

The Medical Use of Smartwatches

A Tertiary Study Comparing Northern and Southern European Nursing homes

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The European elderly population is increasing at a rapid rate. With the aging population, a shifted lifestyle and several healthcare needs follow due to non-communicable diseases, which could become both labour-intensive and expensive. However, with the advancement of technology in recent years, a new area of preventative monitoring has been developed, using wearables such as smartwatches within the healthcare field. The objectives of this study are threefold. First, investigate the average use of smartwatches within healthcare, and to which degree it is being used on patients. Second, to explore the differences between the medical use of smartwatches in nursing homes between northern and southern Europe. Third, measure the growth of the use of smartwatches within nursing homes. To do so, a systematic literature review was performed, covering the period from 2010 to 2021. Although, a total of 712 studies were retrieved, 16 were included in this review. The results show an overall positive assessment of the use of smartwatches within nursing homes, both in northern and southern Europe. However, there is a difference in use, based on the assessed needs, such as the difference between climates. The use of smartwatches within nursing homes has great potential, both within northern and southern Europe. Although the user's privacy and security are hardly discussed, both need to be a bigger concern.

CCS CONCEPTS • Human-centered computing~Accessibility~Accessibility technologies • Social and professional topics~User characteristics~Age~Seniors

Additional Keywords and Phrases: Systematic Review, Nursing Home, Smartwatch, Elders, Wearables

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1 INTRODUCTION

In 2020, it was estimated that 151.7 million, or 20.3% of the European population were 65 years of age or older, with an expected growth of 8.08% within 2050 [10]. With the current growth of the elderly population, a

shifted lifestyle and several healthcare needs follow, due to non-communicable diseases, such as cognitive decline, respiratory diseases, and cardiac diseases [25]. In recent years a new area of preventative monitoring has been developed rapidly in fields such as healthcare, using wearables such as smartwatches. Those wearable devices can be defined as a mobile electronic device that has adopted the technologies of sophisticated biosensors and wireless data communication, which allows for both the access and the transmission of data [18]. In healthcare, smartwatches can be used to perceive, record, and analyze to maintain the user's health, and can even help with physiological and pathological information for self-monitoring with real-time, accurate detection [17]. However, even with the unobtrusive nature of smartwatches, elders might feel that their newfound independence is at the cost of constant surveillance or the loss of any privacy within their homes [24]. Therefore, it will be important to secure the elders' privacy, especially with the location-based tracking of a smartwatch, as well as for sensitive information such as average and recorded bpm [9].

There are currently no systematic reviews on the subject conducted in Europe. However, there are one systematic review on assessment of smartwatches for management of non-communicable diseases in the ageing population [12] and other SLR on IoT Wearable Sensors and Devices in Elderly Care [25]. Both reviews reveal a lack of clinical trials, which would strengthen the results of the experimental studies. Therefore, the purpose of this review is to evaluate the difference in the medical use of smartwatches within nursing homes between Northern and Southern Europe. With the prediction of wearable devices playing a greater role in health care [17], a systematic review is deemed to be necessary to assess the needs of the aging population, and the possibility of self-monitoring for the betterment and wellbeing of the community.

2 METHOD

This study has been undertaken as a systematic literature review (SLR) [15], where the goal is to assess literature regarding European countries within the realm of the medical use of smartwatches in nursing homes. The identification of relevant papers was conducted as follows:

1. Research questions were formulated based on information found in the Australian systematic review regarding the use of smartwatches within nursing homes;
2. Relevant keywords associated with the research questions were identified;
3. The inclusion and exclusion criteria were developed;
4. Studies were chosen based on purposive sampling: a) All titles and abstracts were checked for relevance before either including or excluding the study; b) Of the previously selected studies, the conclusion was read before including or excluding the study; c) Of the previously selected studies, the full-text reading was done before including or excluding the study; and d) Studies that passed through after the full read of the text were included into the review.

2.1 Research Questions

The research questions addressed by this study are:

RQ1: Is there a reported difference in the number of clinical trials on the medical use of smartwatches between northern and southern Europe?

RQ2: Is there a reported difference between northern and southern Europe in the use of smartwatches for medical use in nursing homes?

RQ3: Is there a reported difference between the benefits in the use of smartwatches in nursing homes between northern and southern Europe?

RQ4: What are the limitations of the current research on the subject in both northern and southern Europe? Concerning the limitations, four questions were considered: Were there limited or no clinical studies on the medical use of smartwatches in nursing homes?, Were there any longitudinal studies conducted on the medical use of smartwatches in nursing homes?, Is the privacy and security of participants considered?, and Is there a reported difference in the quality of studies conducted before and after 2015?

2.2 Inclusion and Exclusion Criteria

The literature on the following topics was included: (i) Studies and trials conducted on the population of Norway, Sweden, Denmark, and Finland will be added to represent Northern Europe; (ii) Studies and trials conducted on the population of Italy, France, Portugal, Greece, and Spain will be added to represent Southern Europe; (iii) Papers discussing the use of smartwatches within home nursing, nursing homes, and eldercare were included; and (iv) Papers discussing smartwatches in the use within the aforementioned areas, supporting and affecting both residents and nurses were included.

2.3 Search Terms and Search Strategy

Several keywords were selected based on the research questions. The Boolean search string was structured as follows:

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("Smartwatch" OR "smart watch") AND ("nursing homes" OR "nursing home" OR "home nursing")  
AND ("Norway" OR "Sweden" OR "Denmark" OR "Finland" OR "Portugal" OR "France" OR "Spain" OR  
"Italy" OR "Greece")
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The search process was a manual search of five academic databases (IEEE, ACM, Springer, Wiley, and ScienceDirect), Google Scholar, and Semantic Scholar. The chosen databases are known to be well-reputed and contain plenty of studies on both technology and the advancement within healthcare.

2.4 Quality Assessment

Each publication was evaluated using the following six quality assessment questions [15]: Q1. Is a focused research question or hypothesis stated?; Q2. Is the literature search or background likely to have covered all relevant studies?; Q3. Were the study methods adequately described?; Q4. Were the privacy of the users considered?; Q5. Were the results of the study adequately described?; and Q6. Is the conclusion supported by the data presented?

To score the studies, they were given points per question, compared to how well they were answered. A maximum of 6 points can be given per study. The scoring procedure works as follows: Y (yes) = 1, P (partly) = 0.5, N (no) = 0.

2.5 Data Collection and Data Analysis

The data extracted from each study were: the source (journal or conference), full reference, classification of the study type, author information (name and location), summary of the study, the research question or hypothesis, methods within the study, to which degree a smartwatch is used within the study and finally, the quality of the study was compared against the quality criteria. The data was tabulated to show: the number of

studies conducted in both northern and southern Europe, the conducted study types, author names and affiliation, the average use of smartwatches, the difference in quality in each study and the number of studies published between 2010-2021.

2.6 The Use of a Smartwatch

The average use of smartwatches was calculated to identify the difference in use between northern and southern Europe, as well as the difference between studies published between 2010-2015 and 2016-2021. The use of smartwatches within the studies was scored using a three-points scale: 1) the bare minimum use of a smartwatch and the smartwatch is not the main technology; 2) the use of the smartwatch but it is not the main technology or medical instrument used; and 3) the high use of a smartwatch and the smartwatch is the main technology or medical instrument used.

3 RESULTS

3.1 Search results

During the search process, 712 papers were screened for relevance using the process described in Section 2. Out of the 712 papers, 16 were included in this review. Of these studies, 7 were conducted within Northern Europe [1, 2, 4, 13, 14, 16, 19], and 9 were conducted in Southern Europe [3, 5-8, 20-23]. Most of the included studies are classified as experimental studies. The average smartwatch use amongst the studies was 2.4 out of a maximum of 3, and the median is 2.4.

3.2 Quality Assessment Results

The quality of the studies was assessed by using the guidelines proposed by Kitchenham et al. [15] (see Section 2.4). The average score for the included papers was 4.5 out of 6, where 4 of the selected studies [1, 8, 20, 21] had a score lower than the average.

3.3 The Differences Within Europe

Northern Europe has the highest quality score, averaging 5, whereas southern Europe averages a 4.2. The same is seen within the average use of smartwatches within the study, where northern Europe has an average of 2.9 whereas southern Europe has an average of 2.3. The difference in average quality is due to two papers within southern Europe. Mincoelli et al. [21] has an average quality score of 2 due to the lack of defined research questions, background, and lack of perspective on the user's privacy and security while Casilari et al [5] has a smartwatch use score of 1, due to smartwatches barely being included within the study.

3.4 The Evolution of Technology

The quality, number of studies, and the average use of smartwatches were compared against the year of publication. Most studies (12) within this SLR were published between 2016-2021. Studies published after 2015 seem to have the highest average quality score, which is 4.6, and the average quality score for studies published between 2010-2015 was 4.25. For the average use of smartwatches, studies published between 2016-2021 have the highest average score, 2.5, whereas studies published between 2010-2015 averages 2.25.

4 DISCUSSION

4.1 The Lack of Clinical Studies Within Europe (RQ1)

There are no clinical trials on the medical use of smartwatches conducted within the selected studies from northern and southern Europe. Therefore, there is no recorded difference. Other continents on the other hand, such as North America could have conducted relevant clinical trials. Therefore, conducting a second SLR based on studies from Canada, China or the United States could be of interest, to fully explore the medical use of smartwatches within nursing homes, and compare towards the results of this SLR.

4.2 The Difference in Use Between Northern and Southern Europe (RQ2)

Within the reviewed literature [1-8, 13, 14, 16, 19-23], a difference between northern and southern Europe is found. Northern Europe has three studies which are published in 2015, while southern Europe only has one. This could portray a difference in access to funds for such medical devices in southern Europe, or the difference in assessed need. Northern Europe has the highest overall quality for the published studies and the highest overall usage of a smartwatch within the selected studies. Southern Europe has the greatest number of studies, which could explain the difference in quality and average use of smartwatches, however, the difference in the number of studies is not big enough to be considered a contributing factor.

One can see that the selected studies within northern Europe mostly investigate the elder's use of smartwatches, how well such technology is received within the patients and caretakers, as well as how they can help assist with fall detection, checking for possible heart problems, e.g., heart attacks, as well as its use within dementia care. Whereas in southern Europe, the use of a smartwatch is navigated towards ambient assisted living for the reminders of trivial tasks, activity recognition, temperature, and air quality within the home, as well as a look into how elders use smartwatches. It reveals the different needs between both European regions due to their different climates. In northern Europe, with a cold climate, having a proper fall detection tool in place is a necessity. Whereas in the warm climate of southern Europe, the focus is on the proper temperature, airflow, and quality, as well as surveillance, as to accurately assess the needs of the patients in case of a heat stroke, or them falling unconscious due to the heat. The difference in the average use of smartwatches is then explained, due to the difference being the different assessed needs between northern and southern Europe.

4.3 The Reported Benefits in the Use of Smartwatches (RQ3)

There is not a reported difference in the benefits of using a smartwatch as a medical device within nursing homes. Northern European-based literature, such as Kutsarovas [15] study on the use of a crowdsensing system within smartwatches, shows the great potential of such technology within eldercare. For instance, giving access to plenty of relevant data for behaviour recognition, which can be used within the fall-risk assessment. Moreover, Boletsis et al. [4] conclude that collected data from smartwatches can help dementia patients stay in their homes longer. Similar results are seen within southern Europe, for instance, Marques et al. [19] study on ambient assisted living technologies.

4.4 Assessing the Limitations of Current Research (RQ4)

4.4.1 *The Limited Amount of Clinical Studies.*

A concern for the study was the lack of clinical trials, as seen in the SLR conducted by Gordon [12]. In our SLR [1-8, 13, 14, 16, 19-23], no clinical studies on the use of smartwatches within nursing homes or elder care were found. As mentioned in section 4.1, the clinical trials are the primary way to evaluate the effects and benefits of new medical devices.

4.4.2 *The Use of Longitudinal Studies.*

A concern for the SLR was the lack of longitudinal studies to show the long-term effects of the use of smartwatches within nursing homes and eldercare. By reviewing the literature [1-8, 13, 14, 16, 19-23], only two longitudinal studies were identified. Haescher et al. [13] show the use of a novel mobile-assisted smartwatch for fall risk assessment within either home care or other nursing environments. They evaluated 30 elderly participants over four weeks. The results show that the fall-risk recognition was tuned up to a level of recognition that lies between 80% - 94% based on the tracked information. Similar results for a fall risk assessment were presented in Casilari-Pérez and García-Lagos [6] study on the use of artificial neural networks (ANN) in wearable fall detection systems. However, most groups of volunteers in the employed testbeds were exclusively composed of young adults. The second longitudinal study was conducted by Rosales et al. [23]. It shows how elders react, interact, and use smartwatches in the first stages of getting used to the new technology, for two months. The results shows that elders have an intrinsic interest in the use of such technology for both keeping up with new technology, as well as for personal use within their health.

4.4.3 *The Discussion of Privacy and Security for Users.*

The lack of security and privacy was a prominent concern due to the constant recording of data and location tracking that comes with the use of a smartwatch. The average score for the discussion of user privacy was 0.35. Of the 16 included studies, 5 properly discusses the privacy measures considered for their study, or the importance of privacy, while 2 somewhat mention users' privacy. Moreover, 6 of the studies that discuss user's privacy were published between 2016-2021, whilst only one was published in 2015. This reveals the increased use and importance of privacy and security within IoT technologies, where privacy no longer will be an afterthought or added in after further research, as seen in [13, 20, 21, 23]. When set against Crabtree et al. [9], where it is suggested that within the domestic home, "privacy" within digital platforms and technology is mostly disturbed by the idea or experience of an unauthorized user gaining access to the recorded data.

Even with a low average score within the discussion of privacy, some studies have a proper discussion on the safety and security of fall detectors as well as the user's privacy, both within the recording and the storing of data. In fact, the ethical issues associated with the use of fall detectors were classified under four principles by a previous study [11]: autonomy, privacy, benefit, and use of resources. As to not violate the elderly's privacy, the sensors within fall detection models should have an as little invasion as possible, while the logged information should be transmitted securely [14]. For example, Concone et al. [7] shows that the transmission of user data is secured between patients and caretakers by using encryption and authentication techniques to guarantee both data integrity and user's privacy. Moreover, Bansell [2] explores how a smartwatch can complement a mobile app in the context of healthcare and provide usability for the target group caregivers.

4.4.4 *The Difference in Quality.*

By reviewing the literature [1-8, 13, 14, 16, 19-23], the difference in quality between the studies published before and after 2015 is somewhat noticeable. As seen in Section 3.3, studies published before 2015 average a quality score of 4.3, whereas articles published after 2015 average a score of 4.6, where the total average score for all articles is 4.5. The reported difference between studies published before and after 2015 is not as noticeable as first assumed, were the reason for adding the difference in quality as a limitation was the initial thought of a huge, reported gap in quality. However, compared to studies published after 2015, studies published before 2015 are reported to be less likely to include the discussion or mention of user's security and privacy within the application of storing data. The use of smartwatches averages a score of 2.43. Studies published before 2015 average a score of 2.25, whereas studies published after 2015 average a score of 2.5. Only one study [5] published in 2015 scores 1, which explains the difference in score. However, the difference in quality between the studies published before and after 2015 is not wide enough to be considered a reported difference.

5 CONCLUSION

This paper presents results of our SLR on the use of smartwatches in northern and southern Europe, intending to assess the difference in quality in publications and the use of smartwatches. The assessed quality and use of a smartwatch within the medical field based on publication year was also assessed, to properly see the difference in quality and use between 2010-2015 and 2016-2021. An average quality score of 4.5 out of 6 was found for the 16 studies included in this review. The lowest quality score was found for southern Europe (4.2, northern Europe scores 5). Between northern and southern Europe, different assessed needs are shown, which explains the difference in their use of smartwatches. However, there is a gap within the average quality of the studies, which could be explained by the amount of early research on the subject in northern Europe. For the use of smartwatches within the medical field, the difference in quality mostly comes out to the lack of privacy and user security discussion within the studies published before 2015. For future work, it would be interesting to perform a multivocal literature review with the addition of other countries, as our review presents few results, which could skew the outcome. By gathering more studies, clinical studies might be added to the study to strengthen the results. It would also be interesting to compare the use of a smartwatch with other means of wearable devices within the healthcare industry to accurately assess the effectiveness of the smartwatch.

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