better right now than I [was] last night. But I don't think it takes that perfect account. And I think that really where we are is burnout, is surviving in a crisis for a year.*"

Even though we administered the Copenhagen Burnout Inventory at the baseline and every month, it was unable to capture what P4 called "burnout of surviving in a crisis for a year." Cao et al. used the Maslach Burnout Inventory-Medical Personnel (MBI) to measure burnout and emotional distress in 37 HCPs [4]. However, they did not find elevated levels of burnout and emotional distress within their sample either. P4 explains this in her own words:

> "*we are not meant to deal with crisis for a year. We're meant to deal with crises for hours, days, maybe weeks. But to continue to just have everything look differently in your life and worry all the time. We're not, as humans, meant to do that.*"

Other participants (P5, P6) also expressed a similar opinion that current questionnaires were not sufficient to capture their perceived emotional burnout. These comments help to answer RQ2b, that the current surveys for psychosocial measures that capture momentary emotional conditions might not be enough to capture long-term emotional exhaustion that may arise from a global pandemic.

Concerning RQ2a, our participants had a mixed opinion about the burden of the EMAs. While some were okay with the EMA frequency and did not consider them burdensome, others mentioned them as burdensome and repetitive. They explained that after surviving a pandemic for a year, their emotional status does not change every day. For instance, P5 said that,

> "*I always am answering roughly the same. So then to me, it's like, I don't need to be answering this often. Because my answers don't change that often.*"

Again, P4 commented that,

> "*it's also like a little bit of like a salt in the wound, where it's like, yeah, this week I've been isolating for, or I've been socially distancing for 360 days instead of 330, or whatever.*"

Participants suggested that the system should not send the EMAs every day since their responses do not change much at this point. Even though the psychologists on our research team expressed the importance of capturing the momentary measures of the participants' emotional condition to provide immediate support, the participants expressed a different opinion. This perspective of the participants indicate a need for advanced adaptiveness in the JITAI; while it should be able to identify the user's momentary needs, it should also adapt to users' willingness to engage with an intervention.

4.3 HCPs' Approach to Emotional Well-Being

To address RQ3, we also explored the sources of emotional burdens for the HCPs and their different coping mechanisms. Participants explained that the pandemic impacted their family life, social interactions, healthy lifestyle behaviors, and increased workload. P6 talked about moral injury, saying that,

> "*there's an ethical dilemma that we're having between, you know, should you die of liver failure and kidney failure? Or should you get a transplant and then have the potential risk of COVID. And I think that liver and kidney failure is worse than COVID. However, it's very nuanced, and it's created a lot of anxiety and stress.*"

[16] also mentioned that moral injury is expected for HCPs during the global pandemic of COVID-19. Again, P4 explained the burden of multiple responsibilities and the lack of decompression time. She said,

> "*I was here [in the hospital] from seven to four, I got home at four, and immediately, like, get home, and my house is a disaster. My kids are crazy. And I just like jump right in. And it's not like I have an easy job. So there is no decompression time until, like, nine o'clock at night, when my kids are in bed. And by then, I'm exhausted. And so it's like, there's just no, there's no downtime ever.*"

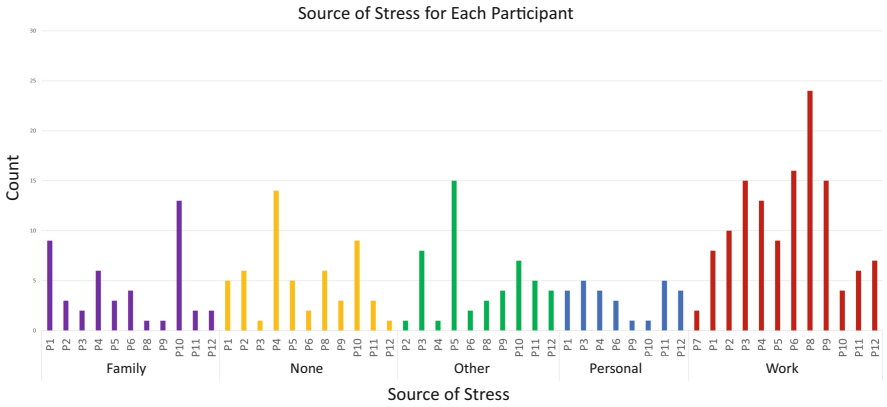

Fig. 2. Source of stress for reported by the participants everyday through the EMA responses at the end of the day.

The participants claimed in the interviews that they have now acclimatized with the increased stress of the pandemic. However, the EMA data unsurprisingly shows that their stress still largely comes from their work (See Fig. 2).

In response to the daily evening EMAs, the participants reported their coping mechanisms for the most stressful part of the day. We observed that participants frequently reported having to face stressful moments and could not do anything to minimize them. Even though, as HCPs, these participants are aware that psychological well-being is essential to function properly and provide the frontline service, they could not do anything to reduce stress in many situations. P4, for instance, mentioned in the interview that,

> "*I've been anxious, but that's not going to change anything. So you have to just live with it, deal with it, and move on, and we manage ourselves because if I am an anxious disaster, everyone around me is an anxious disaster. And that does not help any of us.*"

Participants sometimes sought support from family, friends, and peers, which was helpful for them. Cai et al. reported that support from family and friends could be effective for the psychological well-being of the HCPs [3]. We also found that some participants felt better thinking that they were not alone in this.

5 Discussion

With more profound insights into how HCPs might interact with an intervention that involves self-tracking technology and EMAs, we now discuss how these findings inform our understanding of the needs and constraints of HCPs interacting with technology for self-care.

5.1 Automation and Context-Sensing

The target participants for this study were HCPs. Unsurprisingly, this population lacks healthy sleep behaviors due to their work shifts [14]. Wearable fitness trackers and automated EMA surveys assume a specific routine for a user's life that might work for most other study populations. However, our study unfolded that this approach might not be practical for frontline service providers (e.g., healthcare providers, firefighters, policemen) who adapt to the irregular lifestyle due to their occupations. Considerations for the range of sleep hygiene indices, such as total sleep time, sleep efficiency, wake after sleep onset, and sleep latency, are critical to consider in aggregation or combination to better measure sleep in this group. Moreover, along with poor sleep hygiene, their services may contribute to increasing their stress (e.g., a global pandemic for HCPs, life losses during a fire incident). Therefore, the technology we design to support them should accommodate their heterogeneous needs, which differ both between individuals and also from day to day and week to week within the same individual.

Sleep monitors, for instance, should be able to detect sleep sessions automatically rather than asking the user about the expected bedtime. Some wearable devices (e.g., *Fitbit versa* [11]) can detect sleep sessions automatically without input from the users. Again, we administered the EMAs in the morning, and the evening, where morning EMA asked about their sleep quality and night EMA asked about the perceived stress for that day. However, a frontline provider may work during the night shift and go to sleep at a different time. In such cases, the perceived stress EMA should be administered at the end of the work shift, and the sleep quality EMA should be administered when they wake up. Standard rules for administering the EMAs might not be meaningful for these participants.

To summarize, the technology should collect data more automatically and be context-aware to balance the burden for frontline providers. Currently available technology for implementing these studies does not support this flexibility, significantly increasing the barrier to running a study that accommodates these participants. While automation and context-sensing can benefit any user, this is especially significant for the frontline providers since they have minimal control over their schedule and are more vulnerable to work-related stress.

5.2 Deployment of Micro-interventions

As mentioned earlier, HCPs are overwhelmed with their schedules and duties, especially amid a global pandemic. Even prior to this pandemic, the significant prevalence of burnout and its critical consequences had been widely reported in the literature [29,40]. As we observed, sometimes HCPs could not make the time to schedule a call with the study-provided therapists for support. This indicates an additional burden associated with the digital intervention or limited awareness of the HCPs' needs and contextual barriers. Many hospitals around the world have made online counseling and educational materials available for their HCPs [24]. However, as we mentioned earlier, participants frequently reported that they simply had to face stressful situations and could not do anything to

reduce their stress. Even though HCPs are aware of the significance of psychological well-being, some of them perceived that they could not improve their situations. Digital interventions need to account for these barriers to provide optimal access to important therapeutic solutions.

Micro-practices [9] could be helpful in such situations since they require only a few seconds to a minute to execute. For instance, a JITAI could automatically collect a user's contextual data and offer micro-interventions (e.g., deep breathing) while they are carrying out other activities that do not require their full attention (e.g., using hand sanitizer, washing hands). However, the JITAIs would also need to consider the 'state of receptivity' [21] of the HCPs while offering such micro-interventions since there can be activities that may not be suitable for micro-interventions (e.g., while performing care for a patient or in the middle of a conversation).

5.3 Explore Alternative Paths for Measurements

In this study, we administered commonly used validated survey instruments to capture the psychosocial measures of participants. However, the participants perceived that these questions did not capture the mental exhaustion or emotional burnout they were experiencing. This could be explained by a misunderstanding of the construct being measured or that the design did not account for constructs pertinent to the HCPs' experience. They also mentioned that a fitness tracker could capture their physical stress (e.g., when exercising) but could not capture their emotional stress. Moreover, the participants wanted more adaptiveness in the frequency of the EMA surveys, which they found burdensome and not worth their effort. Further, alternate forms of measures could be used to reduce the burden or sense of repetitiveness. Some constructs might have been most effectively measured using quick visual analog scales rather than lengthy self-report measures. Together, these observations indicate we should pursue alternate options for measurements to capture these psychosocial measures.

One opportunity to adapt the frequency of the EMAs is to observe the stress measured by the fitness trackers when the participant is sleeping since they represent emotional stress more than physical stress [34]. On the one hand, the stress-level data provided by the *Garmin Vivosmart 4* does not provide an overall estimation of participants' stress during sleep-time. On the other hand, the *Fitbit API* does not allow exporting the heart rate variability data for researchers. As a result, we could not incorporate this optimization in our study regardless of the device we used.

Some fitness trackers or smartwatches (e.g., *Fitbit Versa* [11]) do measure heart rate variability, heart rate, and sleep patterns and translate into stress management scores during the users' sleep-time, and use this data internally. In an ideal world, a JITAI could integrate this data to estimate the users' stress levels. However, currently, fitness trackers alone cannot measure emotional burnout accurately since they cannot integrate other external context information (e.g., an exercise session right before sleeping; psychotherapeutic practices, such as

exposure therapy, that elicit a stress response). A JITAI might ask further check-in questions through EMAs for more accurate estimation if the stress measurements are elevated in the fitness trackers. If they are not elevated, the JITAI might skip administering the EMAs on that day or randomly decide whether to send the EMA survey or not in a microrandomized fashion [1]. This approach might help to reduce participants' response fatigue from daily EMAs.

The participants mentioned that their responses to many of the EMA questions might not change every day because of cognitive worries and coping patterns established across the duration of the pandemic (e.g., if they are worried about their family). Specifically, the participants pointed out that the presence of a global pandemic made some factors persistent for them (e.g., risk of a COVID-19 infection for their family members). Therefore, there was limited variation in some of the EMA responses. For such questions, as the participants suggested, the JITAI might first ask if their perceived level of stress changed or not. For instance, the JITAI could show the participants their previous responses and ask if their perception has changed in the last 24 h. Alternatively, it could ask them if their perceived mental condition changed in the last 24 h without showing their previous responses. However, we do not have a 'one-size-fits-all' solution to what question format might work best for the participants, and different ways of asking this question may bias or prime participants in different ways that would require further investigation. Regardless, if they respond in the affirmative, a JITAI could follow up with further questions for better measurements and other contextual information.

6 Study Limitations

Since this study was conducted amid a global pandemic, the frontline HCPs who participated in this study were already experiencing longitudinal stress due to increases in expected clinical duties. This snapshot of their experience is, therefore, contextually bound and does not include a pre-pandemic baseline. Further, the additional burdens of being a clinician in a pandemic context likely resulted in limited recruitment. Additionally, the conditions of the pandemic have been shown to vary over time by geographic location (e.g., higher incidence due to spread, clinical resources taxed due to population demands). The participants were all employees of the same healthcare system in the same location and a relatively small sample size, thus limiting generalizability. In the future, we plan to study a wider and greater number of frontline HCPs to understand their experience with tracking biopsychosocial measures and design technology to better support their overall well-being.

7 Conclusion

A global pandemic causes significant psychological strain for the world population, especially for frontline health care providers. These providers are especially critical to population health during global health events like the current

COVID-19 pandemic. To maintain optimal functioning, it is critical to support their physical and psychological well-being. This paper explored how HCPs might interact with a JITAI-like system that collects biopsychosocial metrics using off-the-shelf fitness trackers and EMAs to implement a JITAI to support their mental health. Our findings indicated that contextual variables, like work demands, influenced the HCPs' engagement with the technology integration. We also identified a need for better tools to capture emotional exhaustion over the long term. Finally, we argue for advanced automation and context-sensing to fuel a JITAI targeted towards frontline service providers and suggest integrating micro-interventions in JITAIs to reduce the response burden further. We believe our contribution would help future research in designing better supportive technology for the many frontline providers who dedicate their professional lives to caring for all people in difficult times.

Acknowledgment. This research was supported by an award from the Immunology, Inflammation and Infectious Diseases Initiative and the Office of the Vice President for Research at the University of Utah. The authors would like to acknowledge Heidi Hansen and Alyssa Louise Duenes for their support in coordinating with different stakeholders of this study.

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