Mental Health Monitoring at Work: IoT Solutions and Privacy Concerns

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Abstract. The fast-paced business environment and new work arrangements have elevated mental health risks, especially occupational stress and burnouts. Mental health becomes a critical aspect for occupational safety and health. Therefore, employers aim to improve employees' well-being and safety at the workplace through dedicated health initiatives. Internet-of-things (IoT) technology is increasingly being used for such purposes. However, its implementation in the workplace is accompanied by privacy concerns related to sensitive data collection. In this study, we provide a meta-synthesis of existing IoT solutions for supporting employees' mental health in office settings. We classify existing studies into use cases with possible implementation options. We also discuss main challenges emerging from privacy concerns along the IoT data lifecycle. We emphasize the opportunity for the connected workplace to improve occupational health in the future workplace,

Keywords: IoT; Mental Health; Connected Workplace; Meta-Synthesis.

1 Introduction

For companies to be successful in the digital era, adapting to the ever-changing business environment and worldwide trends is essential. This creates a fast-paced working environment in companies undergoing digital transformation. Companies strive to provide the optimal working conditions for their employees to be more efficient and productive. The current COVID-19 pandemic brought additional challenges and change to the workplace. With the increased numbers of cases worldwide, companies were obliged to shift to remote working and home office mode. In today's workplace, flexibility is key. Flexible work arrangements, with respect to work schedule and

location (such as remote working or working from home), are essential today to help employees concurrently manage work and personal life with the increased digitalization. However, this flexibility comes with a price, which is the normalized extended availability.

Tamers et al. [1] illustrate that the blurred boundaries between work and personal life can result with constant pre-occupation with work and work-family conflicts which increases stress. In fact, work stress and mental health are important topics when it comes to occupational health. Not only because of the work arrangements, but also with the increased pressure given the fast-paced business environment [2]. Schneider and Kokshagina [3] explain that the digital workplace creates a pressure of constant connectivity and availability, which can result in technostress. Han et al. [4] explain that work-related stress can occur when there is a poor match between people's working ability and assigned tasks. They emphasize that heavy stress might lead to depression and other health problems, such as cardiovascular diseases musculoskeletal disorders, which can affect productivity and performance.

Excessive stress has been proven to lower work efficiency and also lead to negative emotions and illnesses [4]. People working under stress or with precarious employment conditions are likely to smoke more, exercise less and have an unhealthy diet. In the specific case of office workers, previous research has highlighted several risks associated with the working behavior and environmental conditions for facility management that can affect the employees' mental health. While employees spend 90% of their time indoors, the environmental conditions in the workplace critically affect the employees' well-being and productivity [5]. Sun et al. [6] explain that indoor air quality has a significant impact on the person's health, comfort, and performance. Also, environmental conditions such as thermal comfort and noise can impact the individual's blood pressure and stress levels, which affects concentration and productivity [5, 7].

The World Health Organization (WHO) emphasizes that the health of employees and workers are essential prerequisites for economic development [8]. To address the different possible health risks in today's workplace, WHO urges companies to develop workplace health initiatives that allow them to monitor employees' health and

provide the necessary services [8]. Accordingly, employers have been continuously investing in digital solutions and interventions through wearable technologies to measure physical or physiological parameters such as movement, body temperature, and heart rate, and sensor networks that enable measuring quality parameters for ensuring the wellbeing of their employees and avoiding health and safety risks [9-11].

Yassaee et al. [12] explain that the Internet-of-things (IoT) initiatives can help in detecting and preventing root causes for certain health issues, and in mitigating health risks. They also mention that introducing IoT into the workplace can help employees be more conscious about their health and proactive in terms of actions. However, the implementation of such initiatives for mental health monitoring in the workplace remains challenging. The use of IoT technology is always accompanied by privacy concerns as it often trespasses the boundary between monitoring online and offline behavior during work time but also outside working hours (e.g., while commuting or at home). The use of wearable devices and sensor networks for continuously tracking and monitoring employees is considered to be a major privacy concern [13, 14]. Due to the sensitive nature of health data, many employees have serious doubts about participating in company-sponsored (or mandated) health and well-being initiatives. Employees fear that personal data is processed by the employer for other purposes, such as, performance appraisals or lay-off decisions [15].

In this paper, we investigate the following question: What are existing solutions for mental health monitoring at work and what are associated implementation challenges? In answering this question, we aim to provide an overview of IoT implementation options for monitoring and improving the mental health of employees. We highlight privacy concerns associated to the collection of sensitive data and discuss future research avenues. Through reviewing IoT initiatives aiming at improving office workplaces, we contribute to research in the IS field through theoretical knowledge on the meta-requirements for privacy-preserving IoT design in occupational settings. For practice, we assist employers by providing an account of existing technologies and realization options as well as outline privacy considerations for successful implementations.

2 Research Approach

We opted for a review of existing literature to better understand the state-of-the-art concerning IoT solutions for mental health monitoring in office environments. The IS discipline continues to grow various applications of information technology for individuals, organizations, and societies, which results in an increased need for synthesizing this type of research to pave the path for future research and to build cumulative knowledge [16]. "Meta-synthesis" is a novel method that is becoming more popular in IS research [17]. It allows the combination of results from qualitative studies to synthesize theoretical knowledge on a specific domain of research. Based on Siau and Long [18], the general procedure of the meta-synthesis involves: First, selecting a group of studies related to a defined research problem. This includes the definition of the research question(s) and the relevant literature to be synthesized. Second, synthesizing translations of the studies. This includes reviewing the literature, identifying relationships and patterns within the collection of studies. Finally, expressing the overarching synthesis through classifications or categorization to postulate or advance theoretical knowledge for further development in a research domain. Accordingly, we perform a meta-synthesis of the existing studies on IoT initiatives for mental health monitoring in office settings. This approach allows us to have an overview of the domain to understand the existing implementation scenarios and associated challenges. Based on that, it enables us to build reference knowledge on the topic from a design perspective and support successful future implementations in practice.

3 IoT Solutions for Mental Health Monitoring

Based on our review, we were able to identify use cases with alternative implementation options to provide an overview and support the derivation of implementation guidelines. Table 1 presents the different studies with indications on the study purpose, devices used and data collected for each use case.

Emotional health monitoring is crucial for detecting occupational stress or burnouts that can affect the health of employees and compromise the quality of work in the long run. For that purpose, wearable devices are distributed among employees that enable the

measurement of biomedical data including heart rate and body temperature for estimation of emotional levels. Han et al. [4], Zenonos et al. [19] and Stepanovic et al. [20] illustrate how wearable wrist bands can help in supporting emotional health by measuring physiological indicators for mood recognition or for detecting stress.

Another use case is the monitoring of the emotional and psychological state of employees for a healthier lifestyle. For this purpose, Fugini et al. [21] illustrate a scenario of a sensor network linked with a video camera for capturing facial expressions and processing posture and hand gestures as well as audio sensors for speech recognition to assess the employee's state and provide suggestions for healthier habits based on the analyzed data.

Another use case of IoT technology in the workplace for supporting mental health monitoring is related to thermal comfort. This is necessary to have a well-suited ambient environment that allows focusing and productive work. Rabbani and Keshav [22], van der Valk et al. [23], and Nižetić et al. [24] all focus on measuring ambient conditions including temperature and humidity sensors for detecting abnormalities and optimal settings. There is also a possibility in such implementations to use wearables [23, 24] to obtain a metabolic reaction to detected discomfort and provide insights on corrective measures as a supporting evidence. However, the main focus here remains the monitoring of the work environment.

Finally, the "connected workplace" is a combination of all the different use cases that enable health monitoring at work. This use case relies on a combination of technology options including wearables and sensor networks for this purpose. Bhatia and Sood [25] and Benhamida et al. [26] envision the connected workplace as a smart office with hybrid technology involving wearables and an inclusive sensor network to combine multiple information on the physical, emotional and environmental conditions to promote a holistic approach to well-being and safety at work. Thus, allowing stress detection and environmental comfort based on the type of data to be processed.

Table 1. Overview of studies on IoT solutions in the workplace.

Purpose	Study	Device	Data collected
Stress detection	[19]	Wearables	Heart rat, skin temperature, acceleration
	[4]	Wearables	ECG sensor: impedance pneumography, accelerometer, body temperature sensor, photoplethysmography sensor
	[20]	Wearables	Heart rate, blood oxygenation, skin temperature, skin blood perfusion, respiration rate, heart rate variability, blood pulse wave
Emotional and psychological state	[21]	Sensor network	Frontal face camera, profile face camera, speech and voice body pose (images), hand gestures (images)
Thermal comfort	[22]	Sensor network	Temperature, occupancy
	[24]	Sensor network + Wearables	Metabolic rate, air temperature, relative humidity, level of carbon dioxide
	[23]	Sensor network + Wearables	Metabolic rate, air temperature, mean radiant temperature air speed, humidity
Connected workplace	[26]	Sensor network + Wearables	Ambient light intensity, background noise, amount of phone calls, computer built-in camera (e.g., eye gaze), smart devices
	[25]	Sensor network + Wearables	Data about health (temperature, blood pressure, heart rate, vital signs), data about environment (cleanliness, room temperature, noise, oxygen level, toxic waste), data about meals (nutritional value, quantity), data about movement (pedometer, accelerometer)

4 Employees' Privacy Concerns

Through our analysis of the different IoT solutions in office settings

for supporting mental health at work, we were able to determine a set of challenges that employers face in their implementation. These challenges stem from the employees' privacy concerns related to "big brother" work surveillance practices that aim to collect, store and process their data [27]. This data-based management ideology can result in excessive data collection and an illusionary sense of control [28], which ultimately leads to a climate of distrust, fear, and cynical employee attitudes [29]

Sensitive data collection is of major concern when implementing IoT initiatives at work. In fact, IoT generates a large volume of data and allows collecting personal data, which is frequently not work-related. Solutions for mental health monitoring involving data collection from wearable devices, where the individual can be identified, are considered the most critical. Data collected indicate health information that might be problematic in certain situations and are considered private. Emotional health data on stress levels and mood are strictly sensitive information. Therefore, employers should pay attention to the privacy management of all the data collected from sensors used for emotional health purposes [4, 20]. On the other hand, data about environmental conditions collected from temperature or thermal sensors could be considered less problematic [22, 23].

In addition, with the blurred lines between the use of wearable devices in private and professional lives, the ownership of data collected remains a dilemma. Stepanovic et al. [20] raise an important issue with the use of wearable devices, where there exist measurements done outside of working days. In their study on work-related stress, the elimination of these data points sounds logical. While the type of data collected from wearables (including activity data, physiolytics and location) can be considered sensitive, entities in possession of this data have an advantage and can eventually process it in combination with other personal data to create user profiles for different purposes – whether occupational or commercial.

While the main purpose of IoT initiatives is supposed to improve the health and well-being of employees, the possibility of the data misuse or being used for other purposes than initially agreed upon is a matter of concern for both, employees (e.g., worried by possible measures

their employer can introduce against them) and employers (e.g., fearing improper re-use and data breaches of device manufacturers). Fugini et al. [21] explain that the use of IoT technology in the workplace has the potential to capture the employee's behavior. As mentioned earlier, activity tracking data could infer certain work behavior not only for health purposes, including absence/presence and working time at desk. Sensor networks can additionally be used for facial expression detection, voice recognition, and vital signals, which can be indicators of actual and mental workloads.

Finally, these initiatives can be seen as a pathway to behavioral control through nudging and interventions imposed on the employees who somehow lose their freedom and do not have the choice anymore to decide on their reactions to certain events. All these considerations become more and more critical with the discussion of the connected workplace where data is collected in an integrated manner and for the different purposes [25, 26], as discussed previously.

5 Conclusion

Our meta-synthesis provides an overview of the currently discussed implementation options as use cases. IoT initiatives rely on wearable devices that gather data on the employee's physical and emotional health status with the aim to trigger corrective behavioral interventions for preventing harm and improving outcomes. Other studies rely on sensor networks that measure ambient environmental parameters for the purpose of increasing an employee's comfort and well-being in the workplace. The combination of these use cases results in a fully integrated workplace design fueled by different technological components. We discuss concerns related to employee health data privacy along the different phases of the data lifecycle. These concerns comprise challenges to the implementation of IoT solutions in office settings.

We emphasize that companies need to take a responsible and active role in reflecting about what is reasonable and ethical when implementing IoT-enabled occupational health initiatives for mental health monitoring. Instead of reacting in case of problems (e.g., a data breach), proactive behavior and reducing unnecessary risks would lead to less resistance. While we highlight different implementation options for the same purpose, we conclude that there

exist alternative designs that minimize the collection of individual data for each use case. These options should be considered and further tested to assess their reliability. We also emphasize that technology choice is a critical aspect as it controls the consequent data treatment process and can mitigate data ownership concerns.

Our synthesis highlights the concept of the connected workplace. This concept is worth consideration by researchers in the field of IoT technology as it embeds a true vision of the future work environment in our ever-changing world. The changing work practices and arrangements, as well as the new health and safety regulations accelerated by the COVID-19 pandemic require further studies on the optimal future work environment design.

Based on the list of studies and the identified concerns, we suggest solutions that minimize individual data collection. Certain studies promote alternative design options for specific design objectives that require less interactions and collection of sensitive data. These studies suggest using IoT solutions that can be considered less intrusive and are specific to the workplace context only. Once data is collected by the IoT device, the employer should plan for an appropriate technical architecture that is trustworthy and that guarantees the safety and integrity of data. A promising technology choice was suggested by Bhatia and Sood [25] and Benhamida et al. [26] for the connected workplace, the Fog-Cloud. It is described as a "highly virtualized platform that provides compute, storage, and networking services between end devices and traditional Cloud" [25]. It is specifically relevant to the IoT scenario as it relies on edge decision mechanism, that is, the data is processed at the edge of the network where it is collected. Thus, the user has the option to filter and transform the data before sending it to the Cloud, which ensures privacy of user data and eliminates ownership concerns. Our analysis of the studies also suggests minimizing work interruptions as much as possible. Benhamida et al. [26] promote the use of non-intrusive designs that do not affect the employee's routine. These designs combine passive data collection through the use of technologies surrounding the employee such as sensor networks or connected digital devices. This is an important point in determining how users interact with the system and how their concerns are formed based on this interaction.

We contribute to both research and practice. For the research community, we illustrate the use of a novel method in the IS discipline corresponding to meta-synthesis. The knowledge synthesis we performed adds to the academic debate on the "future workplace" through discussing the potential of IoT technology for improving employee mental health. Researchers in the domain can benefit from this overview to build a cumulative research tradition on the applications of IoT in organizational environments. While IoT technology has a great potential in ameliorating the work environment in the future workplace and can play an effective role in increasing productivity, we also highlight existing downsides to this digital trend. Our synthesis also accounts for data-related challenges in the implementation of IoT initiatives in office settings. For practitioners, we provide implementation options, through the presented use cases, that can guide their implementation decisions and choices when engaging in IoT initiatives for occupational health. We present "sensitive issues" related to employees' privacy risks which they need to have in mind when implementing IoT, and we recommend actions against malicious practices as a way forward for protecting employees' privacy and establishing further engagement in health initiatives at the workplace.

6 References

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