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Health Promotion in Office Environments: A Worker-Centric Approach Driven by the Internet of Things

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Abstract. Health promotion in the workplace is one of the main challenges that the World Health Organization (WHO) has set in its agenda for the 21st century. Motivated by this concern, many companies across the world have reacted launching awareness campaigns and wellness promotion programs. One of the recurring problems on different application scenarios is the lack of adherence of the target audience (i.e. disengagement, early drop-out or high attrition rates). In this context, the potential of the Information and Communication Technologies (ICT) and the emerging paradigm of the Internet of Things (IoT) can play a mediating role between the proposers (i.e. managers) and the target audience (i.e employees) to increase motivation and follow-up. The presented work reviews the main challenges of IoT-based interventions for workplace health promotion and presents a participatory worker-centric concept for enhancing individuals' well-being in office environments. Our approach seeks to stress the importance of empowering workers providing to them fine-grained control of their own well-being and self-care. To this aim, we propose turning work environments into ideal confident-settings to persuade and motivate end-users attaining substantial changes that will persist over time.

Keywords. Health promotion, Internet of Things, Workplace, Office environments, Persuasive computing, Participatory sensing, User-centered design

1. Introduction

Well-being at work is gaining increasing importance on overall health promotion [1]. The attempts to design and implement interventions to foster healthier workplaces have evolved from an occupational health concern to one that includes workers' lifestyle changes [2]. The real challenge arises from setting up an ideal scenario and work-context to support health promotion and improved health-related behaviors. Indeed, for an intervention to be accepted, it requires understanding the physical, emotional and social factors that influence workers and employees to improve their everyday personal health practices [3]. The analysis on the effectiveness of workplace health promotion programs carried out until 2013 [4] shows that, although they obtained promising insights about

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positive effects, interventions fail when heterogeneous audiences are targeted. To avoid such a lack of adherence or uptake, the adoption of ICT and context-aware services can help with this endeavor. Our approach focuses on the enabling role of ICT in the ideation and creation of personalized and participatory health care interventions in work environments through a worker-centric approach. In this context, IoT can be considered an emerging paradigm to mediate the relationship between humans, in this case employees, and ICT.

The potential of IoT to enable appropriate solutions for health promotion lies on the services that it provides rather than just offering a machine-to-machine concept which enable them to interact, communicate, collect and exchange data. IoT involves different domain areas in which the digital transformation of health care is starting to be applied. Smart Home Care or Ambient Assisted Living are some examples of this new trend [5]. As a consequence, the health domain shows a tendency to move from a reactive and hospital-centric approach to a predictive and human-centered one [6]. From the insights derived from these research areas, mixing IoT, user-centered design and work environments seems promising to foster health promotion. Indeed, to the best of our knowledge, little or no pieces of research have pointed out the suitability of IoT for the work environment whereas it has proved to be a very suitable tool for health promotion. To cope with this unaddressed emerging gap, this work proposes engaging technologies to correct unhealthy behaviors associated with work environments (e.g. muskulo-scheletal disorders due to inappropriate sitting at the office) while promoting changes that stick over the time. In particular, it focuses on office environments, where its inherent sedentary nature is directly related to a decrease in the workers' health [7].

We introduce our human-centric proposal which places workers at the center of the process of caring for their own well-being. The concept here presented corresponds to our vision of a worker-centric sensing approach and aims to provide insights of transformations that workplaces could undergo to become socially-engaging places that respond to the workers' needs. Besides, this article contributes with a three-fold approach: (i) it analyzes the main health implications of office environments, (ii) illustrates the main challenges associated with the use of the Internet of Things for health promotion and (iii) highlights some specific factors that IoT platforms designed for workplaces should take into consideration.

2. Health Problems Associated to Workplaces and Related Work

The direct influence of work on individuals' physical or physiological health and wellness is a renowned problem [8]. Thereby, work environments offer an opportunity to identify unhealthy behaviors associated to this space and to correct these unhealthy practices [9]. As a consequence, the academic world is more concerned than ever about the importance of bringing well-being into the workplace, making the promotion of wellness an issue tackled from a interdisciplinary point of view [10]. Beyond occupational health and the responsibility of providing safe and hazard-free work environments, healthy workplaces must also deal with the psychological and social conditions of the work space.

The review of the consulted literature shows that assessing occupational sedentary behavior in the workplace stands out as one of the most addressed health related concerns

[11]. Its deleterious impacts on health include obesity and cardio-respiratory, metabolic or cardio-metabolic risks [12]. When considering the office environment, its influence becomes bigger driven by the health outcomes of long periods of inactivity and sitting times [13]. As example, obesity corresponds to another identified problem that also correlates to a decrement of productivity [14]. Furthermore, ergonomic-related problems arise from the physical inactivity that may result from long working hours and posture contributes to musculoskeletal disorders [15], carpal tunnel syndrome due to typing work [16] or the development of computer vision syndrome because of the exponential adoption of ICTs [17]. However, workers' physical problems are not the only ones that may occur in work environments, symptoms of stress constitute also an important challenge for enhancing worker psychological health[18]. To conclude this review, according to the literature [19], the workspace itself must be taken into account seriously for its inappropriate indoor environmental conditions which are also associated with a decrease in the workers' comfort and health.

Once identified some of the problems and unhealthy behaviors in these spaces, the second step involves correcting the bad practices that are recognized and promoting new healthy-ones that persist over time. Under this context, technology enables the possibility of monitoring human factors and provides context-aware guidance, achieving the main purpose of delivering information to anyone anytime and anywhere [20]. The suitability of the introduced Internet of Things technology is widely validated for health and well-being promotion [21] and several efforts have been made pursuing the objective of developing IoT applications for it. In this sense, the PEROSH initiative [22] elaborated a decision support framework for selecting useful wearables and a proper data collection strategy for avoiding sedentarism. Moreover, Pendersen et al. [23] presented an e-health intervention designed to increase workday energy expenditure. Other works modeled physical fatigue in the workplace using wearable sensors [24] and proposed a non-intrusive monitoring system to avoid lower back injuries [25]. Finally, some scholars evaluated a smart chair to improve the sitting behavior [26] or approached interventions for encouraging workers to take more regulars micro-breaks [27].

The results of these interventions have also been subject of meta-reviews to validate the appropriateness of the different experimental conditions and its real effect on workers health. In 2014 Malik et al. drew on the impact of health interventions on activity levels [28]. They concluded that, although some evidence of efficacious was found, the reviewed works showed a similar volume of successful and non-successful studies and overall results were inconclusive. Taking only into account the positive outcomes, they found a strong argument for pursuing research efforts in order to design physical activity interventions for promoting wellness in workspaces. A more recent work (2017) evaluated its impact in terms of health outcomes (i.e. body mass index -BMI-, total cholesterol and blood pressure). In this study, the authors detected a slight decrease on BMI associated to the fact that individuals were changing their exercise behaviors, but no significant changes in cholesterol and blood pressure levels [29]. These results seem to correspond to the existing literature which tends to be careful overstating conclusions from inconclusive data.

Despite the difficulties for making strong validations of the direct influence of technology on workers health, workplace interventions show potential for attaining some sort of efficacy through it. Increasing the effectiveness of health promotion activities involves encouraging workers to promote lifestyle changes that persist over the time. Hence, in

this work we envisage to reinforce the role of end-users as a mean to design successful interventions, addressing how IoT can contribute to obtaining socially-engaging places to promote changes that persist over the time.

3. Drivers and Challenges

According to the literature, designing an adequate IoT solution that meets the requirements to foster workplace wellness awareness has to put the focus on three principal areas: (1) the technology-driven sensing solutions, (2) the recognition of the monitored activities and (3) the design of engaging user experience strategies. Hereafter, these areas are further explained in relation to the state of the art. Firstly, advances in embedded devices and sensors enable a wide range of pervasive applications and services. Wearable devices are a good example of the adoption of IoT in health care as they constitute a common variable for a wide range of applications and solutions [30]. Secondly, enabling a monitoring framework in order to obtain information related to the users' health allows to analyze user patterns and recognize unhealthy behaviors or habits. Current trends in artificial intelligence (AI) take part in the development of new services for that interest [31]. The classification of behaviors related to office environments applying AI has been addressed by Oliver et al. [32], while other works bring together sensors and data to delve into the suitability of the sensing technologies [33].

Besides the technology factors, a final requirement for workplace health promotion through IoT is related to the participation of employees. However, getting the involvement of the target audience is just the first step forward increasing their engagement and adherence to the programs. In this sense, user experience and the human factors are closely related to ease of use and accessibility of the solutions [34]. The findings obtained from the reviewed literature and the insights voiced by its authors reveal different needs and considerations that may not be well covered and should be addressed to overcome the primary objective of building healthy workplaces. Numerous scholars have pointed out the challenges associated with the design and development of IoT-based solutions and, in particular, wellness promotion mechanisms. Hereafter, we seek to address the most relevant ones that smart work environments should overcome to become suitable worker-centric health promotion tools.

3.1. Engagement in Health Interventions

Succeeding in designing an effective tool for health promotion requires the thorough analysis of the role of end-users. Besides, promoting lifestyle changes involves motivating people to change and consequently adopt more beneficial behaviors. Persuasive technology has been established as a mature proposal and engaging mechanism for this purpose [35]. Delivering a contextualized guidance depends on when and how to interact with the workers to effectively influence their behavior (e.g. just-in-time or about-to-do moments). However, the diversity of profiles makes necessary to design adaptive and personalized assets for optimizing the interactivity between people and devices to promote the adherence and adoption of the technology. Designing a strategy for involving every user in their own self-care stands out as a paramount challenge for getting such engagement.

3.2. Usable and Non-invasive Technologies

One of the biggest concerns when creating an adequate and portable access to pervasive devices is to achieve that without interrupting end-users' work tasks or minimizing their attention theft at work. Thus, creating a non-intrusive but confident ecosystem surrounding the user that allows collecting data without any effect on workers' routine or implication on its productivity [36]. However, health promotion domains are especially challenging scenarios that involve deploying sensors that can be intrusive and power-hungry, losing its autonomy. Designing multi-modal Internet of Things sensor-based systems from the principles of ubiquitous computing needs to avoid falling into over-instrumenting spaces and to be the less intrusive as possible. To achieve this goal and to assess positively the worker's satisfaction, there is a need for the development of feasible, easy-to-use and comfortable solutions.

3.3. Efficiency and Computational Limitations

One of the cornerstone challenges to tackle when planning IoT solutions is to deal with the complexity of a network that has to seamlessly enable the data collection, transmission and sharing through an infrastructure formed by sensors and devices in distributed environments. Every IoT solution should be supported by a scalable and modular architecture with an abstraction level on top of technologies or protocols. In general terms, the main purpose of a traditional IoT network architecture is to connect the physical layer, formed by the devices or "Things", with the Cloud layer where data is processed and managed. However, current trends seek to move this processing and analyzing capabilities from this remote Cloud to what is called the Edge (an intermediate layer that traditionally acted as a gateway or proxy). This approach, based on Fog or Edge Computing, changes the remote management of the data to a local stage, allowing data to be processed closer to where these are generated [37]. In contrast with Cloud computing-based solutions, the local processing of the information benefits those applications where time is critical and latency must be avoided. When health monitoring implies running activity recognition techniques on remote devices, a paramount factor to consider is the computational and energy limitations of its embedded technology [31]. Thus, it is necessary to evaluate which techniques are more suitable in terms of efficiency or if it is necessary to outsource that detection. The main problem arises when demanding applications compromise energy consumption, battery live or the computational capability of the remote devices. The challenge of health-related IoT solutions is to take advantage of the Edge Computing approach when its requirements involve time-sensitive data. Planning a supportive combination of edge nodes and remote devices can provide powerful means to drive health promotion ecosystems [38].

4. Approaching Wellness to Users: A Worker-Centric Proposal

Once analyzed the different trends in health promotion and the role of ICT on them, in this section we present our vision of an IoT based solution for encouraging the adoption of healthy habits in the workplace. Keeping in mind the emerging challenges mentioned thought this paper, we propose a new concept of tangible and unobtrusive instruments

to provide personalized information and guidance to employees. The system is made up by a set of electronic smart devices devised with the idea of designing non-intrusive and easy-to-use technologies to obtain and analyze data related to the state and actions of workers' health. This set of devices, conceived as an electronic kit which is provided to each end-user, is comprised of an assortment of different kind of embedded sensors that enable workers to augment the work environment and directly decide and control what is monitored by the system. When placed on different objects, sensors-based devices are able to obtain data such as movement, temperature or position-related measurements that can be used to monitor how workers interact with their environment and to detect unhealthy behaviors. For example, a single smart device consisting of an acceleration sensor -or accelerometer- can be used to detect movement in different situations. Depending on where is attached, it can be used to measure: (i) Physical activity or prolonged sitting times (worker's body or chair) (ii) Hydration level (bottle of water) (iii) Caffeine intake level (coffee mug). The aim is to let the system know how and when these objects are being used (i.e. activity recognition) and to provide the users with a set of subtle interactions that let them understand if the action they are doing is being performed properly or not (i.e. ambient feedback). Based on these data, sufficient information is available to effectively influence employees and guide their habits towards healthier behaviors by applying technological persuasion techniques.

Besides the technological requirement of the concept, the central pillar of this strategy relies on involving the users on an engaging strategy that leads them to appropriate lifestyle changes. The proposed approach places the users at the center of the process of caring for their own well-being, obtaining contextualized and personalized information based on their actions and behaviors with a minimal impact on their daily routine within the workplace. Coping with the lack of adherence to wellness interventions, the presented strategy stressen the importance of empowering employees in their own choices as a tool to improve self-satisfaction. Letting workers be the master of their actions resembles the participatory sensing concept [39] and illustrates how health promotion can take advantage of involving users on their own self-care. The self-exploring process of obtaining the monitoring data reflects the idea of technology appropriation that makes the user feel and appear as the center an intelligent workplace for enhancing individuals' everyday quality of life.

5. Conclusions

Throughout this paper we have analyzed the role of technology and in particular the Internet of Things paradigm for health promotion in the workplace. To success bringing wellness into these spaces, we have gone over the main health implications of office environments and its future outcomes (i.e. sedentarism or musculoskeletal disorders). This has allowed us to understands the factors that directly correlate with the physical, mental and social well-being of workers and employees. Then, we have identified the main gaps of current IoT solutions and the challenges that should be addressed for this emerging trend to become a suitable tool for health promotion: engagement in health interventions, usable and non-invasive technologies and efficiency and computational limitations. Special attention is given to current solutions designed to respond to real workers' needs, instead of just to those that provide or deploy technology from the point

of view of the things that computer scientists can do rather than the things they should do for wellness promotion.

Despite understanding that these factors are essential for designing engaging technologies to correct unhealthy practices, the lack of adherence of the target audience continues to be a recurrent problem. As a consequence, although showing some promise for its efficacy, existing literature illustrates difficulties for making a strong validation of the direct influence of workplace interventions on workers' health. Boosting the effectiveness of workplace health promotion requires increasing the participation and motivation of employees. In this way, we have presented a worker-centric approach that empowers employees and makes them feel they are the center of their own well-being while addressing how IoT can mediate providing substantial changes. Prioritizing the role of end-users and motivating socially-engaging places convert work environments into optimal settings to encourage the adoption of lifestyle changes that persist over time, succeeding on the first step for influencing on workers' health.

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