Supporting the Self-care Practices of Shift Workers

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ABSTRACT

Working in shifts can cause great disruption in a person's life, impacting their health, family, and social life. Previous work has raised numerous issues of shift work, but there is little understanding of how workers practically deal with the challenges of shift work. This study investigates how shift workers engage in self-care to avoid health issues and deal with their shifts in practical terms. Findings show that shift workers engage in numerous activities for preparing, managing, and recovering from night shifts. Moreover, we describe the design of a mobile app for shift workers, designed based on the characteristics and self-care practices of shift workers.

CCS Concepts

•**Human-centered computing** → **Ubiquitous and mobile computing systems and tools; Empirical studies in interaction design;** •**Applied computing** → **Health informatics;**

Author Keywords

Shift workers; shift work; self-care; sleep; mobile apps; self-care technologies.

INTRODUCTION

Most people work between 8:00 and 18:00 on weekdays, but a considerable number of workers have less orthodox schedules. Shift workers, as usually named, have rotating schedules and changing routines on a daily or weekly basis. Shift work is extremely common in some areas due to 24-hour coverage (e.g., healthcare) or the pressure to reduce production costs (e.g., factories). A recent survey from the European Union reports that 21% of European workers do shifts, and of those 90% work during at least one night every month [27].

Engaging in shift work can have a strong impact in the life of the workers. Shift workers are less likely to report a good fit between their work and their family or social life, and they report a greater impact of the work in their health [27]. Moreover, shift workers can develop multiple health issues due to their work engagement [19, 2, 26, 11].

Since there is no expectation that shift work disappears in the near future [27], interventions can only aim to improve the conditions of the workers. Previous work has investigated perspectives of shift workers, but there is little understanding of how people manage shift work in practice. With this work we seek to explore the self-care practices of shift workers, recognizing the ability of workers to act according to what is best for them, and the role technology can have in supporting their self-care practices [25].

In this paper we describe the findings from a qualitative study with shift workers. Drawing on interviews with different shift work professionals we document how shift workers engage in self-care to manage their shift work in everyday life. Findings suggest that people perform a considerable amount of work to deal with their shifts, and there are multiple areas where technologies could intervene. Moreover, we describe a mobile app for supporting the self-care practices of shift workers.

This paper has two main contributions. First, it describes the self-care practices of shift workers. Second, it discusses how technologies can help shift workers in improving their management of shift work, providing an example of a mobile app inspired by their issues and practices.

The paper begins by introducing shift work and existing technologies for managing it. Following is a description of the methods used in this work. Then, we detail how shift workers engage in self-care to manage their shift work. The fourth section discusses ways in which technologies can support shift workers, and the fifth section presents a mobile app that supports shift workers. Sections six and seven respectively discuss the results of this work and conclude the paper.

BACKGROUND

Shift work

The expression shift work is used broadly to name work activities that happen outside the traditional work schedule [10]. There are a variety of work arrangements under this category, but in this paper we refer to workers with rotating shifts, created to cover 24 hours. For these workers, weekdays and weekends are no different, as they may work (and have days off) at different points of the week. The time for sleeping and resting is also indefinite, as people may work at different points during the day. Moreover, shift workers do not usually have a fixed schedule, rotating between shifts on a daily or weekly basis.

Shift work is very common in some professional areas [27]. Security needs shift work to cover 24 hours of operation. Healthcare also needs 24-hour coverage and has a shortage of specialized personnel – which is partially reduced with shift work. Production industries use shift work to increase production output. And mining uses shift work to optimize the use of expensive machinery.

The health consequences of shift work are well studied in the literature. The most immediate issues felt by workers concern difficulties in getting to sleep, shortened sleep duration, and daily somnolence [2]. The impact in sleep is so prevalent that there is a disease named Shift Work Sleep Disorder, characterized by symptoms of insomnia or excessive sleepiness associated to shift work schedules [26]. Shift work is often associated with poorer mental agility and reduced performance [11]. Moreover, epidemiological studies associate shift work with gastrointestinal issues, peptic ulcer disease, coronary heart disease, and compromised pregnancy outcomes [19]. The impact of shift work on health accumulates as years go by, and it can even lead to early retirement [32].

Shift work also has an impact on the social and family life of the person. Working outside common work hours (and weekends) means that workers are often misaligned from the schedules of family members and friends [3]. Moreover, the fact that some workers do not have a regular schedule hampers the possibility of establishing a family routine [9].

The self-care of shift work

Some issues of shift work can be avoided if people engage in specific practices. For example, people can maintain their sleep rhythms[1] despite working nights, if they sleep only for short periods during the day [16]. The ability to intervene on one's health led us to use the concept of self-care in relation to shift work. Self-care in this paper relates to the activities that people living with a chronic condition undertake to manage the condition as part of their everyday life [24]. We frame shift work as a chronic condition because workers are exposed to issues of shift work until they quit or retire, and during this period they cannot escape its consequences. Like chronic patients, shift workers can only accept their condition and self-manage it in the best way possible.

There are some articles discussing the self-care of nurse shift workers, but authors used self-care as a synonym of maintaining healthy behaviours. For example, Gabrielle et al. [13] investigated how older female nurses dealt with an ageing body, reporting that shift workers were careful about their diet and tried not to put themselves in situations where they could injure themselves at work. Nahm et al. [22] discussed the practices of nurses in maintaining a regular weight and reducing stress. In both cases, authors investigated preventive practices, that could be equally applicable to non-shift workers. In this paper, we were concerned with how shift workers self-care to deal in practice with their shift work.

Studies investigating the perspective of shift workers are not very common, but there are some. For example, Silva-Costa et al. [31] investigated how nurses rested during night shifts, focusing on the organizational and environmental characteristics. Nasrabadi et al. [23] described how nurses saw their work in shifts, reporting on the inability to attend family and social activities, but also on the opportunity of learning more through shift work. The most common studies seem to be about the tolerance of people to shift work, detailing the personal characteristics and social conditions that are related with continuing being a shift worker [10, 30]. In essence, we know that some shift workers cope better than others, but we do not understand how people cope in practice.

Technologies for the self-care of shift workers

Technologies for the self-care of shift workers are not very common, but there are two types of technologies worth mentioning. First, there are some mobile apps that enable shift workers to keep a calendar of their shifts (e.g., Shifts[2], or Shiftdays[3]). Since workers have rotating schedules, it is important for them to keep track of their most updated schedule. These applications enable users to enter their own shift types and easily assign them to a specific day. They also enable users to straightforwardly change shifts with colleagues.

Another self-care technology specifically designed for shift workers has to do with bright light lamps. These lamps emit light with specific characteristics to adjust sleep rhythms when they become de-regulated [12, 5]. Examples include goLITE Blu[4], or SunTouchPlus[5]. Bright light lamps are used under medical guidance as they can easily deregulate further the sleep rhythms of shift workers.

It is interesting to observe the lack of technologies for the self-care of shift workers, specially when taking into consideration the recent interest of the HCI community in sleep tracking [20, 18, 8]. One would imagine that mobile apps such as Sleep Cycle[6], wearables such as Fitbit Charge[7], or devices such as Beurer SleepExpert[8] would afford use by shift workers. However, apart from clinical studies using actigraphy (e.g., [4]), we could not find studies reporting on sleep-tracking technologies being used by shift workers.

The overall lack of self-care technologies for shift workers motivated the design of the Clockwork mobile app. If self-care technologies can have such an important effect on chronic patients [25], we intuited that they could have a role in the self-care of shift workers who also deal with multiple daily challenges because of their work arrangement.

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[1]Sleep rhythms is the expression used to name the need to sleep at specific times during the day. The body has an internal clock of 24 hours, and, through the release and inhibition of certain hormones, increases or decreases alertness at regular intervals.

[2]Shifts is described at: http://builtbysnowman.com/shifts.

[3]Shiftdays is described at: http://shiftworkdays.com.

[4]goLITE Blu is described at: https://usa.philips.com/c-p/HF3332_60/golite-blu-energy-light.

[5]SunTouchPlus is described at: https://naturebright.com/sun-touch-plus.html.

[6]Sleep Cycle is described at: https://sleepcycle.com.

[7]Fitbit Charge is described at: https://www.fitbit.com/dk/charge.

[8]Beurer SleepExpert is described at: https://beurer.com/web/gb/products/wellbeing/sleep-and-rest/sleep-sensor/se-80.php.

METHODS

To understand how shift workers engage in self-care in everyday life, we conducted interviews with shift work professionals. Interviews were intense, qualitative, and semi-structured. The interview guide touched on shift work challenges, rest and sleep practices, health impacts, and work-life balance. We had an interview script, but offered space for participants to explore other topics they considered relevant.

We interviewed 29 participants (18 females, 11 males), resulting in 10 hours of audio-recordings. We interviewed 2 doctors, 9 nurses, 13 orderlies[9], 3 security personnel, 1 maintenance worker, and 1 fisherman. We chose to involve different professional categories to increase comparison between participants. Experience of participants in this work arrangement varied, ranging from less than a year to 34 years of experience in shift work ($M = 10$, $SD = 8.8$). The ages of participants ranged between 26 and 61 ($M = 46$, $SD = 10$).

We recruited participants through personal contacts of the research team and José de Mello Saúde, a health care provider partner in Clockwork project. The project was investigating how to support middle-aged to older shift workers and thus 21 participants were above 45. Besides these workers we also interviewed younger ones to increase comparison between participants. All interviewed participants worked around two large cities of Portugal. Participants were interviewed in their workplace, in our facilities, or at their home, according to what was more convenient for them. Most interviews were held in-person, yet two were conducted over the phone. All interviews were transcribed verbatim and the quotes that appear in this paper were translated from Portuguese to English.

Our analysis was inspired by the constructivist grounded theory methodology [7]. Following the transcription of the interviews, we performed iterative coding using Scrivener software. Data analysis drove data collection and the interview guide kept being updated to focus on relevant themes. We constantly compared excerpts and participants to enrich the analysis. We achieved meaning saturation [15] with the 29th interview. Unlike code saturation, which is focused on the appearance of new codes, meaning saturation is focused on the in-depth and nuanced understanding of phenomena reported by those codes.

We obtained informed consent from all interviewed participants, after presenting the researchers, the project, and the reasons for the interview. All participants volunteered to participate, and received no monetary compensation. The names of participants reported in the paper are fictional.

THE SELF-CARE PRACTICES OF SHIFT WORKERS

The fieldwork presented here describes how workers engage in self-care to deal with their shift work. In particular, we discuss the activities of preparing, managing, and recovering from a night shift. We do not intend to claim that practices for managing night shifts are the sole self-care practices of shift workers, however, our interviewed participants found dealing with night shifts the hardest part of their job. For this reason,

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[9]Orderlies, also known as nurse assistants or hospital attendants, are staff who provide non-medical care to patients and ensure cleaning and order.
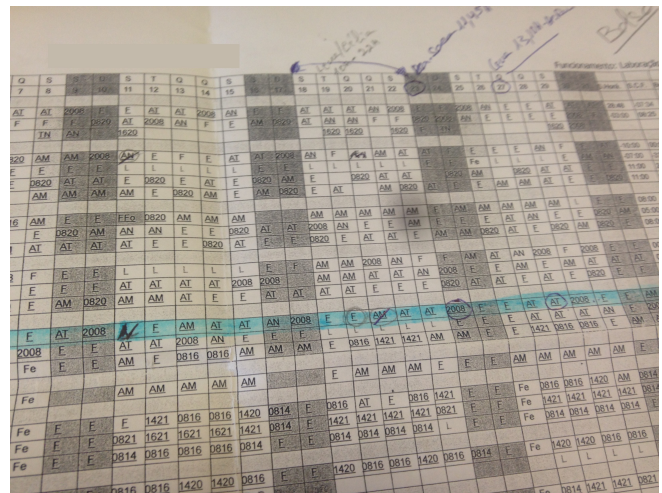

Figure 1: Shift schedule from a medical unit annotated by one study participant. Notice the annotations, corrections, and shift changes.

these self-care activities are a good example of the complexity of managing shift work.

Before describing the actual self-care practices, it is important to provide context on the shift workers we interviewed. Our nurse and orderly participants typically had three shifts of 8 hours (mornings, afternoons, and nights) where they performed similar work. Doctors worked mornings doing consultations and had one 24-hour shift every two weeks in the emergency department. Security and maintenance personnel had three types of shifts doing similar activities, and worked 5 days in a row before resting or rotating to the next shift. The fisherman worked mostly during nights and had some irregular activities happening at other times. In all cases but the fisherman, the shift schedule was distributed once a month. The direct supervisor manually assigned schedules to the workers of their team, taking into consideration the availability of personnel, special circumstances of the workers (e.g., pregnancy, breastfeeding, health conditions), and the work law. Nevertheless, the executed shift schedules were often different from the initial timetables. In fact, workers often exchanged shifts between each other to accommodate non-work commitments (see arrows and annotations in Figure 1). Swapping shifts was not always positive for their health (e.g., when accumulating shifts), but it was extremely important for shift workers to attend family or social events.

The interviewed participants who worked in healthcare worked often in two or three institution. They performed similar activities in each of them, but had to work in multiple places as a single institution did not hire them for enough hours. However, working for multiple institutions meant that workers had to switch shifts with other colleagues, and, if colleagues were not available to replace them, perform double shifts.

Participants suffered from numerous consequences of shift work. They had multiple sleep issues and hardly ever reached 8 hours of sleep. Shift workers faced difficulties in spending

time with their family, and found it hard to maintain a social life. However, and despite these negative impacts, shift workers were happy with their setup. Every worker mentioned the advantages of being able to go to public services without missing work, hanging out with family and friends during weekdays, and the ability to create holidays by joining rest and days off. In essence, shift workers had adapted to their work arrangements and made the necessary adjustments to work and live well under their conditions. Similar to Nasrabadi et al. [23], quitting shift work was not out of question for our participants, but for the moment they perceived a good balance between advantages and inconveniences.

Preparing for a night shift

Working nights is extremely disruptive for shift workers. Even though people get used to it, night work always impacts the body of the worker. For this reason, workers engage in preparation activities to help make working nights more bearable.

The most common preparation activity was taking a nap in the afternoon that preceded a night shift[10]. These naps helped shift workers staying awake during the night, however, they did not compensate the sleep lost during the night. Participants reported sleeping between two and four hours, in bed or in a comfortable chair or sofa. Pamela talked about these naps as very effective in preventing her from falling asleep during a night shift.

> *"When I do nights, no, I don't have any problem staying awake. To me it is not a problem because I rested a little bit. I took a nap in the afternoon."* Pamela, orderly, 49

Participants often described following a list of activities in their preparation for a night shift. These activities were consistently the same and had a particular order.

> *"I have a system, don't know if it's shared by other colleagues: in the days that I work nights, I wake up early and after lunch, around 3 o'clock I lay down for a bit. I sleep around two hours, two and a half [hours]. Then I take a bath and I'm ready."* Grace, orderly, 56 years

Like many workers, Grace had a ritual for preparing for a night shift. Performing these activities (early rise, nap, bath) in this particular order helped Grace become more relaxed and with further strengths for facing the night shift[11]. However, besides having a practical intent, these activities were important to mark the day. They were routines that helped signal to the body that it was time to become alert and prepared to engage in work. Instead of optional, they were mandatory steps to feel rested while working the night.

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[10]Taking a 2 hour nap before a night shift is recommended in the medical literature for shift workers [16]. Moreover, workers saw a real benefit of taking a nap on their work quality and on their overall well-being during a night shift.

[11]Shift workers tended to have a routine for preparing for a night shift, yet the activities differed from person to person.

Managing sleep pressure during a night shift

Workers who do night shifts have to deal with sleep pressure[12] at some point during their work. The night shift often encompasses less activities to perform, reduced social interactions because there are less workers, and an overall quieter environment; all factors which can contribute to increasing one's sleep pressure. Even though workers do not feel sleepy when they are highly engaged into activities, when work is monotonous or rare, they will get sleepier and might fall asleep.

Shift workers do all sorts of things to make sure they stay awake. Participants reported drinking water, tea, coke, or coffee. They talked about washing their face, moving around, or even working while standing. They listened to music, played smartphone games, saw YouTube videos, browsed the web, checked email, watched TV, or read books. Common between all activities was their potential in keeping workers awake and in the case of the latter, their entertainment role.

The activities of some workers are more prone to inducing sleep. Staying in the same place for hours watching video cameras, as is the case of security officers, often makes these workers sleepier. On the opposite side, working in a packed emergency department can render clinicians alert for hours. In any case, the sequence of days (or nights) without sleeping appropriately – the so called "accumulated fatigue" – also made it hard to keep awake.

The consequences of falling asleep are also different for distinct workers. Doctors, who do 24-hour shifts, are expected to sleep during part of the shift. Nurses and orderlies might have some time reserved to rest during their shifts. Security personnel, on the other hand, are forbidden from sleeping in their shifts to ensure the security of the places they are guarding. Nevertheless, all workers will go through the need of keeping themselves awake at some point during their shifts, and they use some strategies for enabling them to keep awake.

Planning work to ensure they are busy

To keep themselves alert during night shifts, participants planned their work to have things to do for the duration of their shifts. One strategy workers used was to save activities from morning and afternoon shifts to do during night shifts.

> *"Fold bags, re-fill nurse trolleys. During the day we should also do it, but we fill them further [at night] for the next day."* Marianne, orderly, 51

Some units organized themselves to distribute work between shifts. For example, in Marianne's unit, replenishing nurse trolleys and folding bags, were activities that nurses and orderlies from the morning and afternoon shifts left mostly for their night shift colleagues. Security personnel also saved some administrative activities for the night shift. Saving work for later enabled to balance work between the most occupied parts of the day, but also helped workers of the night shift to stay awake more easily.

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[12]Sleep pressure is the expression used to name the need people feel to sleep. The more time people spend awake, the greater their sleep pressure becomes.

Another strategy participants used to fill their shifts with activities was to divide work into small batches, intertwined with rest periods, distributed throughout the shift.

"We have a set of activities that we have to accomplish during the night [...] I split [them] in order to not having to stand so still." Sarah, nurse, 26

Sarah split her tasks over the course of the night, so that activities covered the whole shift period and enabled her to rest. She confided that doing all activities in a row would be too tiring and hinder her from performing work with perfection. Thus, to do work with quality, she divided activities into smaller batches and rested between those times.

Switch work functions with colleagues
Besides keeping themselves occupied, shift workers also used to change between more sleep-prone and more active tasks with their colleagues.

"Here we are two during the night. We switch with a colleague. The colleague comes into the cameras and the other colleague goes into the atrium. That one walks around there." Adam, security officer, 52

Security officers like Adam use the fact that there are two people working in security to change functions with each other and hinder sleep pressure. Once the security officer watching video cameras starts feeling sleepier, the other officer walking around the atrium comes to switch work functions with them. This way, security officers can share the burden of sleep pressure together, and hinder their sleep when they start feeling worse. A nurse who works in surgery also gave a similar example.

"And that happens sometimes, when the shifts are heavier and I am able to tell to the responsible nurse that I am so tired that I cannot instrument any further. [I tell her] switch my position. I will circulate." Caroline, nurse, 54

When Caroline felt exhausted she would switch functions with another nurse from the operation room. Instead of passing instruments to the surgeon and preparing work in the sterile area, she would take the circulating nurse role, that enabled her to move more and did not require the same level of concentration and attention to detail. This change enabled the nurse to manage her effort and to work well until the end of the shift.

Planning rest and sleep periods during the shift
In some cases, workers can take action to ensure some rest or sleep time for them. Among the participants interviewed, doctors working on emergency departments were probably the ones that slept longer, as they were not always needed and their shifts lasted 24 hours. Nurses and orderlies also had some time to rest provided the service kept working as expected.

"In the service of [name of other participant], which is where I worked, we were four working the night shift and we could divide. Two of us rested." Neil, nurse, 36

In the previous place where Neil worked there were multiple nurses working together, and thus they created a rest/sleep schedule. Each nurse would get a two hour slot where they could rest, and in which other nurses took care of their patients[13]. Resting at work was not fully restorative because it was short and workers slept while expecting to be shortly woken up by their colleagues. Still, organizing a rest schedule guaranteed workers rested and the work was under control.

Some units also had snack breaks during the night shift. During snack breaks, workers drank tea, coffee, and ate snacks and cakes. While these events had the practical purpose of enabling workers to eat, they were also opportunities to rest and have social interactions. With the recorder off we heard stories about baking cakes or bringing special snacks to these events, as everyone brought something to share with the others. Snack breaks were intimately social, but the opportunity to rest should not be undermined.

Having said that, it is important to recognize that not every shift worker is able to sleep or rest, but most participants talked about the possibility to at least sit in a more comfortable chair during part of their shift to rest. Even though rest/sleep moments may not be part of the official schedule, workers made sure they created space for them, to more easily endure the night shift.

Engage in conversations
It can be hard to stay awake with the silent environment workers face during night shifts. For this reason, some workers start conversations with other people around them. Some security officers told us about spending hours talking over their walkie-talkies simply to ensure they would not fall asleep.

"Sometimes we pick up the radio. Talking with the colleague also helps... Even if it's just talking about... – where are you going tomorrow? Tomorrow it's your day off." Adam, security officer, 52

The conversations over the walkie-talkie were not particularly meaningful or work-related. Security officers talked about what they did during their last days off and their plans for the next ones. Small talk was just enough for getting them going for some extra hours.

Recovering from the night shift
After a night shift, the shift workers usually headed home. They felt the impact of the shift in their body, and engaged in some activities to help them recover from it.

Preparing for resting
When workers arrive at home they usually start preparing everything for resting. The sleep made in the afternoon did not bring the same effect as sleep made during the night, but it was important to rest for some time nonetheless. For this reason, shift workers engaged in activities that prepared themselves to go to sleep, and they performed as well other activities that influenced their environment.

"In the next day I go home, take a shower, breakfast, and sleep." Danah, doctor, 29 years

Taking a shower, eating, and sleeping were usually mentioned by participants as activities they do when arriving at home.

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[13] Silva-Costa et al. [31] reported similar scheduling practices in a study investigating how nurses rest during night shifts.

These activities were important for relaxing and resting. Similar to pre-shift preparations, activities for preparing rest were conducted in a particular order, which hints that they may signal to the body that it is time to go to sleep.

Besides getting themselves ready to go to sleep, workers engaged in preparations that adapted their environment for sleeping. Participants reported closing the window blinds of their room, asking family members to stay outside the room, and sending small children to the nursery; all activities that can reduce the noise and lights around shift workers. These measures were necessary because, as shift workers referred, sleeping during the day is not the same as sleeping during the night. There is more traffic in the streets, more people walking and speaking outside, and family members walking and talking around the house, which can make it hard for shift workers to sleep. For this reason, shift workers had to prepare the environment around them to be able to sleep.

Resting without changing sleep rhythms
After all arrangements, shift workers eventually went to sleep. Participants reported sleeping for a short interval and then to wake up. The purpose of this sleep period was not to replace completely the sleep lost in the previous night, but rather to help the body recharge energies to keep them going through the day.

> *"When I do a night, my goal is to arrive home and sleep, but I cannot sleep much (...) I try to sleep, imagine, from 11:00 to 14:00. Around 3 hours, so that at night I have the will to sleep. Because if I extend the nap in the morning, then at night I do not sleep."* Elisabeth, orderly, 51 years

After some hours of sleep, shift workers are still tired, but they need to wake up for avoiding changing their sleep rhythms. If shift workers continue sleeping non-stop, it is possible that in the evening they will not be sleepy as usual, and thus will not be able to sleep. A couple of days sleeping at odd-times will be enough for changing the sleep rhythms of the workers, making them feel the urge to go to sleep during the morning or afternoon.

In some cases, shift workers went to sleep only after lunchtime, using the morning for other activities (e.g., exercising, shopping, or home chores). Still, and despite starting to sleep at a different time, shift workers would also wake after a short amout of time. There was still the possibility of not being sleepy at a later point, and thus participants avoided staying in bed for too long during the afternoon.

IMPLICATIONS FOR DESIGN
The insights from the previous section provided a glimpse of the complexity of working shifts. In this section we reflect about some of the larger challenges identified, providing a vision of how technologies for self-care could be useful in helping address those issues.

Managing shift work entails a great amount of practical work
Our involvement with shift workers made it clear that they need considerable preparation and organization for managing their shifts. The practical work needed to manage shift work provides the motto for self-care technologies that can support

shift workers. Even though organizational interventions can help implement better working environments, shift workers will most likely endure issues from shift work, and it is important that they have appropriate tools for dealing with those issues in ways they find fitting their lives.

Shift workers can develop health issues in the future
The shift workers we interviewed were very well adapted to their work situation. They did not encounter overly disturbing health symptoms and were proficient in organizing and planning their work. Nevertheless, they are prone to develop illnesses in the future. Technologies to support the self-care of shift workers, similar to those targeting people living with other chronic conditions [25], can play a role in helping workers understand their current status and adopt practices that avoid problems in the long-run.

A need for sleep tracking technologies
The sleep problems of shift workers are numerous and the impacts in their life are quite visible. It is common to hear people saying that they do not sleep much, but workers rarely have a good idea of how much they are actually sleeping. For this reason, shift workers seem to be good candidates for research that tracks and supports sleep. Workers could also benefit from advice on how to improve sleep habits; however, advice should be not offered in a way that makes users feel demotivated as they cannot do anything to improve their sleep rhythms. Moreover, and unlike people without sleep problems who may stop using technology shortly [21], shift workers have a motivation for tracking their sleep and can see results from their actions in their sleep time and/or quality.

A need for sleep preventing technologies
The findings presented a number of strategies workers adopted to stay awake, some of which even included technologies. However, technologies can help further, for example, by detecting when workers are falling asleep, and provide some sort of stimulus that can wake them up, and help avoid the consequences of sleeping at work.

Changing work schedules
Although work schedules should have a satisfactory balance between work and rest time, the real schedules of workers are quite different. Workers swap shifts with colleagues in order to accommodate other commitments in their lives. Moreover, a significant number of participants work in more than one place, and since there is no communication between different institutions, the actual work schedules might not be very balanced in terms of rest. Technologies can be useful in keeping an updated schedule and providing some insight of the amount of work pursued.

CLOCKWORK APP: A MOBILE APPLICATION FOR SUPPORTING SHIFT WORKERS
The insights from the interviews motivated us to design a mobile app to support the self-care of shift workers. The Clockwork app collects and displays data about one's sleep schedule, as well as activity level and light exposure measured during working shifts. The app also enables shift workers to enter their shift schedules and receive recommendations to

promote healthy practices. The goal of Clockwork app is to enable self-reflection and self-awareness of shift workers, by making visible habits that are hard to remember (e.g., hours slept in past week) or providing recommendations at relevant times (e.g., avoid drinking coffee 6 hours before sleep).

The Clockwork app is part of a larger system, Clockwork system, designed for both shift workers and health and safety technicians. Figure 2 displays the architecture of the system which is composed by the following devices:

- Smart Badge - a wearable device with an inertial measurement unit (IMU) and a light sensor, to track the activity and light exposure of shift workers when it is not practical to carry their smartphone (see [28, 29]). Data is stored temporarily and transmitted to the smartphone with Bluetooth Low Energy (BLE);

- Beurer TL 55 Day & Night (Beurer, Germany) - a commercial lamp for performing light interventions that can regulate sleep rhythms;

- Clockwork Box (RK Tech Kft, Hungary) - a device with a noise sensor, a spectrometer, and a thermometer, to monitor conditions of the work or rest environment. Health and safety technicians are expected to visualize data in the Evaluation Software to adjust work environment conditions;

- Firebase[14] (Google, USA) - a real-time database for storing data collected with the different devices;

- Server - for producing recommendations or reminders of healthy practices for shift workers.

This paper focuses on the design of the Clockwork app due to its relevance in supporting shift workers in managing their shift work. Further detail about other parts of the system can be found at [28, 29]. We opted for developing a smartphone application because smartphones are prevalent in many countries, can collect data using internal sensors, can display information, and provide internet connection. Smartphones are also appropriate for collecting self-reported data and displaying recommendations, which is relevant in this context.

Monitoring sleep

The Clockwork app enables shift workers to semi-automatically report their sleep and visualize sleep intervals of the past days. This feature addresses some of the difficulties of monitoring one's sleep schedule to potentially avoid health issues caused by sleep deprivation. Even though all participants were aware that they should be sleeping on average 8 hours, without tracking their sleep, they did not know how close they were to meet the target. Moreover, without tools to log their sleep and to remind them of when to log it, it was hard to sustainably know how much they slept.

To facilitate sleep tracking we combined an automatic logging system with self-reported data. The mobile application runs an algorithm that analyses data from the smartphone's accelerometer and records an event if more than 40 minutes are spent without moving the smartphone. Inactive periods

are displayed on the smartphone to enable users to see them and confirm them in case they were sleeping (see Figure 4, bottom left). Besides confirming detected inactive periods, shift workers can remove or edit entries, or add new sleep intervals that were not detected.

Sleep periods are classified as one of two different categories: (longer) sleep and naps. The distinction between sleep and nap periods has to do with a time threshold that is defined by the user. We were inspired to distinguish between sleep and nap periods because participants did not think of all their sleep periods as being similar. If sleep occurred solely in short time bursts and in less comfortable places, it would not restore their strengths. On the contrary, if sleep was lengthy and in bed, the results would be more satisfying. While setting up the application users choose how long a nap can be, and from that moment sleep periods with that duration or smaller are classified as naps. Nevertheless, the classification can be overridden by the user, if they feel the classification onto naps or sleep does not correspond to the sleep quality they had.

The visualization of sleep periods appears in two different screens of the app: the dashboard (Figure 3) and the detailed sleep view (Figure 4). The dashboard displays the hours slept during the past 7 days. The detailed sleep view displays the hours slept and napped during a specific week, starting with the current week, but enabling users to move backward and forward to display sleep data from other weeks. In both screens, there is a plot with vertical bars representing the total amount of hours slept during each of the days. The bars from the plot of the detailed sleep have two shades of blue, to distinguish between naps and sleep, and enable users to see the duration in shorter or longer sleep intervals.

Monitoring physical activity

The Clockwork app tracks and display workers' activity level during work shifts. In other words, the app identifies and displays work intensity, and thus enables workers to monitor the amount of effort they invested on each shift. This feature was motivated by the need to manage effort throughout the night and the difficulties in keeping track of one's activity level as time goes by. Even though most shift workers engaged in practices to manage their effort on a shift-by-shift basis, fatigue accumulated, and they had no overview of past effort.

The mobile application runs an algorithm that classifies physical activity into four activity levels, namely: Sedentary, Light, Moderate, or Vigorous. The Compendium of Physical Activities [1] classifies types of activities (e.g., walking, cleaning a table) into these four activity levels according to the energy expenditure of each activity. The algorithm we developed takes data from the accelerometer of the smartphone[15], and classifies it into four levels of activity using certain acceleration thresholds[16]. The algorithm only runs while users are working because the purpose is to better enable shift workers to manage their effort while at work.

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[14]Firebase is described at: **https://firebase.google.com**.

[15]Besides running on the smartphone, the algorithm also runs on the Smart Badge, which enables users to gather data from their activity when using their smartphone is not practical or possible.

[16]The rational and design of the algorithm for classifying activity into a specific activity level have been reported elsewhere [29].
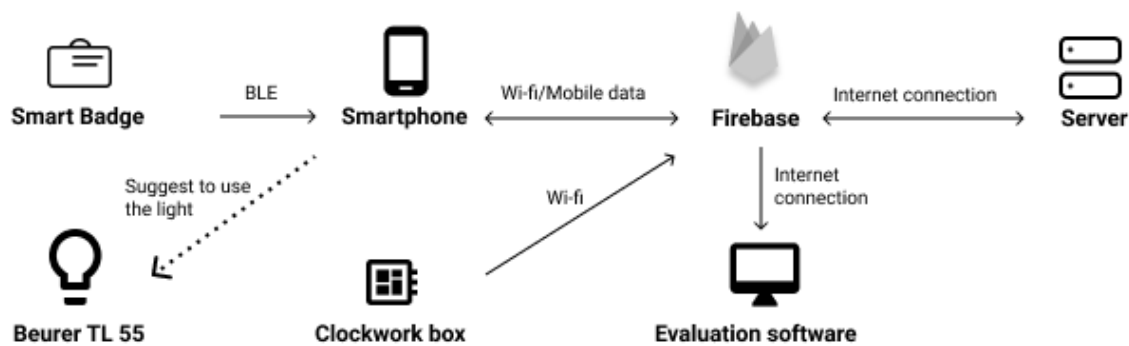
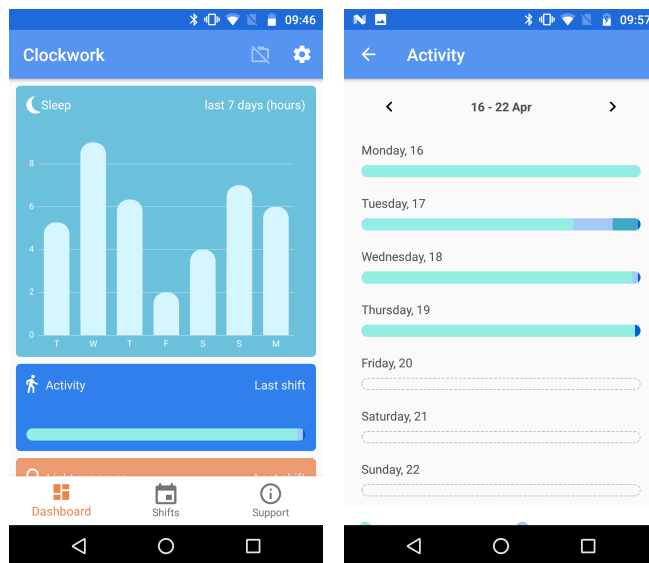Figure 2: Architecture of the Clockwork system

Figure 3: Left: Dashboard displaying an overview of sleep, activity level, and light exposure. Right: Screen displaying activity levels for the current week.
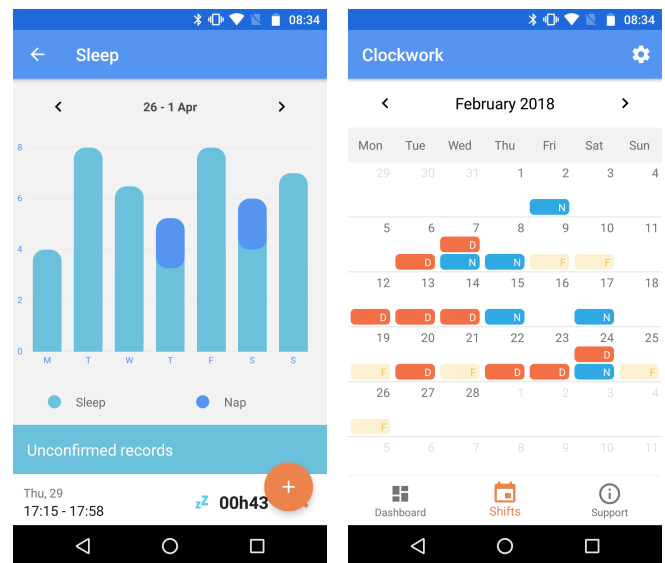

Figure 4: Left: Total amount of sleep and naps for the current week, with list of individual entries. Right: Calendar view with the shifts for the month.

The data collected can be visualized in two different screens. The most recent data is displayed in the Dashboard, where the amount of time spent in Sedentary, Light, Moderate, or Vigorous activities during a certain shift appears (Figure 3, left). Users can observe in this screen if they are committing a great physical effort during a certain shift, and thus potentially reduce their activities or take a rest. The second screen is the detailed activity screen, that displays the activity level of each day of a specific week (Figure 3, right). Users can move backward and forward to display data from other weeks, and in case there are days without work, they are represented with a hairline element. The detailed activity screen was designed to enable users to understand if they are committing to great effort during longer periods of time, so that shift workers can act on their work practices.

Monitoring light

The mobile application enables workers to monitor how much light they are receiving during work. According to the liter-

ature, the level of lighting at the workplace is a contributing factor to a productive work environment, and to the well-being of workers [17]. To help workers access the light conditions of the workspace, the Smart Badge contains a sensor for measuring light exposure, which is then processed by the smartphone to determine the percentage of time spent above the minimum recommended threshold (200 lux) during the shift [14]. Light data will only be collected through the Smart Badge, since its sensor (in the front) is not often exposed to light.

Light exposure for the latest shift is displayed on the Dashboard (Figure 3), and there is also a detailed view, similar to the activity view, with data from previous shifts. Light data is displayed on a bar representing the percentage of time in which workers were exposed to the recommend light during the work shift, in order to help workers assessing the lighting conditions of their work environment.

Managing shifts

The Clockwork app has a feature for entering one's work shifts (Figure 4, right). This feature addresses the need of shift workers to keep track of their schedule, despite changing shifts with colleagues. During the interviews we noticed that workers had different methods or tools for keeping track of their shifts. Some workers carried a printed version of the monthly shifts map provided by their employee, others used an application such as Google Calendar for keeping track of their shifts, and others used a dedicated mobile application for the same purpose. By providing shift workers with a way to keep their shift schedule, we enabled them to have an updated schedule always with them. Additionally, the app has information about when users are working and can thus start tracking activity or even provide contextual recommendations.

Our application enables workers to set up their own shift types. For each shift they define a name of the shift, an acronym, and a colour. This flexibility is useful because different workers will have different shift types and it is possible that a worker has the same shift (e.g., morning) in two different employees. We also provide an option for workers to report if a specific shift type corresponds to a working one, which enables to store also days off and holidays in the calendar.

Contextual recommendations

The Clockwork app offers contextual recommendations to promote healthy habits. During the interviews we understood that participants were well aware of many guidelines of how to manage shift work (e.g., sleeping at specific times after a night shift, drinking coffee), however some guidelines can be harder to achieve due to practical issues. The contextual recommendations provide reminders at specific points so as to improve sleep and rest practices.

In terms of the user interface, this feature leverages the notification system of Android smartphones. At a specific time the user hears a sound and observes a notification on the top of the smartphone screen with a recommendation message. We were careful in designing the recommendations so that they did not convey information that users already know of. All messages represent information that is relevant to know about, or know at a specific time, and there is a random element in the system that hinders notifications from being displayed always at the same time[17]. We expected workers to be knowledgeable about recommendations and thus enable users to turn off each of the recommendation notifications.

The recommendations that are part of the app are:

- Avoid drinking coffee - triggered 6 hours before the end of a night shift, because coffee should be avoided 6 hours before going to bed [6];

- Take a nap before a night shift - triggered randomly 4-8 hours before a night shift so that users can plan their rest before work as recommended in [16];

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[17]One of our reviewers reminded that a notification can loose importance if it is triggered at a random time. However, by triggering notifications in a certain time period, we can ensure that notifications are relevant and actionable, while avoiding to tire the user with notifications always at the same hour during the day.

- Report on hours slept in the past days - triggered randomly every 5-7 days, and displays the average number of hours slept in the days before. The idea is to help users meet their sleep target;

- Report on excessive hours of work - triggered on a day off, if the sum of worked hours during the past 7 days is greater than 48. The goal is to remember workers to avoid weeks with steep effort;

Finally, the system can send notification to remind workers to fill in their shift calendar if there are not shifts for the next week. While this recommendation does not have a direct impact on the users, it is nevertheless important for the functioning of the overall system.

DISCUSSION

The interview findings presented above show that managing shift work is extremely challenging and complex. Workers do not simply show up to their work, but rather engage in numerous activities, for example, when preparing, managing, and recovering from night shifts.

Studies investigating how shift workers engage in self-care are quite rare, being restricted to investigations about how shift workers rest during their shifts [31], and how people prevent injuries, stress, and obesity [13, 22]. To this body of work, this paper provides a qualitative account of how shift workers deal with shift work, and in particular, their night shifts.

The framing of self-care used in this study seems to afford an appropriate fit to the activities of shift workers. In fact, the categories of self-care put forward by Nunes and Fitzpatrick [24] all apply to the participants involved in this study. First, shift work entails great work, for example, in recovering from night shifts. Second, the activities of shift workers are intertwined and ingrained in daily life; this can be seen, for example, when workers take their kids to the nursery as part of their rest preparation. Third, people negotiate and compromise, for example, when they change their shifts with colleagues, which can go against their health, but enables workers to attend family and social activities. Moreover, self-care is dynamic, as there is always some uncertainty in shift work, for example, in how tired or sleepy people feel during a certain shift.

The Clockwork app presented in this paper is one of the first to aim to support the self-care of shift workers. Moreover, and unlike previous applications, it targets shift work holistically, providing functionalities and data about different aspects relevant to shift workers.

CONCLUSION AND FUTURE WORK

This paper presented self-care practices of shift workers. It was clear that shift workers engaged in numerous activities to be able to manage their night shifts. Reflecting on the interview findings we present a number of design implications, that open areas of research that can better support the self-care of shift workers.

Moreover, we also proposed a mobile app that fits the practices of shift workers and can track their sleep, activity, light exposure and enable workers to keep track of their shifts. This

app is one of the first to support the self-care of shift workers, doing so in a holistic fashion, supporting different aspects of the self-care of shift workers.

While we have designed the Clockwork app, its usefulness to shift workers still needs to be verified in feasibility trials. For this reason, we are conducting a two-month pilot with a small number of volunteers to better understand the usability, acceptance, and overall potential of the system to support the self-care of shift workers.

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