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THE IMPACT OF EMPLOYEE PRE-VISIT MONITORING BY USING SMARTWATCHES ON OCCUPATIONAL HEALTH EXAMINATION

[Master's thesis]

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Kas töötajate monitoorimine nutikellaga enne töötervishoiukontrolli tõstab töötervishoiukontrollide kvaliteeti?

[Magistritöö]

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Tallinn 2024

Author’s declaration of originality

I hereby certify that I am the sole author of this thesis. All the used materials, references to the literature and the work of others have been referred to. This thesis has not been presented for examination anywhere else.

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Abstract

Background: The occupational health check process in Estonia is outlined, emphasizing its purpose in monitoring employees' health and detecting potential work-related and occupational diseases. A 2020 study reveals shortcomings in the current approach, including a lack of personalization, trust issues, and limitations in addressing diverse work modes. To address these challenges, this research proposes the integration of wearable devices, such as smartwatches, as a promising alternative for longer and personalized health monitoring, aiming to enhance the early detection of work-related and occupational diseases.

Methodology: In this research, two research methods were employed. To understand the perspectives of occupational health doctors, semi-structured interviews were conducted. The other part involved a web-based questionnaire for employees, where the willingness to share data could be identified. The results supported the existing literature, indicating that occupational health doctors are aware of the potential utilization of smartwatches in clinical settings but are hesitant to use them in employee monitoring. Main concerns included data overload, overmedicalization, and lack of accuracy. Most employees expressed high satisfaction with the occupational health service but were interested in receiving additional feedback from occupational health doctors, thus expressing willingness to share data from their smartwatches. Those employees who were initially unwilling to share data reconsidered if the employer introduced monetary or non-monetary incentives.

Conclusions: Smartwatches could be an efficient tool to add personalization to occupational health visits, but further research is needed for this.

Annotatsioon

Taust: Töötervishoiu kontrolli eesmärk Eestis on jälgida töötajate tervist ning avastada võimaliku tööst põhjustatud haigused ja kutsehaigused võimalikult varajases faasis. Ühe 2020 aastal läbi viidud uuringu järgi tuvastati peamiste väljakutsetena töötervishoiusüsteemis vähest personaliseeritust, usaldamatust ning vähest tähelepanu töötaja töölaadile. Antud väljakutsete lahendamiseks pakub antud uurimus välja nutikellade implementeerimist töötervishoiu kontrolli, mis võimaldab töötajaid monitoorida pikema aja jooksul ning saada parem ülevaade töötaja tervisest tema tööpäeva jooksul, mis omakorda võimaldab avastada kutsehaigused ja tööst põhjustatud haigused võimalikult varajases faasis. **Metoodika:** Uuringus kasutati kahte uurimismeetodit. Töötervishoiuarstide vaatenurkade mõistmiseks viidi läbi poolstruktureeritud intervjuu. Teine osa hõlmas veebipõhist küsimustikku töötajatele, kus tuvastati töötajate valmidust oma nutikellade andmeid jagada töötervishoiuarstidega. Tulemused toetasid olemasolevat kirjandust, näidates, et töötervishoiuarstid on teadlikud nutikellade võimalikust kasutamisest meditsiinis, kuid on kahtlevad nende kasutamisel töötervishoius. Peamised mured hõlmasid andmete ülekoormust, liigset monitoorimist, mis võib viia ärevuseni patsientide seas ja nutikellade täpsuse puudumist. Enamus töötajaid avaldas rahulolu töötervishoiuteenusega, kuid soovisid siiski saada täiendavat tagasisidet ja seetõttu olid valmis oma nutikellade andmeid jagama töötervishoiuarstidega. Need, kes algselt ei soovinud andmeid jagada, osalt võiksid ümber otsustada, kui tööandja premeeriks rahalise või mitte rahalise stiimuliga. **Järeldused:** Nutikellad võiksid olla tõhus vahend personaliseerituse lisamiseks töötervishoiu kontrollile, kuid selle idee elluviimiseks on vaja läbi viia täiendavaid teadusele põhinevaid uuringuid.

List of abbreviations and terms

Occupational doctor	A doctor specialized in understanding the impact of occupational hazards on employees' health
Occupational Health and Safety Act	Outlines the obligations of the employer with the aim to ensure the health and safety of the employees
GP	General Practioner
ECG	Electrocardiogramm

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1 Introduction

Healthy and productive employees have become one of the most crucial assets for companies. Hence it is important for employers to prioritize the welfare of their employees by adhering to the Occupational Health and Safety Act [1]. Among the various obligations that employers are required to fulfil, regular occupational health checks for employees hold significance [2].

1.1 Occupational health assessment

The purpose of the occupational health check is to monitor the health of employees and detect any potential occupational or work-related diseases in their early stages [2]. According to regulations, employees are required to undergo an occupational health check at least once every three years. These checks must take place during working hours and are covered by the employer. The health check is based on a comprehensive assessment of the work environment's risks, which helps identify the specific hazards to which employees may be exposed. [1]

In Estonia, occupational health services are provided by specialized healthcare professionals, including occupational health doctors and nurses. Presently, there are approximately 64 active occupational health doctors in the country. The leading providers of occupational health services in Estonia include Meliva, Confido Arstikeskus, and the North Estonia Medical Center. [2]

Occupational health examination starts with filling out the health declaration prior the visit. The visit usually lasts between 20 – 60 minutes depending on the service provider and also the amount of tests and measurements needed. The list of tests and measurements depends on the hazards the employee is experiencing during ones working hours, but it also depends on the service provider as well. For instance for an office worker tests and measurements could be blood sugar, ECG, eye exam and heart rate measurement. For an employee working in manufacturing and who is exposed to chemicals clinical blood tests are included and most probably also exercise test. After the tests and measurements are

done the employee meets the occupational health doctor who analyzes the results; the doctor asks additional questions and consults the employee. Based on the findings, the doctor issues a health check decision, which determines the employee's suitability to work and may include any applicable restrictions. An example of the decision can be found in Appendix 6. The health check decision may also include recommendations for both the employee and the employer. These recommendations can cover a range of measures, such as adjusting the work to the employee's abilities or promoting physical, mental, and social well-being. [1],[2]

According to a 2020 study, which aimed to evaluate the current state of the occupational health industry in Estonia, several issues were identified. Firstly, the service has been found to lack personality and fails to meet the diverse needs of employees. Additionally, it was found that the occupational health service is not correlated with employees' mode of work. [2] This brings forth concerns that employees may not share all their health concerns with doctors due to a lack of trust in the healthcare system and in the healthcare providers themselves. Furthermore, as the health check is conducted only once every three years, employees may only report recent events and fail to remember health events that were happening for instance a year ago. Additionally, the employee's current emotional state and the fear associated with the visit can potentially impact the results of the occupational health check. [21]

Considering these challenges, it is clear that alternative methods are necessary to monitor and analyze patients' data in order to gather reliable information for the early detection of work-related diseases and illnesses. One potential alternative is the inclusion of wearable devices, such as smartwatches and activity monitors, as part of the occupational health check process. By incorporating these devices, a more comprehensive and personalized understanding of the patient's physical health during work can be achieved.

1.2 Wrist-worn smartwatches and activity monitors

In 2020, the number of wearable devices in use, such as smartwatches reached approximately 600 million, and this number has been steadily growing [7]. Smartwatches and activity monitors worn on the wrist, are equipped with various built-in sensors and algorithms that enable the collection of both clinical and behavioural data from patients during their everyday activities. Examples of clinical data include blood pressure, heart

rate, oxygen saturation, and body weight. Behavioural data, on the other hand, encompasses activity levels, types of activities, and social interactions. [4]

Data from wearables is typically transferred to smartphones via Bluetooth technology [3], allowing for further analysis and interpretation. The latest and most advanced wearable devices are equipped with numerous sensors including accelerometers, gyroscopes, magnetometers, barometers, altimeters, photoplethysmography (PPG), and global positioning system (GPS) capabilities. [6]

Accelerometers play a key role in collecting data on physical activity. Modern smartwatches are capable of measuring acceleration in three directions, enabling the gathering of information on movement type, step count, energy expenditure, energy intensity, sleep patterns, and more. Gyroscopes, magnetometers, barometers, and altimeters are utilized to estimate the type of activity a person is engaged in, providing measurements of movement and device position. [6]

Photoplethysmography (PPG), a sensor equipped with light-emitting diodes, emits light through the skin and estimates the user's heart rate by measuring reflections from blood volume. However, to enhance the accuracy of heart rate measurements, algorithms often combine data from the accelerometer with PPG data. [6]

Global Positioning System (GPS) technology is employed to track and record positioning, speed, and altitude information [6].

Taking into account the problems in the occupational health industry, such as lack of personality and non-need-based occupational health checks, the aim of the research is to investigate if pre-visit monitoring of employees using smartwatches increases the quality of occupational health check visits.

Based on the research aim, the research questions are the following:

1. Are occupational health doctors open to accepting as part of the pre-visit data as well as a person’s self-reported data from smartwatches and if yes, what data interests them the most?

2. Are employees open to sharing their data from wearable devices with occupational health doctors in order to get more substantive recommendations?

3. Does patients’ self-reported data provided with smartwatches give a better overview of the employees' health condition compared to classical health examination visits?

Keywords used: smartwatch, occupational health service, monitoring patience, wearables accuracy

2 Literature Review

The use of wrist-worn smartwatches is growing every year and their technology is evolving to a degree that it is considered to be close to a medical device and can be used to monitor patients' physical activity and vital signs in their natural environment. It is found that over the next 25 years the use of wearables in healthcare will save over $200 billion in healthcare costs due to the reduction of patients needing to stay in hospital for rehabilitation and treatment, as well as the reduction of patient-doctor interaction time. In addition, wearables are more affordable, have a smaller footprint and device capability. [7]

2.1 The benefits of utilizing smartwatches in patients' monitoring

The benefits of monitoring employee's vital signs with a smartwatch are huge. Compared to usual medical devices used in clinics, smartwatches are small, easy-to-use and relatively affordable. [20] Also according to a study among GP's they see major benefits such as low-cost and user-friendliness. Additionally, the ability to adjust the parameters to patient health outcomes and the large amount of data can be used in medical research are also considered as great benefits. [8]

In industries, where work is physically demanding, an ageing workforce and a high number of occupational diseases and injuries, wearables could help to detect early signs of fatigue, high heart rate, stress and high physical activity. It could prevent injuries that are caused by fatigue and also occupational illnesses that are caused by high physical workload. [20]

Focusing on the patient–wearable relationship, wearables can increase the self-responsibility of patients due to the immediate feedback that those devices are providing. From the GP-patient relationship perspective, wearables could be seen as partners or assistants. The real-time data transmission could help to monitor patients who are geographically in difficult areas. It could be especially beneficial for certain health

conditions like epilepsy and cardiac diseases. It could add the doctors' visits more value by having the data from wearables as part of the doctor's visit. Also, it would increase the autonomy and responsibility of people, when giving them a tool to manage their own health. On the other side, it could reduce the need for interaction with the doctor. [8]

2.2 Challenges and concerns related to smartwatch utilization

One of the primary concerns raised by GPs is the reliability and accuracy of the devices available on the market. This leads to the next challenge: more reliable and accurate devices tend to be more expensive, which could potentially contribute to socioeconomic inequality [8]. A study conducted among social minorities, involving over 780 individuals, revealed that 78% of respondents did not own a fitness tracker, but 58% expressed interest in having one. Their primary reasons for wanting a fitness tracker included step counting (27%), increasing exercise levels (16%), and monitoring heart rate (16%). However, cost (281) and a lack of knowledge on how to use the devices (109) were cited as major obstacles. Respondents who expressed interest in owning a fitness tracker highlighted a desire to learn how it could improve their health [11].
GPs also indicated a lack of scientific evidence regarding reliability and validity, which contributes to their hesitancy in recommending these devices as part of treatment [8]. However, Germany introduced a legislative change allowing physicians to prescribe health apps for smartphones or wearables, which are covered by the national sickness fund [10].

2.2.1 Data overload and overmedicalization

One potential risk in the patient-wearable relationship is the potential for overmedicalization. Continuous monitoring and instant feedback can lead to increased anxiety and stress among patients. Additionally, patients may overly rely on the data provided by wearables instead of trusting their bodily sensations and instincts. [8]

From the perspective of the GP-patient relationship, doctors have expressed concerns about being overwhelmed with data from wearables that they need to analyze and provide feedback on. Doctors also worry about how patients will perceive the results if they prescribe additional measurements using clinical devices and the data differs from what the smartwatch indicates. Some patients may not be willing to undergo additional tests or

measurements and may overly place their trust in the data provided solely by the smartwatch. [8]

It is essential to strike a balance between the use of wearables and the overall clinical assessment and judgment of healthcare professionals. Clear communication and education regarding the limitations and proper interpretation of wearables' data can help mitigate these risks and ensure a more balanced approach to patient care. [8]

2.2.2 Privacy concerns

According to a study conducted among runners, 73% of them utilize wearables to measure their athletic performance, with 42% expressing willingness to share their wearable data with third parties. It should be noted that these results might differ if surveyed among individuals with chronic diseases or a more sedentary lifestyle. Additionally, the willingness to share data tends to decrease among higher age groups.
Another study conducted in Canada found that 41% of smartwatch users were young or mature adults with higher education, higher income, and already in good or very good health. Conversely, another study revealed that one-third of participants discontinued using their smartwatches after six months, particularly among individuals with health issues who preferred not to be reminded of their condition or the need for physical activity. [10] For individuals with chronic illnesses, data security is a crucial concern, as they fear potential discrimination in the workplace or social circles [8].
Research conducted in Germany indicated that 12% of individuals would be willing to share their data for research purposes in exchange for a reward, while 40% would not. In comparison, in Germany, 30 million people participate in a payback system offered by American Express, where they receive rewards for sharing their data. The difference in these findings may be attributed to a lack of awareness among individuals regarding the fact that their data is being sold to third-party companies by American Express. When directly asked about sharing their data with third parties, individuals tend to be suspicious. [10]

As many wearables offer their software for free, a common monetization strategy is selling the data to third parties. While this aspect is typically mentioned in privacy policies, many people do not take the time to read them. Additionally, most health apps and wearables lack medical device certification, meaning they are not regulated by any

governing organization. One potential solution could involve doctors recommending reliable health apps and wearables. It is worth noting that GPs acknowledge wearables in healthcare as inevitable, but many feel they lack the necessary education about the market and technology to confidently make recommendations. [8]

2.2.3 The Accuracy of Smartwatches

There have been several studies demonstrating the impact of wearables on increasing physical activity in clinical settings. However, it has been suggested that to avoid overwhelming doctors with excessive data, it is necessary to provide use-cases and blueprints for different patient segments such as obesity, cardiovascular diseases, and type II diabetes. [9]

In a research study, heart rate was measured in 102 patients using a smartwatch, simultaneously with an ECG device. The objective was to identify different arrhythmias in patients' heart rates. Apple and Fitbit smartwatches were used in this study. The research aimed to detect arrhythmias such as atrial flutter and atrial fibrillation. Both smartwatches showed high accuracy in detecting atrial flutter, but their accuracy in detecting atrial fibrillation varied. Interestingly, the Apple watch demonstrated better results in detecting atrial fibrillation compared to the Fitbit smartwatch. [12]

Another study measured heart rate and energy expenditure using various devices. Participants followed a standardized protocol involving activities like sitting, walking, cycling, and running. The findings indicated that the lowest error rates were observed during cycling, while the highest error rates were observed during walking. Most devices exhibited accurate heart rate measurements, with an error rate below 5%. However, higher errors were observed in energy expenditure estimation, with an error percentage exceeding 20%. Notably, the Apple Watch demonstrated the lowest errors in both categories [13].

Wearables generate a significant amount of data, which can be challenging to process. However, they are instrumental in paving the way for personalized medicine. Smartwatches provide insights into an individual's specific resting heart rate tendencies, in contrast to clinical measurements that are compared to population-based norms. A study revealed that smartwatch-generated data outperformed clinical measurements due to their everyday usage in a natural setting, whereas clinical measurements are obtained in controlled environments. Additionally, in a study comparing longer-term monitoring

with smartwatches versus clinical measurements, it was found that longitudinal measurements with smartwatches provided a better overview of resting heart rate compared to measurements conducted in a clinic. This difference can be attributed to people's fear or anxiety associated with hospitals and doctors. [14]

While vital signs measured by smartwatches, including heart rate, body temperature, blood pressure, respiration rate, height, and weight, cannot provide definitive diagnoses, they serve as useful indicators for evaluating general health. In the same study, machine learning models were developed to detect diseases such as inflammation, diabetes, and cardiovascular diseases based on vital sign measurements. The study found that wearables data yielded more accurate information for the predictive models compared to clinical measurements. This can be attributed to the sheer volume of data and the real-life settings in which the measurements were obtained. [14]

2.2.4 Does Longer Monitoring Impact Patient Outcomes?

The current process involves doctors asking patients to recall their lifestyle up to the present moment. However, by monitoring patients with smartwatches, physicians and patients can access hard data, enabling them to make informed decisions regarding lifestyle adequacy. [15]

Before implementing a new monitoring method, it is essential to consider whether it provides more benefits than harms. Monitoring can serve various purposes. One objective is to evaluate the effectiveness of an ongoing treatment or supervise a known disease or condition that may worsen or recur but is currently under control. In the latter case, individuals may not exhibit any symptoms yet or receive any treatment, and the primary aim of monitoring is to detect changes in health conditions as early as possible, facilitating early intervention and treatment at the early stage of the disease or health problem. [16]

The primary goal of monitoring is not to provide a diagnosis, but rather to identify trends that indicate the need for further investigation or potential changes in current treatment or patient management. The implementation of new approaches in monitoring needs to consider the benefits and harms associated with this method. Compared to clinical testing, monitoring allows for the detection of potential diseases at an earlier stage. Additionally, negative results can reassure patients that there is no disease or that their condition is under control. Moreover, monitoring is less invasive for patients, as it reduces the need

for frequent clinical tests that require injections and minimizes the number of repetitive tests. [16] Fitness trackers, in particular, are considered non-invasive devices for remote monitoring [17].

However, it is important to acknowledge the potential harm that monitoring can bring. False-negative monitoring results can leave patients in the dark about potential diseases, while false-positive tests can lead to unnecessary treatments, additional tests, and over-diagnosing. For patients undergoing continuous monitoring, anxiety and distress can arise, even when the results consistently show no abnormalities. [16]

Remote patient monitoring offers numerous benefits, including improved patient outcomes, reduced healthcare utilization, decreased costs, generation of substantial data for research purposes, and increased efficiency in physician workflows [17].

Monitoring using smartwatches is enhancing the timeliness of care, integration into treatment workflows, and ultimately leading to better treatment outcomes. Additionally, remote monitoring ideally improves the efficiency of physicians' work, allowing them to focus on diagnosing, educating, and treating patients. However, it is crucial to acknowledge that patients may not always be willing to share their data with physicians. [17]

3 Methodology

The research consists of two parts. In order to understand the perception of occupational health doctors regarding the use of smartwatches in occupational health monitoring, semi-structured interviews were conducted. Secondly, a web-based questionnaire was conducted to determine if employees are willing to share their data with occupational health physicians.

For the semi-structured qualitative study, interviews were conducted among occupational health physicians in Estonia. Thirteen occupational health doctors out of 64 active occupational health doctors in Estonia were selected for the interviews. The main criteria were the accessibility to the contact information of the doctor. In addition, the author tried to find participants from different regions and various service providers. Of the 13 occupational doctors 4 of them declined citing time constraints and a lack of opinion on smartwatches in Medicine, but 9 agreed to participate in the interview.

The interview consisted of 11 questions, which were adapted from a questionnaire in the article "Health Professionals' Attitudes to Patients' Use of Wearable Technology" [18]. The original questionnaire comprised 13 questions and focused on the GPs. The author decided to use this questionnaire because there are no similar research conducted among occupational health doctors. The questionnaire was translated into Estonian and modified to suit the occupational health industry. Some adjustments were made to ensure conciseness and brevity. The final question, "If NHS/government should invest in this area," was omitted, as the focus of the questions should solely be on the occupational doctor, occupational health examination, and the user, rather than the healthcare industry as a whole. The original questionnaire can be found in Annex 2, while the modified questionnaire used in this study is provided in Annex 1.

Doctors were invited to participate in the interviews via email, with the option to join either a video conference call or a mobile phone call. There was two phone calls and 7 video calls. In both cases, the calls were recorded and transcribed using an Excel spreadsheet. The average duration of the interviews was 15 minutes. Before the start of

each interview, consent to record the session was obtained, and the recording includes this consent statement. The questions were posed by the author of this research, and the respondents provided their answers. They had the freedom to provide as much context as necessary to support their answers. The interviewer refrained from asking additional questions to ensure that the participants were not going off-topic. The interviewer clarified the question and reflected back to ensure that the interviewer and the participant understood each other. The aim was to allow the respondents to freely express their thoughts and provide any necessary clarifications.

To determine if employees are willing to share their data from smartwatches with occupational health physicians, a web-based questionnaire was introduced. The questionnaire was created using Google Forms and consisted of 17 questions. However, depending on the respondents' answers, some individuals may have encountered fewer questions. Some questions had multiple choice answers and some had free-text answers.

The original questionnaire is based on the article "Employee acceptance of wearable technology in the workplace" [19]. It was translated into Estonian and was adapted to specifically understand participants' perceptions regarding the usage of smartwatches and their relationship to occupational health services. To understand the changes made in the questionnaire in Appendix 5 there is a table with the original questions and the adjusted questions used in this study. Questions that did not serve the purpose of the study aim were marked with N/A (not applicable). As this questionnaire did not pose questions about the employee's perception of occupational health examination, therefore these questions were added by the author. The final questionnaire used in this study is in Appendix 4.

In the questionnaire employees from 6 companies participated. The companies where chosen using convenience sampling. The author had easier access to those companies because most companies are not interested in allowing University students conduct their studies on their employees. Nevertheless, the companies were also chosen to demonstrate different modes of work: office workers, manufacturing workers, and customer service.

The questionnaire itself was voluntary and made available to employees through various means such as email, intranet, and Teams channels. While the questionnaire may have

had a limitation in terms of limited participation to technology-savvy employees, these channels were chosen as they served as official communication channels, ensuring familiarity among respondents. The questionnaire was reminded to employees one time after the initial announcement. The employees had two weeks to submit their responses. It should be noted that voluntary participation may introduce bias, as individuals who are more interested in the topic may be more inclined to complete the questionnaire.

The responses were collected via Google Forms and an Excel spreadsheet with all the respondents was downloaded. The data was analyzed and grouped to create figures which are presented in this work.

4 Results

The research was conducted in two parts: a semi-structured qualitative study to understand occupational doctors' perceptions and a web-based questionnaire to understand employees' perceptions.

4.1 Interviews with occupational health doctors

In the semi-structured interviews, nine occupational doctors were interviewed, consisting of four women and five men. While two doctors were working in the same company, the rest were employed by different companies.

The interviews started with general questions, including whether the doctors considered themselves "technologically savvy." Four of them responded positively, three considered themselves average, and two answered negatively. Furthermore, out of the nine doctors, four of them used smartwatches personally, with three using Huawei smartwatches and one using a Garmin watch. On the other hand, five doctors did not wear any smartwatches.

Regarding the topic of monitoring, all doctors had heard of use cases where smartwatches were employed in clinical settings. However, they were uncertain if this method was officially validated. Some responses included statements such as, *"I have heard that doctors are using them at their own initiative, but not heard that it is officially validated,"* and *"I know that there are options, but I don't know if it is clinically accepted."* Two doctors mentioned that smartwatches were utilized in cardiology to measure pulse and heart rate. Additionally, one doctor highlighted the use of smartwatches by somnologists to monitor sleep data. When asked if longer monitoring should be applied in occupational health checks, three doctors didn't see enough value in it, expressing concerns about overmonitoring leading to health anxiety. In contrast, six doctors believed it could provide some value, but offered caveats in their responses. For instance, they stated, *"it should be handled reasonably to provide more context and background of the employee"*; *"necessary in certain cases"; "in certain areas, it could be a good option – for employees*

with a high working load, where I could see how many steps the person is taking in a working day."

When asked about the potential benefits of smartwatches in the work of occupational doctors, six doctors recognized their value, while three were opposed. Those who acknowledged the benefits would like to see data related to physical activity, heart rate, stress, sleep, and oxygen saturation. They believed this would offer valuable insights into the impact of night shifts and the physical workloads of employees. In contrast, sceptics mentioned concerns such as *"it would be another screen that people would be attached to," "the measurements are not accurate,"* and one doctor stated, *"I don't see that it would help me, but it would show that the employee is caring about their health."* Two doctors acknowledged that smartwatches were not entirely accurate, but emphasized that they provide valuable patterns and trends what would be already enough to get important insights.

Most doctors did not believe it was necessary to apply a specific monitoring period before regular health checks to obtain additional health data. They suggested that it could be applied to specific employee groups, particularly after health checks, if clinical measurements indicated deviations. One doctor also highlighted the importance of regulatory frameworks to ensure data consistency and establish clear guidelines for data transfer to doctors.

When discussing the potential benefits of smartwatches in occupational health, one doctor highlighted that they could be considered as assistants. Another doctor mentioned that remote initiation of measurements would make their work easier, eliminating the need for patients to physically return for follow-ups. One doctor also noted that continuous monitoring through smartwatches could be particularly beneficial for employees in high-risk professions, such as firefighters and pilots, who could receive instant feedback. Another doctor emphasized that integrating smartwatches into their work required consideration of two aspects: *"the employee should be able to collect, forward, and, to some extent, summarize the data, and the doctor needs to have a technical database that brings up red flags instead of manually analyzing the data."*

According to doctors, potential harms associated with smartwatches include anxiety and fear of overmonitoring, the additional burden of analyzing extensive data when employees present two months' worth of information. In addition, they brought out also concerns about data privacy and the potential for false positive and false negative results. One doctor also raised the issue of inequality in accessing medical services, as doctor visits could be occupied by individuals who believe they have health issues based on smartwatch data, while others who genuinely require medical attention may not seek it due to not owning a smartwatch.

When asked, doctors did not believe there was a need for more patients to wear smartwatches and refer themselves to doctor's visits based on the data collected. In occupational health, employees are already required to regularly visit occupational health doctors according to legal regulations, making separate notifications unnecessary. However, some doctors mentioned that early visits could be beneficial if smartwatch data indicated excessive physical workloads, which could help prevent work-related illnesses.

Doctors seem to have different levels of knowledge regarding the technological capabilities of smartwatches. One doctor expressed confidence in the sleep data collected by smartwatches, while another indicated hearing that such data was not reliable.

Although patients have not specifically asked doctors for reliable recommendations regarding smartwatches, doctors have observed that patients openly share and discuss their smartwatch data during consultations. While doctors do not actively request to see this data, it sometimes emerges during conversations, allowing them to review specific metrics like step count.

4.2 Results from the web-based questionnaire

The questionnaire was completed by 121 employees from various companies. The age range of the participants was between 18 and 64, with an equal split between men and women. In terms of education, 51% of the respondents had a higher education degree, 46% had completed secondary education, and 3% had primary education. The majority of employees (80%) held office jobs, while 13% had physically demanding roles, and 7% worked in customer support.

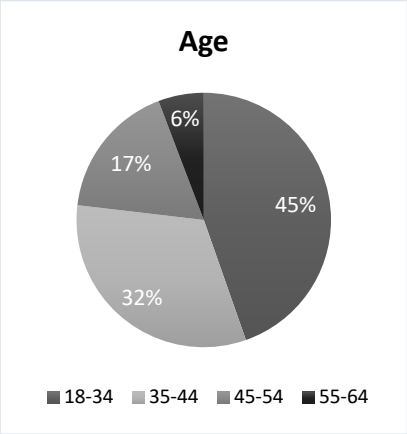

Figure 1 Participants' age

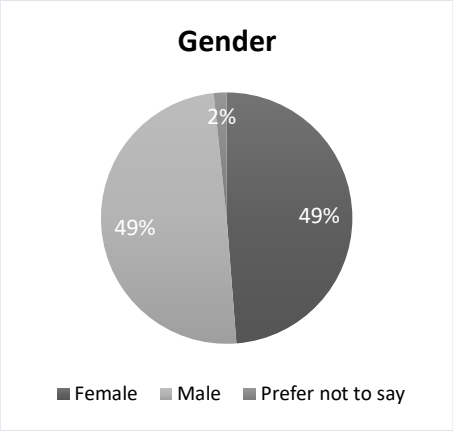

Figure 2 Participants' gender

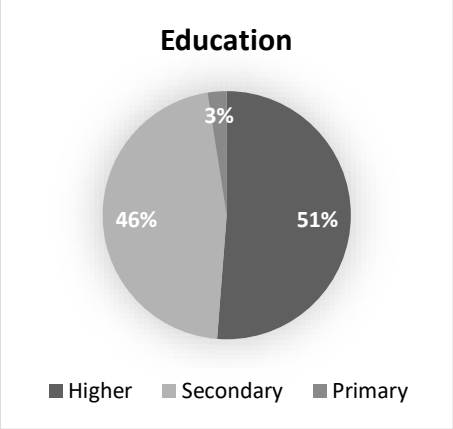

Figure 3 Participants' education level

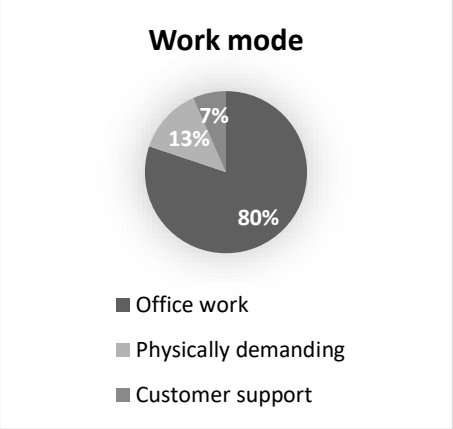

Figure 4 Participants' work mode

Regarding smartwatch usage, 76% of the respondents currently used a smartwatch, while 24% did not. The most commonly mentioned brands were Samsung (23 people) and Apple Watch (22 people). When asked to evaluate their health status on a scale of 1 to 5, with 5 being the highest, 65 people rated their health as 4. (Figure 5) The main reason to have smartwatch is to observe general physical activity. (Figure 6)

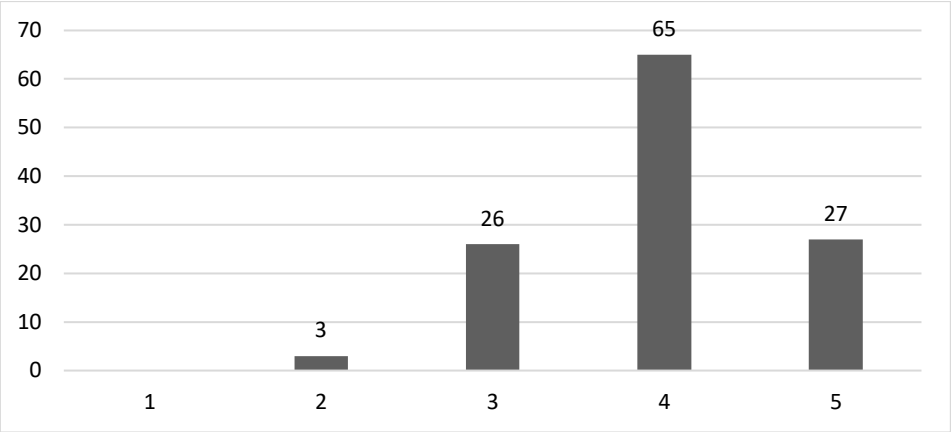

Figure 5 How participants evaluate their current health status

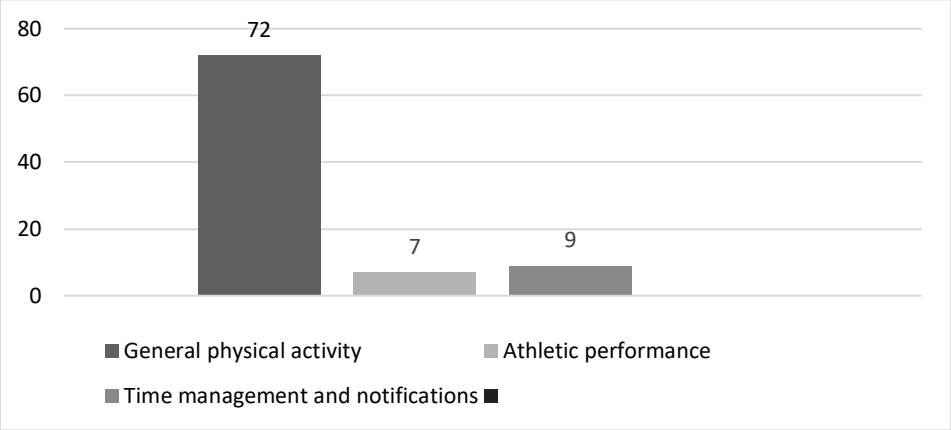

Figure 6 Participants' use-cases for smartwatches

Out of the 121 employees surveyed, 87 had visited an occupational health doctor within the past 3 years. Among these 87 individuals, 60 employees expressed satisfaction with the duration of the doctor's visits, giving a rating of 4 or 5 on a scale from 1 to 5. A significant number of people (22) rated the visit duration with a 3, indicating a need for longer appointments. In terms of the attention received from doctors, 65 respondents rated it as a 4 or 5. Eight people felt that they did not receive enough attention, while 14 people rated it as a 3. Among the 87 employees who visited occupational health doctors, 59 found the feedback they received to be good and tangible. Nineteen respondents gave a rating of 3, indicating some dissatisfaction, and 9 were not satisfied at all by marking 1 or 2. Overall, the respondents expressed satisfaction with the quality of the health check. (Figure 7)

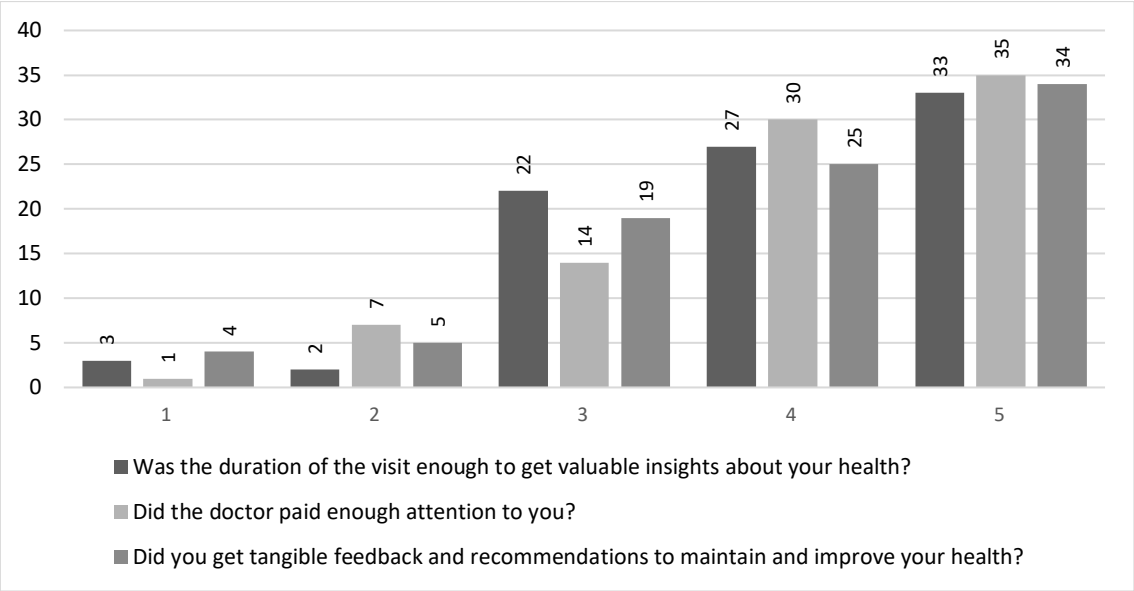

Figure 7 Participants' evaluation of the occupational health check visit

When asked about the importance of data security to employees, 79 out of 87 respondents considered it to be important to very important, rating it as a 4 or 5 on the scale from 1-5 (Figure 8).

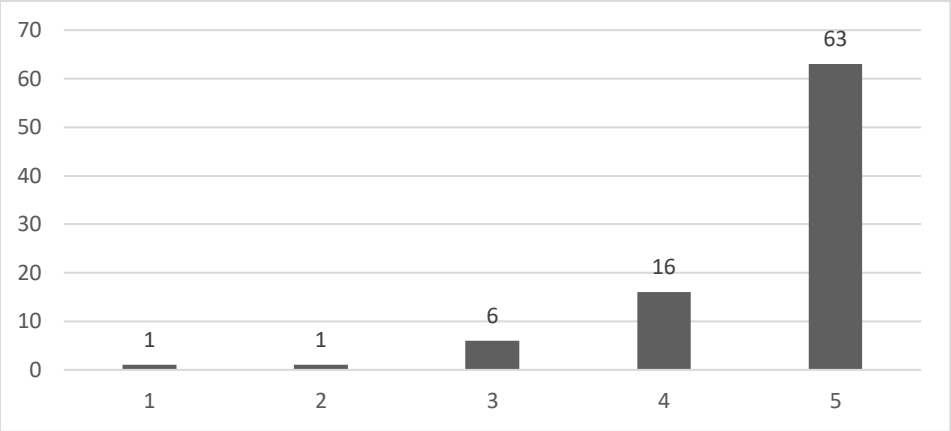

Figure 8 Participants' perception of the importance of data privacy

However, 66 people indicated their willingness to share their data with occupational health doctors, while 21 would not. (Figure 9) The main reason for not sharing the data was a lack of trust in its reliability. Among the 21 individuals who would not share their data with occupational health doctors, some stated that they would reconsider if their employer provided monetary or non-monetary incentives.

5 Discussion

Following the Occupational Health and Safety Act, employers are obligated to conduct regular occupational health examinations for their employees. Employers must arrange for their employees to undergo examinations by an occupational doctor at least once every three years. Subsequently, the physician issues a decision, assessing the employees' suitability for work and specifying any required restrictions.

The crucial reliance on occupational health examinations by employers is underscored by their primary goal of detecting occupational and work-related diseases at an early stage. Failure to diligently adhere to this protocol may expose employers to legal liabilities. Notably, a 2020 study highlights a primary critique centered around the inadequacy of personalization in the examination process, wherein the occupational health assessment fails to consider the specific occupational nuances of individual employees. [2]

Hence, the objective of this study was to evaluate a novel approach aimed at enhancing personality and comprehending the impact of workdays on employees' vital signs. Integrating smartwatch data into the pre-visit information could provide more personalized insight into the employee's workload, stress levels, and fluctuations in heart rate.

5.1 Exploring Occupational Health Physicians' Views on Incorporating Smartwatch Data in Pre-Visit Information for Occupational Health Examinations

During this study, interviews were conducted with occupational health doctors to ascertain their perspectives on incorporating smartwatches as part of pre-visit data. The majority of the interviewed physicians were familiar with the use of smartwatches in clinical settings. However, a significant portion of them expressed reservations about the reliability of smartwatches for medical applications.

Nonetheless, in the context of occupational health, precision in results is not paramount; rather, the emphasis lies on capturing trends and tendencies. For instance, if an employee's smartwatch consistently indicates elevated physical activity over five consecutive working days, it may signify an excessive workload, potentially leading to physical overload-related illnesses. This correlation has been acknowledged in earlier literature [20].

Nevertheless, the technology embedded in smartwatches is advancing swiftly, accompanied by a corresponding surge in research. As elucidated in the preceding background chapter, there are instances where data derived from smartwatches proves to be more accurate, benefitting from its real-life context and increased data volume [14]. This phenomenon is anticipated to be equally impactful during occupational health visits. The accumulation of extensive data throughout working hours holds the potential to provide a more comprehensive depiction of employees' workload and working conditions.

One concern highlighted by a physician in previous research [8] pertains to potential conflicts arising when there are discrepancies between smartwatch data and clinical measurements. The physician noted instances where employees expressed skepticism towards results obtained from medical devices, necessitating the replication of measurements using two different devices for verification. It is crucial to acknowledge that certified medical devices should take precedence, with smartwatches viewed as auxiliary tools providing supplementary information. This perspective aligns with the sentiments expressed by one of the interviewed doctors.

Conversely, the smartwatch may hold an advantage due to its continuous monitoring during working hours and the ability to accumulate data over an extended period.

This raises another issue, namely the substantial volume of data that requires processing. Doctors expressed concerns about the time constraints during visits, indicating the feasibility of inspecting and analyzing the extensive data. To address this, a proposed solution is the development of a platform designed to highlight deviations, guiding doctors to areas that require closer attention. Many smartwatches offer applications featuring graphical representations, facilitating the interpretation of long-term trends.

Furthermore, there is a concern regarding the storage and visualization of data if medical decisions are predicated on smartwatch data. Doctors emphasize the necessity for a system that securely stores or visualizes this information, as a substantiated basis for the decisions made during the examination.

An additional concern associated with data overload is the risk of overmedicalization inherent in continuous monitoring and feedback. During the interviews, several doctors emphasized that occasional deviations in heart rate and sleep patterns are natural. However, the immediacy of feedback to patients could potentially induce health anxiety, leading to unnecessary concerns about their overall health.

Yet another obstacle pertains to the awareness and familiarity of doctors with smartwatches. According to the interviews, only 4 out of 9 doctors owned a smartwatch, and they generally assessed their technological proficiency as average. Notably, those doctors who exhibited an innovative mindset and greater awareness of technological advancements were more inclined to incorporate smartwatch data into their pre-visit assessments.

One doctor highlighted the utility of scrutinizing pilot data to evaluate the effectiveness of medications, particularly in situations where direct measurements are impractical. Similarly, the use of smartwatch data among firefighters to gauge vital signs during stressful scenarios was acknowledged. While on-site measurements remain valuable, the authors contend that additional data acquired during high-stress situations and increased workload could potentially unveil signs of work-related or occupational diseases.

Educating doctors about the capabilities of smartwatch technology, its underlying mechanisms, and the latest updates and research demonstrating the credibility of these devices becomes crucial [8]. Some doctors expressed skepticism about the accuracy of smartwatches, indicating a need for enhanced understanding of the technology and its potential applications.

The primary obstacle identified by the author is the absence of a legislative framework governing the processing of smartwatch data, a concern underscored by a doctor in the interviews. Furthermore, doctors noted that employees often voluntarily present their smartwatch data, seeking feedback. In the absence of data storage, this practice may serve as an interim solution until a comprehensive legislative framework is established.

While doctors, in general, did not perceive a necessity for extended monitoring periods, the prevailing reliance on self-reported health declarations and in-visit measurements prompted reflection on the potential subjectivity of decision-making. The absence of more continuous monitoring could raise questions about the objectivity of current health assessments.

5.2 Employee Willingness to Share Data from smartwatches with Occupational Health Physicians

The ownership of smartwatches is an increasing trend and the main aim is to monitor their physical activity levels. This inclination aligns with findings from prior studies, where the interest in owning a smartwatch was notably associated with a desire for an overview of step counts and a commitment to increasing exercise levels [11].

Conversely, individuals who already own or express interest in owning a smartwatch tend to perceive their health as good or very good. Notably, those grappling with chronic illnesses or leading a more sedentary lifestyle are less likely to engage in the collection of health data [10]. This divergence in interest has potential implications for the quality of occupational health examinations, wherein individuals motivated by an interest in their health may be more proactive in presenting data and seeking feedback. Meanwhile, those in need of interventions may be less inclined to participate.

Moreover, integrating smartwatches into medical examinations could introduce socioeconomic disparities, given that more accurate smartwatches are often associated with higher costs [11]. This could inadvertently lead to inequality in occupational health examinations, with individuals owning expensive smartwatches receiving more personalized feedback than those without. A potential solution to mitigate this issue involves the commencement of collecting self-reported data through a health declaration form three months before the visit. This approach aims to garner a more extensive understanding of employees' workload and its impact on their health.

The survey conducted among employees revealed that out of 87 individuals who had visited an occupational health doctor in the past 3 years, 66 expressed willingness to share their smartwatch data to receive more personalized feedback. This inclination signifies a

notable interest among employees, despite their general satisfaction with the current quality of occupational health examinations, to obtain additional personalized insights.

Among the respondents who initially declined to share their data with the occupational health doctor, 7 indicated a reconsideration if incentivized by their employer. This aligns with findings from prior research, which showed a general suspicion among individuals regarding data sharing. However, a reward system made the people reconsider. [10]

The occupational health examination serves as a beneficial means for employees to undergo regular health checks, with the associated costs borne by the employer. Beyond its advantages for employee well-being, it also serves as a crucial liability protection measure for employers. Interestingly, certain wearable device companies, such as Oura Ring, provide business solutions, enabling companies to purchase health trackers for their employees. The Oura Ring, for instance, is a wearable ring that monitors various health metrics, including physical activity, sleep patterns, stress levels, menstrual cycles, and heart rate variability [22].

In the context of Estonia, where health-related costs of up to 400 euros per year per employee are exempt from special tax, it would be advisable to explore whether the acquisition of wearables could fall within this category. Such an approach could incentivize employers to contribute towards the increased adoption of smartwatches among employees, potentially leading to the acquisition of more reliable and sophisticated devices. This, in turn, could foster a more comprehensive and data-driven approach to occupational health monitoring.

5.3 Monitoring could Detect Early Signs of Potential Work-Related and Occupational Diseases

Existing literature on monitoring emphasizes the implementation of monitoring practices when the benefits outweigh the potential harms. The primary objective of monitoring is the early detection of changes in health to implement early intervention plans. [16]

While a majority of the interviewed doctors recognize the potential benefits of prolonged employee monitoring, there exists hesitancy regarding its universal approach and monitoring period, specifically whether it should be pre-visit or post-visit. One proposed suggestion is to prescribe monitoring post-visit in the occurance of deviations. However,

as a counterargument, utilizing smartwatches before the visit could contribute to reduced healthcare costs by eliminating the need for a second visit. Yet it is important to bring out, that as a private healthcare service, cost considerations are not the primary concern of occupational health services. The costs are borne by the employer. Nevertheless, the potential strain on doctors' resources for a second visit due to the lack of occupational health doctors.

Another concern raised during interviews is the possibility of false negative and false positive results, a matter also highlighted in the literature. False negatives may wrongly reassure employees about their health, while false positives could induce health anxiety [16]. Addressing this concern involves the use of more reliable devices and, in cases of uncertainty, employees retain the option to consult their General Practitioner for further evaluation.

5.4 Main contribution

In Estonia, research on occupational health has been relatively scarce, with the latest comprehensive study conducted in 2020. Before there was a long gap. The findings from this research identified key challenges and proposed solutions, some of which have been incorporated into legislation. Despite these advancements, it is evident that occupational health necessitates more dedicated attention.

Occupational health serves as a significant tool for employers, ensuring they have diligently considered all necessary measures to safeguard the health of their workforce. However, the limited number of active occupational health doctors, currently numbering at 64, and not many medical students interested in this field, defines the need for alternative strategies to uphold or enhance the quality of occupational health services. Implementing innovative solutions could be a solution to address these challenges.

Mandatory occupational health plays a crucial societal role by providing access to individuals who may not have visited a General Practitioner for a long period. It serves as a purpose to detect early signs of diseases, potentially linked to adverse working conditions or unhealthy lifestyle choices.

Given that occupational health examinations are obligatory for employers across all countries in the European Union and beyond, dismissing or eliminating them is not an

option. The objective of this work is to present a solution aimed at enhancing the quality of occupational health services without straining the resources of occupational health doctors.

5.5 Limitations

The sample group of both doctors and employees may be deemed somewhat biased due to the voluntary nature of participation. Those who chose to participate likely had a specific interest in the subject matter, introducing a potential bias. Moreover, the selection of companies was based on the author's accessibility, as not all companies may have been open to involving their employees in a student's Master Thesis.

The limited size of the sample group raises concerns about the comprehensiveness of the insights gained into the opinions of both employees and occupational health doctors.

From an ethical standpoint, there are considerations about the contact persons in the companies being acquaintances of the author, potentially creating a situation where employees might feel pressured to participate in the survey. Additionally, the pre-existing contact between the author and most occupational health doctors could introduce a level of constraint, potentially impacting the candid expression of their true thoughts and opinions. These ethical considerations should be acknowledged and addressed in the interpretation of the study's findings.

5.6 Future research

Similar study with several improvements and expansions should be considered:

1. **Increased Sample Size and Mandatory Participation:** Expanding the sample size and making participation mandatory could mitigate potential biases introduced by voluntary participation. This would yield a more representative and diverse set of opinions from both occupational health doctors and employees.

2. **Segmentation of Results:** Outline results between office workers and those in sectors like manufacturing, logistics, and construction would offer a more nuanced understanding of how different work environments may impact perceptions and attitudes towards occupational health and smartwatches.

3. **Clinical Trial with Medical Devices and Smartwatches:** Conducting a clinical trial comparing measurements obtained from medical devices in a clinical setting with those from a reliable smartwatch. This comparative analysis could provide valuable insights into the accuracy and feasibility of using smartwatches for health monitoring in specific work settings.

These enhancements would contribute to a more comprehensive and nuanced exploration of occupational health perceptions and the credibility of smartwatches used as pre-visit data.

6 Conclusion

The study aimed to investigate the potential impact of incorporating employee pre-visit monitoring through smartwatches into occupational health examinations. The author employed a semi-structured approach to interview occupational health doctors, to understand their perspectives on utilizing smartwatch data. Simultaneously, a web-based survey was conducted among employees across various companies to determine their willingness to share smartwatch data with occupational health professionals.

Key Findings:

1. Occupational health doctors acknowledged awareness of smartwatches used in clinical settings but expressed reservations about their accuracy for occupational health purposes.
2. The duration and scope of monitoring employees with smartwatches raised questions, necessitating further discussion.
3. Employees generally expressed satisfaction with occupational health services but showed openness to receiving additional feedback from doctors, demonstrating a willingness to share smartwatch data.
4. Some employees initially reluctant to share data indicated a reconsideration if the employer introduced incentives, either monetary or non-monetary.

In conclusion, as the adoption of smartwatches continues to rise, the field of occupational health is poised to encounter more challenges in the next decade. Therefore innovative approaches to health examination visits are inevitable to address emerging complexities and ensure the continued efficacy of occupational health services.

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Appendix 1 – Interview questions for occupational health doctors – Estonian

1. Kas Te peate ennast tehnoloogia osas teadlikuks inimeseks?
2. Kas Te monitoorite enda tervist mõne seadmega(nutikell/-sõrmus)? Kui jah, siis millist seadet Te kasutate?
3. Üldiselt rääkides, kas Te näete vajadust monitoorida töötaja tervisenäitajaid pikema aja jooksul?
4. Kas Te olete kuulnud meditsiinis erinevate nutikellade/-sõrmuste kasutamisest tervisenäitajate monitoorimise eesmärgil ?
5. Kas Te näete, et nutikellade/-sõrmuste kasutamine võiks Sinu töös kasuks tulla?
    a. Kui jah, siis milliseid näitajaid Te tahaksite sealt kaudu näha?
    b. Kui ei, siis miks?
6. Milline on Sinu hoiak enne töötervishoiu kontrolli määrata töötajale teatud perioodiks tervisenäitajate monitoorimine nutikella/-sõrmusega?
7. Kas mõni Teie patsientidest on tulnud sooviga saada tagasisidet oma nutikella/-sõrmuse andmete kohta? Või viidanud oma selle andmetest tulenevalt mõnele terviseprobleemile?
8. Kas Teie patsiendid on küsinud arvamust, kas ja milliseid seadmeid nad võiksid eelistada? Milline on Teie arvamus nendest seadmetest?
9. Kuidas Teie kujutaksite ette muutust oma töös, mida võiksid tuua kaasa nutikellade/-sõrmuste kasutamine töötervishoius eeldusel, et need muutuvad järjest täpsemaks?
10. Kas Te eelistaksite näha kasutusel rohkem nutikellasid/-sõrmuseid ja patsiente, kes enda andmetest tulenevalt näitavad üles soovi arsti külastada?
11. Kas Te näete, et nutikellade/-sõrmuste laiem kasutus töötervishoius võiks kaasa tuua ka mingeid kahjusid või negatiivseid mõjusid tulevikus? Kui jah, siis mis need oleks?

Appendix 2 – Original interview questions for GP's [18]

1. Would you say you are generally 'technologically savvy'?
2. Do you monitor your own health, if so, what devices do you use?
3. Do you see any advantages/disadvantages to using biometric feedback, generally?
4. Would you say as a health professional any advantages/disadvantages for you in your job by tracking biometrics?
5. Have you heard anything in your field about wearable computing devices being used?
6. If you think wearables could be useful, what kind of biometrics would you like to be see being used?
7. How do you feel about prescribing wearable devices to individuals?
8. Have any of your patients discussed devices they use, and asked you about the readings or outputs that they have gained?
9. Have they asked for any kind of advice regarding buying or wearing these devices? How do you feel about this?
10. How do you envision wearables impacting your job if they continue on the path they are projected to follow?
11. Would you like to see a future with more wearables and people being able to refer themselves to hospital or surgery using their own info from their wearables?
12. Could you see any potential disadvantages of wearable technology in the future? If so, what are these?
13. Do you think the NHS/ Government should be investing in this area?

Appendix 3 – Web-based questionnaire used to understand the perception of employees – Estonian

1. Ettevõte
2. Vanus
3. Sugu
4. Rahvus
5. Ametikoht
6. Kõrgem omandatud haridus
    1. Kõrgkaridus (ülikool, rakenduslik kõrgharidus)
    2. Keskharidus või kutseharidus
    3. Põhiharidus
7. Tööiseloom (kontoritöö, teenindus, tootmine/tehnik)
8. Kuidas sa hindad oma tervist?

Väga halb 1 2 3 4 5väga hea

9. Kas Sa ise oled kasutanud või kasutad praegu mõnda nutikella/-sõrmust, aktiivsusmonitori?

    1. Jah 2. Ei

10. Millist seadet sa kasutasid/kasutad? (too välja tüüp – nutikell, aktiivsusmonitr, nutisõrmus ja bränd)

    ..... *(vabatekst)*

11. Mis on peamine eesmärk, miks sa seda kasutad?

    1. Üldise füüsilise aktiivsuse jälgimine

    2. Tervisenäitajate nagu vererõhk, pulss, uni jälgimine

    3. Arst soovitas

    4. Ajaplaneerimine ja teavituste saamiseks

    5. Muu (täpsusta)

12. Kas sa kasutad nutikella/-sõrmust, aktiivsusmonitori pidevalt?

    1. Jah 2. Ei, mõned päevad jäävad vahele

13. Kui oluline on Sinu jaoks terviseandmete turvalisus ja privaatsus?

    Ei ole üldse oluline 1 2 3 4 5 On väga oluline

14. Kas sa oled käinud töötervishoiuarsti juures?

    1. Jah 2. Ei

Kui vastasid jah, siis palun vasta järgmistele küsimustele:

15. Visiidi pikkus oli piisav, et vajalikul määral tagasisidet saada oma tervisele

Visiidiks oli liiga vähe aega 1 2 3 4 5 visiidiks oli täpselt nii palju aega, kui oli vaja

16. Arst pööras Sulle piisavalt tähelepanu

Ei pööranud üldse mulle tähelepanu 1 2 3 4 5 arst oli väga põhjalik

17. Sain tervisekontrollist head tagasisidet ja soovitusi, kuidas oma tervist säilitada või parandada

See tagasiside ei andnud mulle midagi 1 2 3 4 5 Sain väga head tagasisidet

18. Kas sa oleksid valmis jagama oma nutikella/-sõrmuse, aktiivsusmonitori andmeid töötervishoiuarstiga eesmärgil saada sisulisemat tagasisidet oma tervisele?

    1. Jah 2. Ei

19. Kui vastasid Ei, siis millisel põhjusel sa ei jagaks?

1. Arvan, et need andmed ei ole piisavalt usaldusväärsed

2. Kardan, et need võivad sattuda kolmandate isikute, sh tööandja kätte

3. Kardan, et nende andmete tulemusena selgub, et ma ei saa jätkata oma tööd

4. Muu põhjus (Täpsusta)

20. Kas sa oleksid valmis oma andmeid siiski jagama, kui selle eest tööandja motiveeriks rahalise või mitte rahalise stiimuliga?

    1. Jah 2. Ei

Appendix 4 – Web-based questionnaire used to understand the perception of employees – Translated to English

1. Company name
2. Age
    1. 18 – 34
    2. 35 – 44
    3. 45 – 54
    4. 55 – 64
3. Sex
    1. Female
    2. Male
4. Education
    1. Higher education (university, college)
    2. Secondary education or vocational education
    3. Primary education
5. Mode of work
    1. Office work
    2. Servicing customers
    3. Manufacturing, technician (higher physical work load)
6. How do you evaluate your health?

    Very bad 1 2 3 4 5 very good
7. Have you been using or are you using currently a smartwatch?

    1. Yes 2.No
8. Which device your are using or have been using previously? (write the type – smartwatch, /-ring, activity monitor and the brand)

    ..... *(free text)*

9. What is the main aim of owning a smartwatch?

    1. *Information about general physical healthÜldise füüsilise aktiivsuse jälgimine*
    2. *Information about specific vital signs – heart rate, pulse, sleep*
    3. *Doctor recommended*
    4. *Time management and notifications*
    5. *Other (specify)*

10. Are wearing the smartwatch all the time?

    1. *Yes, I am wearing it all the time*
    2. *2. No, sometimes I forgot to wear it or make breaks*

11. How important is the data security for you?

    Not important at all 1 2 3 4 5 Very important

12. Have you been visiting occupational health doctor in the past 3 years?

    1. Yes 2. No

If you answered yes, then please answer the following questions:

1. Was the length of the visit long enough to get tangible feedback?

   Not enough time 1 2 3 4 5 Enough time

2. Did the doctor paid enough attention to you?

Did not paid attention at all 1 2 3 4 5 the doctor was very thorough

3. Did you get suggestions from the occupational health doctor how to improve your health?

The recommendations did not have value 1 2 3 4 5 I got very good suggestions

4. Are you willing to share the data of your smartwatch with the occupational health doctor to get more thorough feedback?

    1. Yes 2. No

If your answer was No, then why? Kui vastasid Ei, siis millisel põhjusel sa ei jagaks?

1. *I think the data is not reliable enough*
2. *I am afraid that it could get to third parties, including employer*
3. *I am afraid that as a result I might not be able to continue work anymore*

4. *Other reason (specify)*

5. Would you consider sharing your data if the employer would provide a monetary or non-monetary incentive?

    1. *Yes* 2. *No*

Appendix 5 – Original questionnaire used to understand the perception of employees using wearables [19]

Question	Answer Options	Question used in Master Thesis	Answer Options	
Consent Form	Yes, I agree to take part in this study; No, I do not agree to take part in this study.	N/A	N/A	
Company name				Was important for the author to identify the source of the answers.
Please indicate your age bracket.	Less than 25 years; 25-34 years; 35-44 years; 45-54 years; 55-64 years; Greater than 64 years	Please indicate your age bracket.	18 – 34; 35 – 44; 45 – 54; 55 – 64	The survey was conducted among employees, where the age starts at 18.
Please indicate your sex.	Male; Female	Please indicate your sex.	Male; Female	
Education		What is the highest education that you obtained?	Higher education (university, college); secondary education or vocational education; primary education	I wanted to understand weather education impacts the use of smartwatches
What is your approximate height?	[drop-down list to select feet and inches]	Omitted. Was not related to smartwatch utilization or occupational health visit.		
What is your approximate weight?	[drop-down list to select number in pounds]	Omitted. Was not related to smartwatch utilization or occupational health visit.		

Please indicate how long you have been employed with the company (If you have more than one job, please answer with the company where you work the highest number of hours per week).	Less than 1 year; 1-5 years; 6-10 years; More than 10 years	Omitted. Was not related to smartwatch utilization or occupational health visit.		
What is the task type you most often perform in your job?	Office or sedentary work; Service or standing work; Manufacturing or materials handling; Construction, utility, or field work; Other (please identify)	Adjusted with the question what is your mode of work?	Office work; work in manufacturing, warehous (includes higher physical work load); servicing customers	That will indicate the difference in the mode of work and using smartwatches.
What best describes your position within the company?	Front-line worker or individual contributor; Direct supervisor of front-line workers; Middle or executive management.	Omitted. Goes with the previous question.		
What are your 3 most common activities on this job?	[open response]	Omitted. Was not related to smartwatch utilization or occupational health visit.		
What is your job title?	[open response]	Omitted. Job title doesn't give an overview of the mode of work, which is important in occupational health.		
Are you a member of a worker's union?	Yes; No.	Omitted. Job title doesn't give an overview of the mode of work, which is important in occupational health.		
In order to be sure we are clear about what we mean about wearable technology, please select the items below that represent wearable technology.	Fitness bands that record the number of steps I take; A sensor strap worn around my chest that records my heart rate; Goggles without sensors that prevent sparks, dust, or fluids from getting in my eyes; A back brace with no sensors; A light beam that is mounted on a saw	Omitted. The definition was given in the introduction of the survey.		

	table to stop the saw blade if my hand crosses it.			
Have you used wearable technology for purposes NOT related to work nor sponsored by work before?	Yes; No.	Adjusted: Have you used a smartwatch/-ring before or are you using currently one?	Yes/No	Question is not related to the utilization of smartwatches and occupational health examination.
Please identify the type(s) of wearable device(s).	[open response]	Adjusted: Which device your are using or have been using previously? (write the type – smartwatch, /-ring, activity monitor and the brand)	Free text	
Its use was for (Please check all that apply):	Personal fitness or activity tracking; Health monitoring by healthcare professional; Scheduling or time management; General use of the internet; Other (please identify).	What is the main aim of owning a smartwatch?	6. Information about general physical healthÜldise füüsilise aktiivsuse jälgimine 7. Information about specific vital signs – heart rate, pulse, sleep 8. Doctor recommended 9. Time management and notifications 10. Other (specify)	
When you used wearable technology for purposes NOT related to work nor sponsored by work, how often did you use the technology?	Daily; Several times a week; A few times a week; Once a week or less	Adjusted: Do you have the device on your wrist all the time?	Yes, I am wearing it all the time; No, sometimes I forgot to wear it or have a break;	
Considering the device with which you have the most experience, what was the quality of your experience?	Very bad; Bad; Neutral; Good; Very good	Omitted. Was too specific.		

How concerned are you about data security and privacy?	Not concerned; Very little concern; Somewhat concerned; Very concerned	Adjusted: How important is the data security for you?	Not important at all 1-5 very important	
Have you used wearable technology for purposes related to or sponsored by work before?	Yes; No.			
Please identify the type(s) of wearable device(s)	[open response]			
It's intended purpose was for (Please check all that apply):	Monitoring productivity; Providing instructions about how to perform my work; Safety through monitoring my movement, activity, or physical state; Health promotion through fitness and activity monitoring; Unknown to me; Other (please identify).			
Did you receive any incentive or bonus for your use?	Yes; No.	Adjusted: Would you consider sharing your data if the employer would provide a monetary or non-monetary incentive?	Yes/No	The interest of this study is to find out if employees are willing to share their data.
What was the bonus or incentive?	[open response]			
Did the bonus or incentive affect your willingness to use the device?	Yes; No.			
My use of wearable technology in the workplace was:	Voluntary; Mandatory	N/A		

What was your experience?	Very bad; Bad; Neutral; Good; Very good	N/A		
How involved were you in choosing the wearable technology you used?	1-Not involved; 2; 3-Moderately involved; 4; 5-Extremely involved	N/A		
Was your supervisor or employer responsive to feedback about the wearable technology?	1-Not responsive; 2; 3-Moderately responsive; 4; 5-Completely responsive	N/A		
I was provided adequate information about how the data produced by the wearable technology would be used.	1-Strongly disagree; 2; 3-Neutral; 4; 5-Strongly agree	N/A		
I was provided adequate information about what would be measured by the wearable technology (such as movement, location, heart rate, etc.).	1-Strongly disagree; 2; 3-Neutral; 4; 5-Strongly agree	N/A		
I was provided adequate information about who would see the data collected from the wearable technology.	1-Strongly disagree; 2; 3-Neutral; 4; 5-Strongly agree	N/A		
Top management at this company: Tries to continually improve safety levels in each department.	1-Strongly disagree; 2; 3-Neutral; 4; 5-Strongly agree	N/A		
Top management at this company: Requires each manager to help improve safety in his or her department.	1-Strongly disagree; 2; 3-Neutral; 4; 5-Strongly agree	N/A		

Top management at this company: Uses any available information to improve existing safety rules.	1-Strongly disagree; 2; 3-Neutral; 4; 5-Strongly agree	N/A		
Top management at this company: Provides workers with a lot of information on safety issues.	1-Strongly disagree; 2; 3-Neutral; 4; 5-Strongly agree	N/A		
My direct supervisor: Discusses how to improve safety with us.	1-Strongly disagree; 2; 3-Neutral; 4; 5-Strongly agree	N/A		
My direct supervisor: Uses explanations (not just compliance) to get us to act safely.	1-Strongly disagree; 2; 3-Neutral; 4; 5-Strongly agree	N/A		
My direct supervisor: Reminds workers who need reminders to work safely.	1-Strongly disagree; 2; 3-Neutral; 4; 5-Strongly agree	N/A		
My direct supervisor: Makes sure we follow all the safety rules (not just the most important ones).	1-Strongly disagree; 2; 3-Neutral; 4; 5-Strongly agree	N/A		
I would voluntarily use wearable technology that tracks my activity or physical status while at work BUT NOT outside of the workplace: To monitor and improve safety from injury.	1-Strongly disagree; 2; 3-Neutral; 4; 5-Strongly agree	N/A		
I would voluntarily use wearable technology that	1-Strongly disagree; 2; 3-Neutral; 4; 5-Strongly agree	N/A		

tracks my activity or physical status while at work BUT NOT outside of the workplace: To monitor and improve workplace productivity.				
I would voluntarily use wearable technology that tracks my activity or physical status while at work AND outside of the workplace: To monitor and improve safety from injury.	1-Strongly disagree; 2; 3-Neutral; 4; 5-Strongly agree	N/A		
I would voluntarily use wearable technology that tracks my activity or physical status while at work AND outside of the workplace: To monitor and improve workplace productivity.	1-Strongly disagree; 2; 3-Neutral; 4; 5-Strongly agree	N/A		
I would voluntarily use wearable technology that tracks my activity or physical status while at work AND outside of the workplace: To monitor and improve my health or fitness.	1-Strongly disagree; 2; 3-Neutral; 4; 5-Strongly agree	N/A		
I would voluntarily use wearable technology that identifies injury or health hazards in my work environment in order to	1-Strongly disagree; 2; 3-Neutral; 4; 5-Strongly agree	N/A		

keep me and others safe at work.				
I would voluntarily use wearable technology that provides online information about work processes to help me know what to do next and how to do it.	1-Strongly disagree; 2; 3-Neutral; 4; 5-Strongly agree	N/A		
Of the following uses for wearable technology in the workplace, choose the one you are MOST willing to use:	[forced choice response of the 7 use cases above]	N/A		
How much money would you need to receive as an incentive or bonus in order to be willing to use the wearable technology that you identified above as being MOST willing to use?	[open response]	N/A		
Of the following uses for wearable technology in the workplace, choose the one you are LEAST willing to use:	[forced choice response of the 7 use cases above]	N/A		
How much money would you need to receive as an incentive or bonus in order to be willing to use the wearable technology that you identified above as being LEAST willing to use?	[open response]	N/A		

Among my peers, I am usually the first to try out new technologies.	1-Strongly disagree; 2; 3-Neutral; 4; 5-Strongly agree	N/A		
I am confident that the use of wearables would improve my safety in the workplace.	1-Strongly disagree; 2; 3-Neutral; 4; 5-Strongly agree	N/A		
I am confident that the use of wearables would improve my productivity in the workplace.	1-Strongly disagree; 2; 3-Neutral; 4; 5-Strongly agree	N/A		
I am confident that the use of wearables would improve my health to enhance my effectiveness in the workplace.	1-Strongly disagree; 2; 3-Neutral; 4; 5-Strongly agree			
I am concerned that information from wearable technology in the workplace might be used to reprimand me, fire me, or otherwise be used against me by my employer, supervisor, or co-workers.	Not concerned; Very little concern; Somewhat concerned; Very concerned	N/A		
I am concerned that my employer might gain access to private or sensitive information about me through wearable technology in the workplace.	Not concerned; Very little concern; Somewhat concerned; Very concerned	N/A		
I am concerned that my data recorded from wearable technology is not	Not concerned; Very little concern; Somewhat concerned; Very concerned	N/A		

secure and could be accessed by people without permission.				
Of the following concerns, choose the one that MOST concerns you about using wearable technology in the workplace:	Information might be used against me by my employer, supervisor, or co-workers; My employer might have access to private or sensitive information about me; Someone who was not intended to see my data might get access to my data; Device might decrease my productivity; Device might introduce new safety hazards; Other (please identify).	Adjusted: Are you willing to share the data of your smartwatch with the occupational health doctor to get more thorough feedback? And if No, then why?	6. *I think the data is not reliable enough* 7. *I am afraid that it could get to third parties, including employer* 8. *I am afraid that as a result I might not be able to continue work anymore* 9. *Other reason (specify)*	The aim of the study was to understand if the employees are willing to share their data and id´f not then what are the reasons.
Of the following concerns, choose the one that LEAST concerns you about using wearable technology in the workplace:	Information might be used against me by my employer, supervisor, or co-workers; My employer might have access to private or sensitive information about me; Someone who was not intended to see my data might get access to my data; Device might decrease my productivity; Device might introduce new safety hazards; Other (please identify).			Omitted. Because it would serve the purpose of the work.
What is the HIGHEST level of school you have completed or the highest degree you have received?	Up to 8th grade; 9-12 but no graduation; completed high school or GED; some college, associate degree, or vocational certificate; Bachelor's degree; Graduate degree	Education	Higher education (university, college); Secondary education or vocational education; Primary education	Used education levels that are common in Estonia
What is your best estimate of the total annual income of ALL family members living with you?	0-34,999; 35,000-54,999; 55,000-74,999; 75,000-99,999; 100,000 or more	N/A		

What is your race? (select all that apply)	White; Black or African American; Asian; Native Hawaiian or Other Pacific Islander; American Indian or Alaska Native; Other (please identify)	N/A		
What is your ethnicity?	Hispanic or Latino; Not Hispanic or Latino	N/A		
I will NOT be injured on the job within the next 12 months.	1-Not confident at all: I will be injured; 2; 3-Neutral; 4; 5-Completely confident: I will not be injured	N/A		
I will NOT be terminated from my current employment within the next 12 months for any reason.	1-Not confident at all; 2; 3-Neutral; 4; 5-Completely confident I will NOT be terminated	N/A		
How confident are you that you can meet your employer's expectations for your job?	1-Not confident at all; 2; 3-Neutral; 4; 5-Completely confident	N/A		
Do you believe you are a productive employee?	Yes; No.	N/A		

Appendix 6 – Occupational health examination decision

Conclusion of medical checkup

Name:
ID code:
Address:
Employer:
Occupation:

Conclusion about workers suitability to working enviroment and working order:

Worker with computer:

Needs/<u>does not need glasses/lenses.</u>

Recommendation of changing working environment or working order:

Next checkup time:

Doctor's name:
Doctor's code :
Phone nr:
E-mail:

Doctor's signature ..... Date:

Employee's signature..... Date:

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