Opportunities, ethical challenges, and value implications of pervasive sensing technology for supporting older adults in the work environment

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Abstract

Responding to the challenges of demographic change, a growing number of eHealth solutions are appearing on the market, aiming to enable age-friendly living and working environments. Pervasive sensing and monitoring of workers' health-, behavioural-, emotional- and cognitive status to support their health and workability enable the creation of adaptive work environments and the provision of personalised interventions. However, this technology also introduces new challenges that go beyond user acceptance and privacy concerns. Based on a conceptual investigation and lessons learnt within the SmartWork project (H2020-826343), this paper outlines opportunities and ethical challenges of pervasive sensing technology in the work environment that aims to support active and healthy ageing for office workers in a holistic way, including their values and preferences. Only by identifying those challenges, implicated values and value tensions is it possible to convert them into design opportunities and find innovative ways to address identified tensions. The article outlines steps taken within the project and closes with a reflection on the limits of technological responses to societal problems and the need for regulations and changes on a societal level.

Keywords: Ethical challenges, smart work environment, human values, healthy ageing, personalised interventions, digital health.

1 Introduction

The challenges of demographic change and an ageing population are manifold, such as the increasing number of people living with chronic conditions (World Health Organization, 2010b), of workers with functional impairments (Liang et al., 2008), of people taking the role of informal caregivers along with their job (Papastavrou, Charalambous, & Tsangari, 2012), and also the gradually increased retirement age (Komp, 2018), and rising costs in healthcare (Harbers & Achterberg, 2012). Older workers tend to remain longer at work than previously, however, involuntary early retirement occurs and is associated with negative effects, such as health, financial status, and adjustment to retirement (Topa, Depolo, & Alcover, 2018). A recent meta-analysis recommended that organisations should avoid forcing workers into earlier

retirement, because "the adverse effects on the individuals, their families, and health and social protection systems are disproportionate in comparison with the economic gain of this measure" (Topa et al., 2018). Simultaneously, the large proportion of older adults gives rise to opportunities, for example, opportunities connected to making use of all the knowledge, experience and wisdom of older workers. These could be shared with or transmitted to younger generations through adequate tools, facilitating a smooth transition to the retirement age. To make sure that the experience and know-how of older adults can be applied in the working environment until their retirement age, there is a need to create age-friendly working environments. As adopting and maintaining a healthy lifestyle can be challenging, eHealth – also referred to as digital health – solutions can play an important role in supporting older adults to stay active and healthy for as long as possible.

Technological interventions in healthcare, consumer health, and the lifestyle market have the potential to support individuals in improving their lifestyle, monitoring their progress, and taking action. The idea of "self-knowledge through numbers" is at the heart of the Quantified Self movement which started in 2007 (Sharon, 2017). The availability of affordable wearable devices that track physical activity, sleep, standing time and other aspects made self-tracking even more accessible. Furthermore, eHealth solutions can support the individual in the difficult process of adopting and maintaining healthy behaviour, for example, by visualising the progress and providing personalised coaching (Jansen-Kosterink et al., 2020). eHealth tools for monitoring and coaching of healthy lifestyle are now more important than ever before. This is reflected in public health policies urging people to take care of their health, and the healthcare sector moving from the more traditional approach with the healthcare professional as expert to the empowerment approach, which considers patients as active and equal partners in their care (Funnell, Arnold, Donnelly, & Taylor-Moon, 1991).

The shift in healthcare from treatment to prevention also addresses challenges in the workplace, as experienced workers who are able to maintain healthy and active can stay longer in their job and their valuable knowledge is not lost. As some biological changes are inevitable with increasing age, the work environment can adapt to this and, for example, not add any additional workload on an individual who is already working at the capacity limit. However, bringing digital health solutions to the workplace does not come without ethical challenges (e.g., the tension between workers' privacy and the employers' need to control and monitor the use of technology (Iavicoli, Valenti, Gagliardi, & Rantanen, 2018). Given the sensitive nature of health data, employees are concerned about sharing personal health data as it can have unexpected consequences (e.g., social pressure, social expectation management and crossing boundaries between private life and workplace (Gorm & Shklovski, 2016). Furthermore, the introduction of technology and information systems have changed working conditions and shifted the balance of power towards the employer and away from employees (Dantas, van Staalduinen, Machado, Jegundo, & Rodrigues, 2019). Adding another monitoring layer via pervasive sensing to this power dynamic might negatively impact the work environment and impede technology acceptance.

Information Systems research has contributed for decades to the literature of health information systems (Chen, Baird, & Straub, 2019), work systems (Alter, 2013), ethical information systems (Mingers & Walsham, 2010), and information systems that support human values (Friedman, Kahn Jr, & Borning, 2006). This article contributes to the field of information systems by conceptually investigating human values and tensions that are

implicated when developing and introducing pervasive health sensing technology to promote work sustainability among older adults.

2 SmartWork project

The European Research and Innovation Action project SmartWork is part of the Horizon 2020 programme and funded under the topic 'Adaptive smart working and living environments supporting active and healthy ageing'. The ultimate aim of the SmartWork project is to build a worker-centric system to support the sustainability of workability, in other words, to help the older adult to work for as long as desired. To achieve this, the SmartWork system integrates unobtrusive sensing and modelling of the worker state using a suite of novel services for context- and worker-aware adaptive work support. The system consists of six separated services; four targeting the older worker (*healthyMe, myWorkAbility, ubiWork, workCoach*), one targeting the manager/supervisor *(digiTeam)* and the final one targeting formal/informal carers *(iCare*):

- **healthyMe:** continuous, unobtrusive, and ubiquitous monitoring of physiological and behavioural parameters to support self-management of chronic conditions, promote behaviour change and improve quality of life of the older worker;
- **myWorkAbility:** continuous assessment of the psycho-physical capacity of the office worker to provide AI-based decision support by predicting short and long-term changes in capabilities and abilities of the office worker and translating such changes into evolving work requirements;
- **ubiWork:** support on-the-fly work flexibility through a computer work environment available anywhere and anytime;
- **workCoach:** on-demand training support and new skills acquisition to support the older worker prolong his/her functional workability;
- **digiTeam:** smart and flexible management of the workforce to increase efficiency and productivity of teams working on specific tasks, and to optimize training and knowledge management activities;
- **iCare:** efficient continuous care management and health risk assessment to be provided to caregivers.

An unobtrusive sensor network containing multiple sensing components facilitates the collection, storage and distribution of health, behaviour, cognitive and emotional information to all six SmartWork services. Given its ambition and complexity, the work performed within the SmartWork project and, in particular, some of the discussions that arose between end-users and technical partners, are taken as starting points to explore the opportunities and ethical challenges of pervasive sensing technology in the work environment.

3 Theoretical Background

The workplace has been established by the World Health Organisation (WHO) as one of the priority settings for health promotion in the 21st century (World Health Organization, 2010a). As most individuals spend a large part of their awake time at work, the workplace offers the setting and infrastructure for health promotion activities. Personal health technology (e.g., wearables) are increasingly introduced in the workplace setting, for example, as part of health

promotion campaigns or insurance discount programs (Gorm & Shklovski, 2016). Health promotion in the workplace brings numerous benefits to the employee, namely reduced stress, increased job satisfaction and enhanced self-esteem, which in turn translates to benefits to the organisation, such as reduced staff turnover, reduced absenteeism, and increased productivity (World Health Organization, 2010a). Workplace health promotion programs support prevention efforts that target the generally healthy population who do not maintain good health (e.g., encourage exercise, fitness, healthy nutrition, weight, stress management) or those that are already at high risk due to certain lifestyle practices (e.g., smoking, sedentary lifestyle, poor nutrition, high stress) (Goetzel & Ozminkowski, 2008). A recent review of workplace health programs between 2000 and 2020 showed that these mostly address physical activity, followed by interventions to promote mental health and stress management, smoking cessation and ergonomics and musculoskeletal disorders (María-Ángeles, Maqueda, Francisco, María-Jesús, & María-Dolores, 2021).

For the ageing population, health promotion at the workplace brings specific opportunities by supporting the sustainability of workability through digital interventions, as addressed in the following three sections. This is followed by a section outlying the data protection principles in Europe, as this is the regulatory framework within which the SmartWork project operates when collecting and processing large amounts of various types of data. The section closes with a brief overview of approaches that account for human values in technology design.

3.1 Supporting the sustainability of workability

Ageing is only loosely associated with a person's age in years and there is a wide range of needs and experiences of older adults (World Health Organization, 2021). There is a set of common age-related changes often starting around the age of 50 to 55, with implications to the daily life of the individual, such as vision-, hearing- and psycho-motor decline (Liang et al., 2008). According to the World Health Organization (WHO), by 2030, 1 in 6 people in the world will be aged 60 years and older, and by 2050, 80% of the world's population over 60 years will be living in low- and middle-income countries (World Health Organization, 2021).

While the proportion of older people is continuously growing and with it the burden of chronic conditions and the occurrence of multimorbidity (Marengoni et al., 2011), chronic health problems also increasingly affect young and middle-aged people (World Health Organization, 2010b). Ischaemic heart disease, stroke, and diabetes emerged as major contributors to the burden of disease in the age group 25-49 (Vos et al., 2020). Hence, in this work we do not provide an age threshold for the "older worker", but instead leave it open to individuals experiencing a health-related decline that impacts their working ability.

Chronic diseases have a great impact on the working population and society. For instance, in the European Union, more than half a million people aged between 25 and 64 years died from major non-communicable diseases in 2013, representing a loss of around 3.4 million potentially productive life years across the former 28 EU countries (OECD / European Union, 2016). However, in most cases, people do not die from chronic diseases but live with the disease for long periods of their life. According to the latest Global Burden of Diseases, Injuries, and Risk Factors Study (GBD), despite steadily improved global health, half of the burden of disease was related to non-communicable diseases and injuries (Vos et al., 2020). Prevention and self-management of chronic diseases are now becoming central in health promotion activities, also at the workplace. An active lifestyle, healthy nutrition, no smoking and limited alcohol consumption are some of the lifestyle factors which impact the course of chronic disease.

Digital health solutions provide the means to deploy interventions taking a holistic perspective of health, bridging the gap between the work and home environment, while respecting a person's preferences and values.

In this sense, to the older worker, health promotion at the workplace using digital health solutions has the specific aim of maintaining workability for a longer period of time, allowing individuals to sustain their working activities until the retirement age.

3.2 Digital behaviour change interventions

In the context of this article, digital behaviour change interventions are a particular type of digital health solution that aims to support an individual in maintaining or achieving a healthier lifestyle. A specific characteristic of this type of intervention is that they allow communication with the user at any time, being at work, on the go or at home. Digital behaviour change interventions have three core components: sensing, analysis, and coaching (Cabrita, op den Akker, Tabak, Hermens, & Vollenbroek-Hutten, 2018). The *sensing* component concerns the acquisition of the data. The data acquisition can be unobtrusive – through the use of wearable or environmental sensing – but can also be achieved by self-reported input from the individual. At the workplace, one can think of assessing the workload by monitoring cardiac parameters with a low-cost webcam (Bousefsaf, Maaoui, & Pruski, 2014), the stress detection with physiological and sociometric sensors (Mozos et al., 2017), or a pressure-sensitive keyboard and use of a capacitive mouse to discriminate between stressful and relaxed conditions (Hernandez, Paredes, Roseway, & Czerwinski, 2014). The second component of digital behaviour change interventions is the *analysis* of the data and deals with the question "how to make sense of the data collected?". Usually, digital behaviour change interventions deal with heterogeneous data, which originate from various sources at different sampling frequencies and sometimes even seem to provide contradictory information. All-in-all, several challenges arise for algorithms aiming at the analysis of health-related data, with methods from data science taking growing attention in the field. The third and final component, *coaching*, concerns the techniques used to motivate the user to change behaviour, often based on the data collected and all information available. While the first two components are mostly determined by state-of-the-art technology, coaching deals with the question of how to motivate the user to change the behaviour. Digital behaviour change interventions aim to persuade users to alter their routines in a way that sometimes users themselves are not willing or motivated to do. The first step of the behaviour change process is often convincing the individual about the need to change, followed by support on how to achieve the desired behaviour and, finally, to provide adequate feedback to motivate the user to stay in the desired behaviour and not to fall back into old habits.

3.3 Digital health interventions at the workplace

So far, most digital health interventions at the workplace have targeted improvements in the *mental* health of employees. Stratton and colleagues performed a meta-analysis investigating the effectiveness of digital health interventions targeting the mental health of employees (Stratton et al., 2017), in which most made use of digital health interventions in the form of education or exercises (e.g., guided meditation), with minimal objectively or subjectively measured input from the participant. Digital health interventions also have a great potential in improving *physical* health at the workplace, for example, by targeting the management of occupational physical activity. While for office workers the aim is on reducing sedentary time, for manual workers the focus should be on preventing or managing musculoskeletal

disorders, for example, promoting management of physical activity between occupational and leisure time (Holtermann, Hansen, Burr, Søgaard, & Sjøgaard, 2012).

Commercial solutions are also appearing with the target of health promotion at the workplace. One example is Fitbit Health Solutions from Fitbit Inc., which provides corporate programs to promote health and well-being in organisations [1]. Fitbit Health Solutions combines the use of tracking devices to measure sleep and heart rate with self-reported information (e.g., on diet habits), and offers specialised coaching programs to promote healthy lifestyles. Another example is the Minddistrict solution, which provides an eHealth platform to promote mental health at the workplace [2]. In Minddistrict, the employee is invited to choose from a set of pre-defined programs based on positive psychology principles, such as "Building confidence", "Finding balance" and "Living an active and healthy life".

Fitbit Health Solutions and Minddistrict are two examples of eHealth solutions facilitating health promotion at the workplace initially motivated by the consumer market and academic research, respectively.

3.4 Data protection principles and regulations in Europe

The appreciation of the holistic nature of a person requires the collection of large amounts of various types of data. SmartWork's unobtrusive sensing network processes a considerable amount of newly generated personal data and also involves the secondary processing of previously gathered personal data from relevant big data registries (e.g., the English Longitudinal Study of Ageing, ELSA, Phelps et al., 2020).

The key legislation under which the SmartWork project must operate is the General Data Protection Regulation 2016/679 (GDPR) (General Data Protection Regulation, 2016). The GDPR is the branch of human rights protecting the rights of the study participant and concerns personal data that are processed in the EU (where processing includes very broadly, any action on personal data). Although multiple parties might potentially claim data (subject, researchers, enterprises), it should be acknowledged that the individual has the right to be clearly informed on why and how data is collected, about potential direct implications to the user (including risks and gains), as well as on its protection procedures on data collecting, storing, processing, transfer, and reporting (including the eventual use of secondary data).

The GDPR makes clear several rights and principles that must apply to the processing of personal data (Art. 5). The data must be processed "lawfully, fairly, and in a transparent manner" (Art. 5.1a), and for specific purposes, and not further processed in an incompatible manner (Art. 5.1b). Article 6.4 provides that it is possible to process data for further compatible purposes, but with safeguards. The principle of data minimisation requires that only personal data sufficient for the purpose can be processed (Article 5.1c) and that it should be accurate (Art. 5.1d). And under Article 5.1f, "personal data shall be processed in a manner that ensures appropriate security of the personal data, including protection against unauthorised or unlawful processing and accidental loss, destruction or damage, using appropriate technical or organisational measures". Furthermore, chapter 3 outlines the rights of the data subject, for example, right of access by the data subject (Article 14), right to erasure (also called 'right to

[1] https://healthsolutions.fitbit.com/

[2] https://www.minddistrict.com/

be forgotten', Article 17), right to restriction of processing (Article 18), or the right to object (Article 21).

It can be seen that the data collected and processed in the SmartWork project falls squarely within the GDPR definitions and thus poses challenging questions. An essential activity within the SmartWork project is to reflect on the ethical challenges the potential solutions pose and on how to conform with principles and regulations (Dantas et al., 2019). Any system that supports workability needs to observe both the spirit and letter of these principles and the way that they are interpreted and developed into implementation.

3.5 Accounting for human values in design

eHealth technology can be conceptualised as a tool that supports people to perform certain tasks (i.e., it realizes functional requirements, for example, scheduling an appointment with a healthcare professional). This conceptualisation of technology as being merely a tool might imply that a specific design is not inherently moral, that morality depends on its use and hence technology would be value-neutral. However, over the past decades, there is growing consensus that technological systems cannot be considered value-neutral and that design as activity is value-laden (Friedman & Kahn Jr, 2007; JafariNaimi, Nathan, & Hargraves, 2015; Miller, 2020). Depending on the particular design or how the technology is used, the eHealth system may support or hinder human values (e.g., supporting trust and transparency through patient accessible clinical notes (Cromer et al., 2017)).

Different approaches emerged that support human values through systems design, for instance, computer ethics, social informatics, Computer Supported Cooperative Work and Participatory Design (Friedman & Kahn Jr, 2007). Other approaches focus on values more in the economic sense, such as value-based software engineering (Whittle, Ferrario, Simm, & Hussain, 2021) or worth-centred design (Cockton, 2020). Value sensitive design (VSD) employs a broader meaning of values, which refer to "what is important to people in their lives, with a focus on ethics and morality" (Friedman & Hendry, 2019). VSD is a theoretically grounded approach that accounts for human values in a principled and comprehensive way throughout the design process by conducting empirical, conceptual, and/or technical investigations (Friedman et al., 2006). Although some values have been identified to be basic or culturally universal (Schwartz, 2012), empirical investigations are crucial to examine which values are affected in what way in the concrete setting (i.e., what people, in a particular context, consider important in life and how they solve or prioritise value tensions that may arise in a particular situation). The importance of empirical investigations is also reflected in the core commitment of value sensitive design, namely taking an interactional perspective in which values are not embedded in technology but implicated through engagement with it (Davis & Nathan, 2015). This means that "although the features or properties that people design into technologies more readily support certain values and hinder others, the technology's actual use depends on the goals of the people interacting with it" (Friedman et al., 2006).

Technology related to health and well-being in the workplace combines two complex applications domains: healthcare and the work environment. Each domain is represented by a multitude of stakeholders who have different interests and values that might be affected by the design. As this theoretical background section shows, eHealth technology approaches for workability sustainability and behaviour change interventions, as well as data protection principles, are available to support the design and development of pervasive health sensing technology in the workplace. However, little is known about the ethical challenges, implicated

values, and value tensions when it comes to the actual shaping of functions and features and the technology usage in practice. The ethical challenges identified and discussed in this paper reveal human values and tensions that may arise due to different interests and perspectives of stakeholders involved, as well as technological and contextual factors.

4 Method

A conceptual investigation of human values and tensions that are implicated was conducted in the context of developing and introducing pervasive health sensing technology in the workplace for older adults. This analysis was performed from the backgrounds of the different authors involved in the project (biomedical engineering, human-computer interaction and media informatics, psychology, research and innovation project management, law and ethics), utilizing available literature, empirical investigations conducted within the project and discussions and decisions made in the course of the project. Furthermore, writing was also part of the analysis, as writing is considered in most qualitative research as an "integral element of the analytic process" (Clarke & Braun, 2013) and "the process through which the analysis develops in its final form" (Braun & Clarke, 2013).

5 Results

Every new technological innovation has the potential to solve problems, but at the same time may introduce new challenges and problems, as these technologies are implemented in a socio-technical context that has its own rules and constraints. This section outlines a non-exhaustive list of opportunities, ethical challenges, human values and value tensions in the context of a smart work environment, that we identified within the SmartWork project.

5.1 Human well-being and privacy in the smart workplace

The value of **human well-being** was defined by Brey (2015) as "a state of persons which designates that they are happy or flourishing and that their life is going well for them." Depending on the underlying philosophical theory, this well-being can mean the absence of pain and the presence of pleasure (hedonist theories), the fulfilment of a person's desires (desire-fulfilment theories), or well-being is conceptualised in terms of a list of objective goods (objective list theories) (Brey, 2015). Other concepts that are often used in healthcare (e.g., quality of life) or the workplace (e.g., work-life balance) can be subsumed also under the value of human well-being.

The value of **privacy** refers to "a claim, an entitlement, or a right of an individual to determine what information about himself or herself can be communicated to others" (Friedman et al., 2006). Warnier, Dechesne, and Brazier (2015) identified three aspects that capture the main points associated with the concept of privacy: freedom from intrusion (the right to be left alone), control of information about oneself, and freedom from surveillance (the right not to be tracked, followed, or watched in one's own private space).

The *ubiWork* service of SmartWork aims to facilitate flexible workplaces, meaning that older workers can engage in work-related activities at the place of their best convenience. Flexible workplaces have many advantages that may contribute to a person's **well-being**. For example, it can contribute to a better work-life balance and accommodate the personal life situation of workers (e.g., allowing them to take care of their children, family members, or others). Nowadays, borders between work and private life are continuously crossed, especially as technology has spread from the workplace to our homes and everyday lives and culture

(Bødker, 2015). Recently, working from home has increased significantly across occupational groups due to the Covid-19 pandemic where many had to shift towards working from home for the first time, demanding them to quickly adapt to this new arrangement (Kramer & Kramer, 2020).

Mobile devices (laptops, tablets, smartphones, smartwatches) allow employees to be available around the clock and to work from home. Thus, in a smart work environment that extends to a home office, data has to be collected while they are in their home environment which increases the chance that also non-work-related data will be collected. In addition, digital behaviour change interventions within the *healthyMe* service require sensing of lifestyle-related data in the home environment. Take the example of stress management interventions by improving sleep quality and sleep duration, which naturally requires the sensing of sleep-related data. This, however, introduces a **privacy** challenge to work-related health promotion activities, as the data collection has to take place also in very private areas of people's lives.

Next to blurring the boundary between work and private life, data collection for a smart work environment also blurs the boundary between health- and productivity-related data. In SmartWork, the *myWorkAbility* service aims to infer the workability of the older worker at any point in time. The workability is determined, among other factors, by the health status of the worker. This service takes into account previous and existing (chronic) conditions which, for example, due to an exacerbation, might impact the workability of an individual at a certain moment. The aim is to achieve a good balance between the physical and mental strain caused in the job and the employee's working capacity and therefore contributes to the person's **well-being**.

This leads us to what is likely one of the strongest ethical challenges of pervasive sensing in a smart work environment: sharing health-related data with the manager or employer. Health-related data is always sensitive and very personal, therefore well protected in ethical and privacy regulations. However, when it comes to a smart work environment, the line between health and productivity-related data can become blurred, especially the ones related to stress and the ways of measuring stress and workload. This creates a tension between the values of **well-being** (which would be supported by tailoring the workload to the levels of stress) and **privacy** (in case a worker does not want to have their health data collected and processed). To illustrate this challenge, it is worth mentioning that this issue was iteratively discussed within the SmartWork project and was the basis for the decision of not sharing any data that may be associated with health or personal performance with the employers.

If the work environment is supposed to adapt flexibly to the needs of older office workers, information on the health status and their workability has to be shared in some shape or form. How can a solution determine the personal needs in a non-invasive way? Moreover, how to ensure any data collected cannot be used as an asset in the power relationship between employer and employee for a different reason than the improvement of the working conditions? Defining a system where these two challenges are overcome will bring a major step forward for the effective implementation of holistic working and living environments.

5.2 Data ownership, control, access, and use

Another major challenge to the SmartWork system implementation is connected to the values of **ownership**: Who owns the data? Who is allowed to access and make use of information? Ownership and property have been defined as "a right to possess an object (or information),

use it, manage it, derive income from it, and bequeath it" (Friedman, Kahn, Borning, & Huldtgren, 2013). Concerning intellectual property, Lipinski & Britz discuss the dual nature of information ownership, which supports the *right to control* (i.e., ownership) as well as the *right of access* to information (Lipinski & Britz, 2000). This means that although ownership involves the right to control the access to information, others may possess the right of access to that information as well. As mentioned previously, having control of information about oneself is key and freedom from surveillance (the right not to be tracked, followed, or watched in one's own private space) are important aspects of **privacy** (Warnier et al., 2015). Furthermore, aspects that are related to people having control over their information are also covered within the GDPR (see section 3.4).

One challenge concerning the right to control data access is closely related to the difficulties of data anonymisation or pseudonymisation. Employees might agree to have their data collected for personal reflection and self-management of their health but might prefer this to be accessible only to themselves (Lidynia, Brauner, & Ziefle, 2018). Whether a worker consents to sharing information with their supervisor is likely to be also influenced by cultural factors. In a survey conducted among Danish (N=49) and Portuguese (N=50) workers as part of SmartWork's requirements elicitation activities, the two groups showed different attitudes towards the potential functionality that allows their employer to be informed about their performance or ability. Danish workers considered informing the employer on worker performance (84%) or workability (68%) not very or not at all useful. However, more than half of the Portuguese workers in the survey considered these functions useful or even very useful (62% informing on worker performance, 66% informing on workability) (SmartWork, 2019).

Considering that the *digiTeam* service of SmartWork intends to enable flexible management of the workforce, to increase efficiency and productivity (from an employer's perspective), and also to optimise training and knowledge management activities, data related to productivity must somehow be made available to managers. Besides the potential underlying ethical and data protection issues, there is also a clear and challenging overlap, since the data that contribute to stress assessment is not only related to the productivity of workers but also their health and well-being. In other words: although health data will not be shared with the managers as such, they are an important factor to assess the current stress level and hence workability. As previously referred, within the SmartWork project, privacy concerns were prioritised leading to the decision not to share this data with employers, but this is clearly a shortcoming to the full exploitation of *digiTeam's* potential.

Related to the ownership of data, another challenge concerns where that data will be stored. An exploratory study by Lidynia and colleagues showed that storing data on a company server was not favourable and participants preferred to keep the data to themselves (Lidynia et al., 2018). Within the aforementioned SmartWork survey with Dutch and Portuguese workers, only a small percentage of the respondents (11%) revealed some apprehension towards their organisation's privacy and data protection policy (SmartWork, 2019). In a recent study in the Netherlands, around seven in 10 workers reported having some or a great deal of trust in their employer's ability to keep their personal health information secure (Mercer, 2020). This might, however, be viewed differently in other countries.

5.3 Autonomy and positive health interventions to support well-being

Autonomy has been defined as the ability of people "to decide, plan, and act in ways that they believe will help them to achieve their goals" (Friedman et al., 2013). Within the medical

domain, patient autonomy encompasses *the right to self-determination* (i.e., the right to make their own decisions without interference from others), and *psychological autonomy* (i.e., the capacity of persons to exercise the right to self-determination) (Katz, 2002).

The main aim of positive health interventions is to support human **well-being** (see definition of the value of human well-being in section 5.1). Health can be seen as one aspect of well-being. Within the SmartWork project, health is not just seen as the state of complete physical, mental and social well-being (as defined by the World Health Organization, 1948), but adopts the more recent "positive health" concept by Huber and colleagues. This new concept of health as "the ability to adapt and to self-manage, in the face of social, physical and emotional challenges" acknowledges the fact that living and ageing with a chronic disease has become a norm (Machteld Huber et al., 2011; M Huber et al., 2016). This holistic concept of positive health encompasses six dimensions: bodily functions, mental functions and perception, spiritual/existential dimension, quality of life, social and societal participation, and daily functioning (M Huber et al., 2016).

Similar to the acknowledgement of health being multidimensional, the SmartWork project adopts a transdisciplinary approach and addresses six main intervention domains:

1. Healthcare interventions for health self-management;
2. Behavioural interventions to promote physical activity, healthy nutrition and well-being;
3. Cognitive function interventions to maintain cognitive capacity;
4. Work management interventions to reduce work-related stress;
5. Work-related training interventions, to facilitate explicit/ implicit knowledge; acquisition and intergenerational transfer;
6. Work environment adaptations.

Within each intervention domain, pervasive monitoring of the older workers' health, their behaviour, and their cognitive and emotional status will take place through the unobtrusive sensor network. In addition, older workers will be asked to report or validate their status on well-being parameters at work regularly. That way, the SmartWork system can assess or validate the risks of functional or cognitive decline, which may lead to absence from work or early retirement. By detecting those risks, the system will recommend to the worker possible interventions (e.g., behaviour change) in form of advice and guidance, as the SmartWork system aims to complement the user's own observations rather than providing diagnosis, prevention or cure.

Balancing the number of interventions that contribute to a person's health in the long run with their perceived well-being, values, and preferences in the here and now, while respecting their autonomy presents another challenge. Adopting the holistic "positive health" concept by Huber implies that potentially several interventions could be useful for a given employee at the same moment to account for the multi-dimensional aspects of active and healthy ageing. However, the number of interventions towards older adults' ability and sustainability at work may bring as many benefits as potential threats. Smartphone or digital notifications, for instance, have been recognised as a major distracting factor, due to the risk of constantly interrupting the ongoing workflow (Ortet et al., 2019). Additionally, combined with the repetitive interruptions from the data collection (e.g., by asking a worker to do self-

assessments and report their experiences), these interventions are likely to create a spiral effect of additional anxiety and stress (Ortet et al., 2019) and counteract their **well-being**. In other words, the same intervention that is supposed to contribute to positive health in one dimension (e.g., bodily functions) might have a detrimental effect on a person's well-being in another dimension (e.g., mental functions and perception). Furthermore, not all intervention needs can be addressed at the same time and some domains are strongly connected to and influence each other (e.g., exercise, sleep, and nutrition habits). Some interventions might objectively contribute to a person's physical **well-being** but interfere subjectively with a person's perceived quality of life (for example, because even though a certain behaviour might be considered unhealthy, it's important for that person). Behaviour change interventions aiming at positive health can therefore be in tension with a person's **autonomy**. In establishing ethical principles of persuasive design, the golden rule of persuasion has been defined as: "The creators of a persuasive technology should never seek to persuade a person or persons of something they themselves would not consent to be persuaded to do" (Berdichevsky & Neuenschwander, 1999).

Thus, one of the challenges for the SmartWork system will be to unveil the most promising and adequate type of interventions for older office workers that are in line with their values and preferences, in an integrated and efficient way, without overburdening them while respecting their autonomy.

5.4 Division of responsibility between employer and worker

Technology can be designed for the value of **responsibility**. The design of technology can affect a person's responsibility in that a user assumes responsibility or is responsible for something, or that it distributes responsibility between individuals or groups (Fahlquist, Doorn, & van de Poel, 2015). Whether an individual is considered responsible for something or this is considered a collective responsibility might depend on the cultural context. For example, when it comes to stress at work, cultural differences have been identified whether the responsibility of moderating life stressors is placed on the individual or shared with the environment (i.e., the emphasis being placed on social causes of illness) (Karasek & Theorell, 1990).

A smart work environment that takes the health of employees into account and supports them in living an active and healthy life can be seen as an extension of electronic performance monitoring (EPM). EPM includes the continuous collection, analysis, and reporting of information about an employee's productive activities (Smith, Carayon, Sanders, Lim, & LeGrande, 1992). The suite of services in the SmartWork project goes beyond EPM by including monitoring of physiological and behavioural parameters that might, or might not, be directly related to the productivity of the worker. The type and mechanism of data collection (sensors and short-questionnaires) can put quite a burden on the worker. In addition to that, as the worker is also the recipient of interventions (coaching, notifications, reminders), this implies a **responsibility** that is put mainly on the individual.

However, the personal behaviour of the worker is only one side of the story, as also the organisation or company has a responsibility to create an environment and design jobs in a way that enables healthy working in the first place (Karasek & Theorell, 1990). For example, while workplace wellness programs may lead to reported better health behaviours, the effect on clinical measures of health and economic outcomes may be limited (Song & Baicker, 2019). From the perspective of the worker, psycho-social factors such as job design, ability to make

decisions and control over work are not only positive contributors to health in the work setting but seem even more relevant than individual lifestyle issues (Dugdill, 2000).

Finally, the extensive monitoring of health and performance might also be in tension with an important aspect of **privacy**: freedom from surveillance, which as mentioned before is the right not to be tracked, followed, or watched in one's own private space (Warnier et al., 2015).

5.5 Power relations at work, accountability, and trust

Power has been defined in different ways, for example, by Max Weber as "the probability that one actor within a social relationship will be in a position to carry out his own will despite resistance, regardless of the basis on which this probability rests" (Weber, 1978). This rather negative perspective on the concept of power has been challenged, critiqued, amended, and extended since then (Hardy & Clegg, 2006). Galinsky and colleagues define power as asymmetric control over valuable resources and outcomes within a specific situation and set of social relations, which implicitly involves both control over and independence from others in obtaining important outcomes (Galinsky, Magee, Gruenfeld, Whitson, & Liljenquist, 2008). In other words, power is the capacity to be uninfluenced by others (Galinsky et al., 2008).

Accountability refers to "the properties that ensures that the actions of a person, people, or institution may be traced uniquely to the person, people, or institution" (Friedman et al., 2013). Accountability is closely related to **transparency**, where accountability provides evidence to justify past actions to others and transparency is the tendency to be open in communication (Hulstijn & Burgemeestre, 2015). Accountability/transparency and privacy are values that are considered typical for value tensions to occur (Friedman et al., 2013).

Trust has been defined as a psychological state that represents the trusted person or object as being trustworthy and (because this may not actually be the case) involves accepting one's vulnerability to others (Nickel, 2015). In the context of online interaction, interpersonal trust means that "we are vulnerable to harm from others yet believe these others would not harm us even though they could" (Friedman, Khan, & Howe, 2000).

A smart work environment can support office workers in a flexible work setting to account for the work they did, even if not in the office and hence enables **accountability** and **transparency** of their contribution to the workforce. It may, for example, show that certain workers are very efficient in the morning vs. the evening, motivating accordingly an adaptation of work schedule and expected availability. A smart work environment that supports some form of performance monitoring can also help workers to reflect on their work, for example, in terms of how long certain tasks take them, which could lead to improving their planning skills. Furthermore, workers receive a more objective measurement of how much they actually work, so that they might be able to set some adjustments (e.g., setting guilt-free boundaries by not checking emails at the weekend considering they already worked overtime). Transparent and objective performance measures might increase the perception of fairness with regard to the division of workload.

Even in companies with rather flat hierarchies, control over resources by people in power still remains and so does the dependence of powerless to those in power. Adding to this dependency health and productivity monitoring tools, which are part of the SmartWork suites, can potentially have negative effects on relationships at work, job satisfaction and attitude.

Accountability/transparency can bring some negative effects, for instance, on the trust chain between management and employee. In a non-monitored work environment, management

and employee have to establish trust in each other and in a balanced give-and-take. The opportunity to check in on a detailed level and the perception of monitoring as being unfair, abusive, or infringing on an employee's rights ('Big Brother' is watching) can create an atmosphere of mistrust (Alder, Noel, & Ambrose, 2006). The perception of monitoring, therefore, stands in contrast to the value of **privacy**. Working conditions in which performance is electronically monitored can be perceived as more stressful and workers can experience an increased level of anxiety, depression, anger, health complaints and fatigue (Smith et al., 1992), hence counteracting their **well-being**.

A lack of trust that the technology is used to their benefit might lead to workers cheating the system (e.g., by pretending to be more active than they actually are) to avoid repercussions. Following from this, another important aspect to consider is the way a smart work environment might affect the relationship between the worker and their colleagues and management. Meaningful work and meaningful relationships are important aspects of the "positive health" concept (M Huber et al., 2016) and hence a person's **well-being**.

Another aspect related to power and control refers to the idea of opting-out (i.e., that participation in performance and health monitoring is voluntary), which would support the value of **autonomy** (see section 5.3). This concerns less the design as such and more how a system like SmartWork would be introduced and used in the workplace. Depending on the culture of the organisation, power dynamics and the relationship between co-workers, voluntary participation might be undermined by peer pressure. Peer pressure is understood as "the social influence of members of a peer group leading others to take certain actions or adopt certain practices" (Kieslinger, 2015). Especially when opting-in is the norm, non-participation especially with regard to performance monitoring might be perceived as suspicious by co-workers. As described in the essay by Solove (2007), the 'nothing to hide' argument is very popular in the public discourse when privacy is balanced against security. Statements like "If you aren't doing anything wrong, then what do you have to hide?" or "If you've got nothing to hide, what do you have to fear?" illustrate how accountability/transparency can be in conflict with **privacy**. However, this conflict or tension might be based on a very narrow view of privacy as a form of concealment or secrecy (Solove, 2007).

The negative perception might depend not only on functionalities but also on how the tools have been introduced and implemented in the particular workplace. For example, perceived organisational support and advanced notice can mitigate this negative view and even increase employee trust (Alder et al., 2006). Another factor that can reduce the negative effect of monitoring felt by employees is a focus on feedback and performance appraisal (Chalykoff & Kochan, 1989). The empirical study by Chalykoff and Kochan was one of the first to investigate employees' viewpoints and responses to monitoring. Their study showed that not the monitoring in itself, but how it is used in practice has significant effects on office workers' general attitudes and behaviours, and that "managerial attention to recognised standards for performance appraisal, feedback, and good supervision can significantly reduce the otherwise negative effects of monitoring" (Chalykoff & Kochan, 1989). One should note, however, that employees who initially oppose monitoring per se might not change their minds even if the monitoring and feedback process is managed well (Chalykoff & Kochan, 1989).

6 Discussion

This paper describes the conceptual investigation of human values and tensions present when introducing pervasive health sensing technology in the workplace. The work was conducted in the context of a European Research and Innovation Action project and reflects the perspective of consortium members from different backgrounds, supported by literature and empirical investigations. We have identified and discussed eight key human values and value tensions that arose when designing and developing a system that promotes workability among older adults, namely human well-being, privacy, ownership, autonomy, responsibility, power, accountability, and trust.

While the results are supported by literature and empirical investigations during the project, further empirical investigation with stakeholders after the technology has been implemented is needed to examine which values are affected when the SmartWork services are used in the work context. The project targets older office workers in Europe. It is unclear, whether the results (challenges, implicated values, and value tensions) are applicable in other countries or age groups that might also benefit from health promotion programs. However, the results can be used as a starting point for such conceptual investigations in other contexts.

Ethical challenges can be seen as a design constraint that might inhibit, but can also enable creativity (Rosso, 2014). Hence, a design constraint can also be re-framed as a design opportunity. The aim to support older workers holistically introduces the challenge of balancing *human well-being and privacy in the smart workplace* and issues considering *data ownership*. The initial conceptualisation of the SmartWork crossed boundaries between private life and workplace; sensitive health-related and productivity-related data. However, as the SmartWork project places a premium on human values, the decision was made to prioritise privacy and autonomy at the expense of fully exploiting the potential of some services.

Another challenge concerns *balancing autonomy and positive health interventions*. Within the SmartWork project, respecting the autonomy of the older worker and their values is of utmost importance. Given their context, preferences and values, workers can prioritise their interventions so that they can accomplish their self-determined goals. It can be helpful, however, to support individuals in identifying which interventions might be more urgent than others concerning their health and work to make an informed decision. Hereby, the person's 'psychological autonomy' is supported, as it increases the capacity of the older worker to exercise their right to self-determination (Katz, 2002). To facilitate the prioritisation of interventions, SmartWork has worked closely with a local occupational oriented health centre that advises companies and people on how to become and remain healthy, vital, and employable. Professionals from various disciplines (e.g., psychologist, physiotherapist, lifestyle coach) shared their expertise from consultations with workers from various backgrounds on how to approach prioritisation of interventions. This informed the SmartWork project also concerning the limits of digital interventions and where a blended approach between professionals and SmartWork might be beneficial.

One important challenge in a smart work environment that makes use of pervasive sensing is to *balance the responsibilities put on the employer and the worker*. The services within SmartWork such as *ubiWork* that supports work flexibility, *workCoach* for on-demand training, and *digiTeam* for flexible team management are a response to this challenge by acknowledging the organisation's responsibility of creating a supportive work environment, whereas the services *healthyMe* and *myWorkAbility* address the lifestyle and behaviour of the individual.

The SmartWork project aims to address the challenges brought by a growing ageing population by supporting active and healthy ageing. Hence, SmartWork can be seen as a technological response to a societal problem (i.e., the demographic change and the growing number of chronic conditions prevalent in the population). However, socio-technological theories pose that technology affects the behaviour of people and people also affect the working of the technology (Klein, 2014). When we consider the first intention under a project such as SmartWork, we see indeed the aim for a greater societal good – to prevent older employees to retire earlier, namely by promoting healthier behaviours and lifestyles and to provide a better exchange of knowledge and skills amongst different generations. However, this same tool can collect data for these purposes, which when misused may justify the dismissal of specific older employees due to lack of productivity. In other words: the challenge concerning *power relationships at work* might be intensified through tools that allow monitoring and shift the balance of power even more towards the employer.

The old discussion of atomic energy – produced for a higher good and forever connected to the atomic bomb and its horrendous effects – seems to always haunt the decision of developing these disruptive technologies. However, progress will always imply risks and increased responsibility. One must not avoid progress but search for better tools to secure a correct use. In that sense, SmartWork, as similar systems to promote workability, shall not live off its good intentions but instead ensure its good use – and keep this objective in all of the development and testing phases still to come.

7 Conclusion

The ageing population and the effects on healthcare, workforce and society is a challenge that has widespread implications for the social structure. The development and implementation of technology can be one way to support active and healthy ageing and at the same time facilitate older adults to stay working as desired. Every new technology, however, potentially introduces new challenges, as technology affects the behaviour of people and people also affect the working of the technology. Before a smart working environment with pervasive sensing and health coaching is implemented and used for a longer time, it remains a question of how it will affect the behaviour of people, organisations, and even society.

A technology that accounts for the values and needs of older employees while supporting an adaptive workplace can also be misused to lay off exactly those who need flexibility or support. Regulations to prevent discrimination against older employees might be needed for those challenges that cannot be answered by a smart design. Within SmartWork, the aim is to design better tools and prevent misuse as much as possible, which in turn may bring about innovations that might not have been envisioned without facing those constraints and challenges. However, there is a limit as to how far a technological response to a societal problem can go. Despite the potential of digital health solutions to support active and healthy ageing, society might have to change in terms of how people with chronic conditions or of older age are viewed. Too often, the ageing population is described in terms of a "burden", especially on healthcare systems due to increasing costs. The underlying view of SmartWork, however, is a positive one, considering the ageing workers as experienced and valuable. Thus, investing in employees in the later phase of the working life in terms of flexible work settings, on-demand training and health support should not be seen as an additional cost factor in an economic sense, but as a means to keep valuable employees as long as possible.

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References

Alder, G. S., Noel, T. W., & Ambrose, M. L. (2006). Clarifying the effects of Internet monitoring on job attitudes: The mediating role of employee trust. *Information & management, 43*(7), 894-903. doi:https://doi.org/10.1016/j.im.2006.08.008

Alter, S. (2013). Work system theory: overview of core concepts, extensions, and challenges for the future. *Journal of the Association for Information Systems, 14*(2). doi:10.17705/1jais.00323

Berdichevsky, D., & Neuenschwander, E. (1999). Toward an ethics of persuasive technology. *Commun. ACM, 42*(5), 51–58. doi:10.1145/301353.301410

Bødker, S. (2015). Third-wave HCI, 10 years later---participation and sharing. *interactions, 22*(5), 24–31. doi:https://doi.org/10.1145/2804405

Bousefsaf, F., Maaoui, C., & Pruski, A. (2014). Remote detection of mental workload changes using cardiac parameters assessed with a low-cost webcam. *Computers in Biology and Medicine, 53*, 154-163. doi:https://doi.org/10.1016/j.compbiomed.2014.07.014

Braun, V., & Clarke, V. (2013). *Successful qualitative research: A practical guide for beginners*: sage.

Brey, P. (2015). Design for the Value of Human Well-BeingWell-being. In J. van den Hoven, P. E. Vermaas, & I. van de Poel (Eds.), *Handbook of ethics, values, and technological design: Sources, theory, values and application domains* (pp. 365-382). Dordrecht: Springer Netherlands.

Cabrita, M., op den Akker, H., Tabak, M., Hermens, H. J., & Vollenbroek-Hutten, M. M. R. (2018). Persuasive technology to support active and healthy ageing: An exploration of past, present, and future. *Journal of biomedical informatics, 84*, 17-30. doi:https://doi.org/10.1016/j.jbi.2018.06.010

Chalykoff, J., & Kochan, T. A. (1989). Computer-aided monitoring: Its influence on employee job satisfaction and turnover. *Personnel Psychology, 42*(4), 807-834. doi:https://doi.org/10.1111/j.1744-6570.1989.tb00676.x

Chen, L., Baird, A., & Straub, D. W. (2019). An analysis of the evolving intellectual structure of health information systems research in the information systems discipline. *Journal of the Association for Information Systems, 20*(8). doi:10.17705/1jais.00 561

Clarke, V., & Braun, V. (2013). Teaching thematic analysis: Overcoming challenges and developing strategies for effective learning. *The psychologist, 26*(2), 120-123.

Cockton, G. (2020). Worth-Focused Design, Book 2: Approaches, Context, and Case Studies. *Synthesis Lectures on Human-Centered Informatics, 13*(2), i-203.

Cromer, R., Denneson, L. M., Pisciotta, M., Williams, H., Woods, S., & Dobscha, S. K. (2017). Trust in Mental Health Clinicians Among Patients Who Access Clinical Notes Online. *Psychiatric Services, 68*(5), 520-523. doi:https://doi.org/10.1176/appi.ps.201600168

Dantas, C., van Staalduinen, W., Machado, N., Jegundo, A., & Rodrigues, F. (2019). *Older Workers, Technology and The Balance of Power: An Ethical Review*. Paper presented at the Proceedings of the 12th ACM International Conference on PErvasive Technologies

Related to Assistive Environments - PETRA '19, Rhodes, Greece. https://doi.org/10.1145/3316782.3322770

Davis, J., & Nathan, L. P. (2015). Value sensitive design: Applications, adaptations, and critiques. *Handbook of ethics, values, and technological design: Sources, theory, values and application domains*, 11-40. doi:https://doi.org/10.1007/978-94-007-6970-0_3

Dugdill, L. (2000). Developing a holistic understanding of workplace health: the case of bank workers. *Ergonomics, 43*(10), 1738-1749. doi:https://doi.org/10.1080/001401300750004140

Fahlquist, J. N., Doorn, N., & van de Poel, I. (2015). Design for the Value of Responsibility. *Handbook of ethics, values, and technological design: Sources, theory, values and application domains*, 473-490. doi:https://doi.org/10.1007/978-94-007-6970-0_18

Friedman, B., & Hendry, D. G. (2019). *Value sensitive design: Shaping technology with moral imagination*. Cambridge, MA: MIT Press.

Friedman, B., & Kahn Jr, P. H. (2007). Human values, ethics, and design. In A. Sears & J. A. Jacko (Eds.), *The human-computer interaction handbook* (2nd ed., pp. 1241-1266): CRC press.

Friedman, B., Kahn Jr, P. H., & Borning, A. (2006). Value sensitive design and information systems. In P. Zhang & D. Galletta (Eds.), *Human-computer interaction management information systems: Foundations* (pp. 348-372). Armonk, NY, USA: ME Sharpe.

Friedman, B., Kahn, P. H., Borning, A., & Huldtgren, A. (2013). Value Sensitive Design and Information Systems. In N. Doorn, D. Schuurbiers, I. van de Poel, & M. E. Gorman (Eds.), *Early engagement and new technologies: Opening up the laboratory* (pp. 55-95). Dordrecht: Springer Netherlands.

Friedman, B., Khan, P. H., & Howe, D. C. (2000). Trust online. *Commun. ACM, 43*(12), 34–40. doi:10.1145/355112.355120

Funnell, M. M., Arnold, M. S., Donnelly, M., & Taylor-Moon, D. (1991). Empowerment: An Idea Whose Time Has Come in Diabetes Education. *The Diabetes Educator, 17*(1), 37-41. doi:https://doi.org/10.1177%2F014572179101700108

Galinsky, A. D., Magee, J. C., Gruenfeld, D. H., Whitson, J. A., & Liljenquist, K. A. (2008). Power reduces the press of the situation: implications for creativity, conformity, and dissonance. *Journal of personality and social psychology, 95*(6), 1450. doi:https://doi.org/10.1037/a0012633

General Data Protection Regulation. (2016). *Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC*. Retrieved from http://data.europa.eu/eli/reg/2016/679/oj

Goetzel, R. Z., & Ozminkowski, R. J. (2008). The Health and Cost Benefits of Work Site Health-Promotion Programs. *Annual Review of Public Health, 29*(1), 303-323. doi:10.1146/annurev.publhealth.29.020907.090930

Gorm, N., & Shklovski, I. (2016). *Sharing Steps in the Workplace: Changing Privacy Concerns Over Time*. Paper presented at the Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems, San Jose, California, USA. https://doi.org/10.1145/2858036.2858352

Harbers, M., & Achterberg, P. (2012). Europeans of retirement age: chronic diseases and economic activity. *Bilthoven: RIVM.* Retrieved from https://ec.europa.eu/health/sites/health/files/major_chronic_diseases/docs/rivm_report_retirement_en.pdf

Hardy, C., & Clegg, S. (2006). Some Dare Call it Power. In S. Clegg, C. Hardy, T. Lawrence, & W. Nord (Eds.), *The Sage Handbook of Organization Studies* (2nd ed.). London: Sage Publications.

Hernandez, J., Paredes, P., Roseway, A., & Czerwinski, M. (2014). *Under pressure: sensing stress of computer users*. Paper presented at the Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Toronto, Ontario, Canada. https://doi.org/10.1145/2556288.2557165

Holtermann, A., Hansen, J., Burr, H., Søgaard, K., & Sjøgaard, G. (2012). The health paradox of occupational and leisure-time physical activity. *British journal of sports medicine, 46*(4), 291-295. doi:http://dx.doi.org/10.1136/bjsm.2010.079582

Huber, M., Knottnerus, J. A., Green, L., van der Horst, H., Jadad, A. R., Kromhout, D., . . . Smid, H. (2011). How should we define health? *BMJ, 343*, d4163. doi:https://doi.org/10.1136/bmj.d4163

Huber, M., van Vliet, M., Giezenberg, M., Winkens, B., Heerkens, Y., Dagnelie, P., & Knottnerus, J. (2016). Towards a 'patient-centred'operationalisation of the new dynamic concept of health: a mixed methods study. *BMJ open, 6*(1), e010091. doi:http://dx.doi.org/10.1136/bmjopen-2015-010091

Hulstijn, J., & Burgemeestre, B. (2015). Design for the Values of Accountability and Transparency. In J. van den Hoven, P. E. Vermaas, & I. van de Poel (Eds.), *Handbook of ethics, values, and technological design: Sources, theory, values and application domains* (pp. 303-333). Dordrecht: Springer Netherlands.

Iavicoli, S., Valenti, A., Gagliardi, D., & Rantanen, J. (2018). Ethics and Occupational Health in the Contemporary World of Work. *International Journal of Environmental Research and Public Health, 15*(8), 1713. Retrieved from https://www.mdpi.com/1660-4601/15/8/1713

JafariNaimi, N., Nathan, L., & Hargraves, I. (2015). Values as Hypotheses: Design, Inquiry, and the Service of Values. *Design Issues, 31*(4), 91-104. Retrieved from http://www.jstor.org/stable/43830434

Jansen-Kosterink, S., Bulthuis, R., ter Stal, S., van Velsen, L., Pnevmatikakis, A., Kyriazakos, S., . . . op den Akker, H. (2020). The Results of an Iterative Evaluation Process of an Mhealth Application for Rewarding Healthy Behaviour Among Older Adults. 62-78. doi:https://doi.org/10.1007/978-3-030-52677-1_4

Karasek, R., & Theorell, T. (1990). *Healthy work: stress, productivity, and the reconstruction of working life*. New York: Basic Books.

Katz, J. (2002). *The Silent World of Doctor and Patient*: Johns Hopkins University Press.

Kieslinger, B. (2015). Academic peer pressure in social media: Experiences from the heavy, the targeted and the restricted user. *First Monday, 20*(6). doi:https://doi.org/10.5210/fm.v20i6.5854

Klein, L. (2014). What do we actually mean by 'sociotechnical'? On values, boundaries and the problems of language. *Applied Ergonomics, 45*(2, Part A), 137-142. doi:https://doi.org/10.1016/j.apergo.2013.03.027

Komp, K. (2018). Shifts in the realized retirement age: Europe in times of pension reform and economic crisis. *Journal of European social policy, 28*(2), 130-142. doi:https://doi.org/10.1177%2F0958928717709174

Kramer, A., & Kramer, K. Z. (2020). The potential impact of the Covid-19 pandemic on occupational status, work from home, and occupational mobility. *Journal of Vocational Behavior, 119*, 103442. doi:https://doi.org/10.1016/j.jvb.2020.103442

Liang, J., Bennett, J. M., Shaw, B. A., Quiñones, A. R., Ye, W., Xu, X., & Ofstedal, M. B. (2008). Gender differences in functional status in middle and older age: Are there any age variations? *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 63*(5), S282-S292. doi:https://doi.org/10.1093/geronb/63.5.s282

Lidynia, C., Brauner, P., & Ziefle, M. (2018). *A Step in the Right Direction – Understanding Privacy Concerns and Perceived Sensitivity of Fitness Trackers*. Paper presented at the Advances in Human Factors in Wearable Technologies and Game Design (AHFE 2017), Cham. https://doi.org/10.1007/978-3-319-60639-2_5

Lipinski, T. A., & Britz, J. (2000). Rethinking the ownership of information in the 21st century: Ethical implications. *Ethics and Information Technology, 2*(1), 49-71. doi:https://doi.org/10.1023/A:1010064313976

Marengoni, A., Angleman, S., Melis, R., Mangialasche, F., Karp, A., Garmen, A., . . . Fratiglioni, L. (2011). Aging with multimorbidity: A systematic review of the literature. *Ageing Research Reviews, 10*(4), 430-439. doi:https://doi.org/10.1016/j.arr.2011.03.003

María-Ángeles, S., Maqueda, J., Francisco, M., María-Jesús, S., & María-Dolores, S. (2021). Evaluation of the Effectiveness of Workplace Health Promotion Programs from 2000 to 2020: Literature Review. *Open Journal of Preventive Medicine, 11*(4), 113-131.

Mercer. (2020). Health on Demand Netherlands Report. Retrieved from https://www.mercer.nl/content/dam/mercer/attachments/europe/Netherlands/Health-on-Demand-Netherlands-Report-Final.pdf

Miller, B. (2020). Is Technology Value-Neutral? *Science, Technology, & Human Values, 46*(1), 53-80. doi:10.1177/0162243919900965

Mingers, J., & Walsham, G. (2010). Toward Ethical Information Systems: The Contribution of Discourse Ethics. *MIS Quarterly, 34*(4), 833-854. doi:10.2307/25750707

Mozos, O. M., Sandulescu, V., Andrews, S., Ellis, D., Bellotto, N., Dobrescu, R., & Ferrandez, J. M. (2017). Stress detection using wearable physiological and sociometric sensors. *International Journal of Neural Systems, 27*(2), 1650041-1650041. doi:https://doi.org/10.1142/s0129065716500416

Nickel, P. J. (2015). Design for the Value of Trust. In J. van den Hoven, P. E. Vermaas, & I. van de Poel (Eds.), *Handbook of ethics, values, and technological design: Sources, theory, values and application domains* (pp. 551-567). Dordrecht: Springer Netherlands.

OECD / European Union. (2016). *Health at a Glance: Europe 2016: State of Health in the EU Cycle*. doi:https://doi.org/10.1787/23056088

Ortet, S., Dantas, C., Machado, N., Tageo, V., Quintas, J., & Haansen, S. (2019). *Pervasive technologies applied to the work environment: Implications for end-users: the foreground for SmartWork concerns and requirements*. Paper presented at the Proceedings of the 12th ACM International Conference on PErvasive Technologies Related to Assistive Environments, Rhodes, Greece. https://doi.org/10.1145/3316782.3322769

Papastavrou, E., Charalambous, A., & Tsangari, H. (2012). How do informal caregivers of patients with cancer cope: A descriptive study of the coping strategies employed. *European Journal of Oncology Nursing, 16*(3), 258-263. doi:https://doi.org/10.1016/j.ejon.2011.06.001

Phelps, A., Marmot, M., Oskala, A., Clemens, S., Banks, J., Rogers, N., . . . Oldfield, Z. (2020). *English Longitudinal Study of Ageing: Waves 0-9, 1998-2019*. Retrieved from: http://doi.org/10.5255/UKDA-SN-5050-18

Rosso, B. D. (2014). Creativity and Constraints: Exploring the Role of Constraints in the Creative Processes of Research and Development Teams. *Organization Studies, 35*(4), 551-585. doi:https://doi.org/10.1177%2F0170840613517600

Schwartz, S. H. (2012). An Overview of the Schwartz Theory of Basic Values. *Online Readings in Psychology and Culture, 2*(1). doi:https://doi.org/10.9707/2307-0919.1116

Sharon, T. (2017). Self-Tracking for Health and the Quantified Self: Re-Articulating Autonomy, Solidarity, and Authenticity in an Age of Personalized Healthcare. *Philosophy & Technology, 30*(1), 93-121. doi:https://doi.org/10.1007/s13347-016-0215-5

SmartWork. (2019). First Version of Codesign Methodology, User Requirements and Use Cases. Retrieved from http://www.smartworkproject.eu/wp-content/uploads/2019/07/SmartWork_D2.2-Co-design-Method_Reqs_Use-Cases.pdf

Smith, M. J., Carayon, P., Sanders, K. J., Lim, S. Y., & LeGrande, D. (1992). Employee stress and health complaints in jobs with and without electronic performance monitoring. *Applied Ergonomics, 23*(1), 17-27. doi:https://doi.org/10.1016/0003-6870(92)90006-H

Solove, D. J. (2007). I've got nothing to hide and other misunderstandings of privacy. *San Diego Law Review.* Retrieved from https://ssrn.com/abstract=998565

Song, Z., & Baicker, K. (2019). Effect of a workplace wellness program on employee health and economic outcomes: a randomized clinical trial. *Jama, 321*(15), 1491-1501. doi:https://doi.org/10.1001/jama.2019.3307

Stratton, E., Lampit, A., Choi, I., Calvo, R. A., Harvey, S. B., & Glozier, N. (2017). Effectiveness of eHealth interventions for reducing mental health conditions in employees: A systematic review and meta-analysis. *PloS one, 12*(12), e0189904. doi:https://doi.org/10.1371/journal.pone.0189904

Topa, G., Depolo, M., & Alcover, C.-M. (2018). Early Retirement: A Meta-Analysis of Its Antecedent and Subsequent Correlates. *Frontiers in Psychology, 8*. doi:10.3389/fpsyg.2017.02157

Vos, T., Lim, S. S., Abbafati, C., Abbas, K. M., Abbasi, M., Abbasifard, M., Murray, C. J. L. (2020). Global burden of 369 diseases and injuries in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. *The Lancet, 396*(10258), 1204-1222. doi:https://doi.org/10.1016/S0140-6736(20)30925-9

Warnier, M., Dechesne, F., & Brazier, F. (2015). Design for the Value of PrivacyPrivacy. In J. van den Hoven, P. E. Vermaas, & I. van de Poel (Eds.), *Handbook of ethics, values, and technological design: Sources, theory, values and application domains* (pp. 431-445). Dordrecht: Springer Netherlands.

Weber, M. (1978). *Economy and society: An outline of interpretive sociology* (Vol. 1): Univ of California Press.

Whittle, J., Ferrario, M. A., Simm, W., & Hussain, W. (2021). A Case for Human Values in Software Engineering. *IEEE Software*, 38(1), 106-113. doi:https://doi.org/10.1109/MS.2019.2956701

World Health Organization. (1948). Preamble to the Constitution of the World Health Organization as adopted by the International Health Conference, New York, 19-22 June, 1946; signed on 22 July 1946 by the representatives of 61 States (Official Records of the World Health Organization, no. 2, p. 100) and entered into force on 7 April 1948. The definition has not been amended since 1948. *http://www.who.int/governance/eb/who_constitution_en.pdf.* Retrieved from https://www.who.int/about/who-we-are/frequently-asked-questions

World Health Organization. (2010a). Healthy workplaces: a model for action: for employers, workers, policy-makers and practitioners. Retrieved from https://www.who.int/occupational_health/publications/healthy_workplaces_model_action.pdf

World Health Organization. (2010b). Tackling chronic disease in Europe: strategies, interventions and challenges. *Observatory Studies Series: 20.* Retrieved from https://apps.who.int/iris/handle/10665/326484

World Health Organization. (2021). Ageing and health. Retrieved from https://www.who.int/news-room/fact-sheets/detail/ageing-and-health

doi: https://doi.org/10.3127/ajis.v26i0.3133