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Welfare Technology, Healthcare, and Behaviour Modelling- An Analysis

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Abstract. Welfare technology is a growing area of research due to the increase in the ageing population. In Nordic countries, public authorities are the primary healthcare providers. Therefore, there is significant of investment to help older people to live as long as they wish at their own home. At the University of South-Eastern Norway, a current project on welfare technology is being developed for this purpose, with a focus on human behaviour modelling. Through the research, gaps were found between the technology and the healthcare aspect of it. Consequently, difficulties for the consumer (the older people) arise. This article presents an analysis of connection and gaps between technology and the healthcare area of welfare technology for the ageing.

Keywords. ambient assisted living, smart house, ageing in place, intelligent environment, Norway, assistive technology

1. Introduction

Welfare technology for older people has dramatically grown in the Nordic countries [1]. The reason for this interest is due to the increase in the ageing population, not only in Nordic countries but also in European Union (EU) member states, European Free Trade Association countries (EFTA: Iceland, Liechtenstein,Norway, and Switzerland), and candidate countries (Albania, the former Yugoslav Republic of Macedonia, Montenegro, Serbia and Turkey) [2].

In Norway, as of 2019, life expectancy increased for both men and women. In addition, 38% (one in five persons) of households are composed of people living alone. By 2060, 20% of the Norwegian population will be 70 and older compared to the current 11% [3]. Fig 1 shows the population projection for Norway. Similarly, in the EU, those aged 80 and over will almost double from 5.5 % to 12.7 % between 2017 and 2080 [2]. Figure 2 shows the population projection for the European Union.

A common approach to help older people to stay at home for as long as possible is smart houses, sometimes referred to as ambient assisting living. The general aim is to assist the older person in case of need, while other studies focus mainly on fall detection [4–7].

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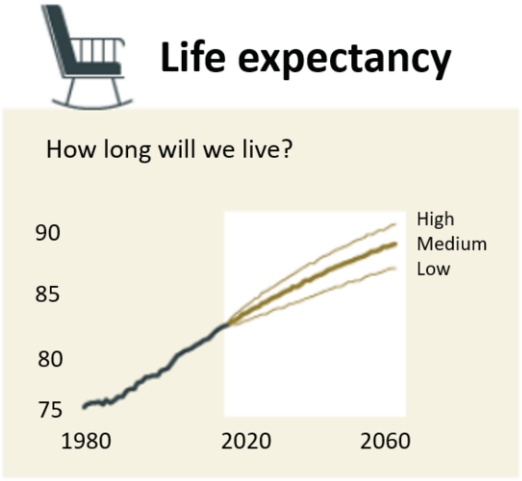

Figure 1. Norway population projections [3]

At the University of South-Eastern Norway (USN), a current project on welfare technology is being developed to help the older people to remain at home for as long as they wish [8,9]. The main focus of the research is on human behaviour modelling (HBM) to ensure the older person lives in safe and dignified conditions. The HBM's goal is to detect anomalies on the person's behaviour pattern and assist if needed.

As part of the same project at USN, the healthcare aspects and older people's perception of welfare technology are also being researched [10]. The contribution between the two areas - technical and healthcare - has shown that regardless of the amount of research in welfare technology for older people, breaches are still found. There are limited studies addressing this topic [11]. Therefore, this article presents an analysis of the gaps between the technology and healthcare aspects when implementing welfare technology for the ageing.

This study's main contribution is towards helping future researchers to connect and consider both sides - the technology and healthcare - when developing welfare technology for older people.

1.1. Aim

The study aim is to discuss the connections and gaps between the technology and healthcare fields when developing welfare technology for older people.

The remainder of this article is presented as follows: Section two introduces the background and reviews the related work. Section three describes the methodology. Section four defines the terminology generally used in welfare technology for the ageing. Section five presents the analysis results. Section six provides recommendations. Finally, the conclusions are given in section seven.

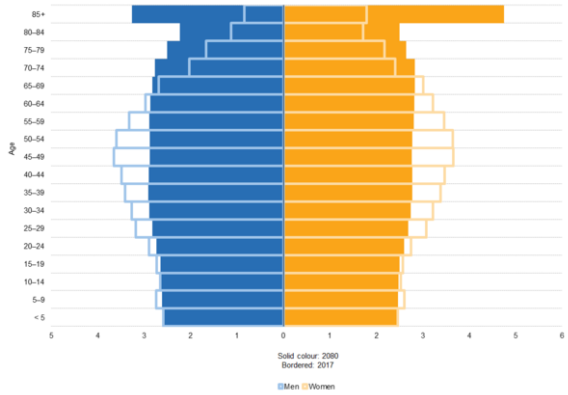

Figure 2. Population pyramid EU-28, 2017 and 2080 (% of the total population) [12]

2. Background

Several studies have been conducted in the area of smart house environments with various reviews in this field available [4, 7]. In the field of healthcare involving smart houses, several research have been made to study older people's perception of smart houses [13–15].

Most of the research in smart houses from the technological aspects deals with improvement, new technology implementation, and activity detection to adapt the smart house to the user. Among the relevant works is the Managing an Intelligent Versatile Home (MavHome), whose goal is to increase the comfort of the users and reduce the operation costs [16]. The "GatorTech" smart house implements several smart devices to "optimize the comfort and safety of an older person" [17].

User activity detection has widely been researched, and several analysis methods have been used [4]. In summary, the analysis methods range from pattern recognition algorithms and computer vision [18],machine learning [19, 20], statistical models [21, 22], among others. However, only a few studies have been conducted in behaviour modelling [9, 23–26].

The studies that have been done in the healthcare area usually report about the ethical concerns on smart houses or older people's opinion about smart houses [15, 27]. There are, however, gaps between the technology and the healthcare research regarding welfare technology. As a result, the end-user (the older person) is ultimately the one who is affected because of these gaps.

3. Design and Methods

An analysis was chosen in this study to report the findings. Initial comparison in the terminology used between the technology and healthcare fields are discussed. Secondly, an analysis of the terminology, healthcare with a focus on the person, ethical and legal challenges, and older people's struggle with technology are discussed. Finally, some recommendations are provided to diminish the gap between the two fields.

4. Terminology

There is a lack of standard definitions for the terms used in smart house welfare technology for the ageing. In most research, the terms ambient assisted living (AAL), smart houses, home automation, welfare technology, ambient intelligence, and others have been used interchangeably.

However, in the area of healthcare, the definition of terms is essential for them. A possible reason could be the use of the MeSH (Medical Subject Headings) terms. As defined in [28], "MeSH is the National Library of Medicine's controlled vocabulary thesaurus, used for indexing articles for the MEDLINE/PubMED database", which means that most article citation is related to a specific set of MeSH terms. The purpose of the MeSH terms is to focus on relevant citations when doing a search of literature. In contrast, keywords search does not narrow down the most relevant citations in a search.

The term's definition is the first difference between technology and the healthcare field. Thus, while healthcare research generally focuses its work with MeSH term, those working in technology use typically keywords.

In this section, the most common terms are defined to provide a guide on the meaning of the following concepts: welfare technology, AAL, smart house, activity recognition, and behaviour modelling.

4.1. Welfare Technology

In Nordic countries, the term welfare technology is commonly referred to as the type of technology used to control the environment, safety, and general well-being of the older or disabled people [29]. The goal is to provide the older person with the option to live as long as possible in their own home. As mentioned in the introduction, the Nordic countries face demographic challenges with the growing older population. Thus, welfare technology seems the optimal solution to this challenge.

The term "welfare technology", as it is, cannot be found in MeSH. Rather, the term "welfare" comprises child, animal, social, and maternal. Therefore, although welfare technology has widely been used in the technology field, healthcare science has not yet introduced proper definition through MeSH for it.

4.2. Ambient Assisted Living

As defined by Rashidi, "Assisted living technologies based on ambient intelligence are called ambient-assisted living (AAL) tools" [30]. This term yet implies defining ambient intelligence, which refers to digital environments that are sensitive, adaptive, and responsive to human needs [31].

AAL is thus regarded as an umbrella term for most welfare technology used to help older people. Ranging from pill reminders [32], improving safety in general, fall detection systems, house automation, monitoring such as video surveillance, and activities of daily life (ADL) recognition.

Although AAL does not appear in MeSH, two other terms are found. The first, "assisted living facilities" is defined as "a housing and healthcare alternative combining independence with personal care. It provides a combination of housing, personalized supportive services and healthcare designed to meet the needs, both scheduled and unscheduled, of those who need help with activities of daily living".

The second term, "independent living" is defined as "a housing and community arrangement that maximizes independence and self-determination". Both terms were introduced in 2003 and 2010 respectively.

It is worth noting that the terms: living independent, community dwelling, and ageing in place, are also used in healthcare as synonyms for independent living.

4.3. Smart House

According to a review on smart houses welfare technology, "Smart house commonly refers to any living or working environment carefully designed to assist residents in carrying out daily activities and to promote independent lifestyles" [7,10]. The general goal is to adapt the house to the occupant's preferences.

When searching in MeSH , there are two terms found. The first term is from 1992, "housing for the elderly", defined as "housing arrangements for the elderly or aged, intended to foster independent living. The housing may take the form of group homes or small apartments. The concept includes housing for the elderly with some physical limitations".

The second term is from 1968, "homes for the aged", defined as "geriatric long-term care facilities which provide supervision and assistance in activities of daily living with medical and nursing services when required".

Synonyms found in the healthcare sciences for housing for the elderly are: retirement life care centers, continuing care retirement centers. In the same way, the synonym for homes for the aged is old age homes.

4.4. Activity Recognition

Activity recognition has been implemented for several decades [4]. People usually tend to follow a pattern in their daily life [33,34]. Hence, recognizing the pattern of the person helps to adapt a smart house to the inhabitant.

Commonly, the actions recognized are activities of dalily life (ADL), such as sleeping, toileting, showering, dressing, eating, etc. These are actions that require "basic skills and focus on activities to take care of one's own body" [35]. By finding repetitive patterns on the person's activity, it is possible to predict the next activity of the person for assistance if needed [5].

4.5. Behaviour Modelling

There is a few studies on behaviour modeling as described in section 2. Yet, the term behaviour has not been fully defined as the previous terms presented in this section. At USN, behaviour is defined as the activity, duration, posture, and location of the person. E.g., having breakfast. Thus, a behaviour is an activity with duration [8,9].

HBM helps to predict the next behaviour of the person and thus adapt better the smart home to its resident as well as construct a safer environment. In addition, modelling the behaviour of the person allows detecting any anomaly on the person's daily pattern. "Anomaly detection refers to the problem of finding patterns in data that do not conform to expected behaviour" [36]. Detecting anomalies can help alert family members or caretakers in case of dangerous situations such as falls.

The terms "activity recognition" and "behaviour modelling" are not found in MeSH, as expected. Probably because both terms are not of relevant use in healthcare science. Table 1 shows terms defined in this section and compared to the MeSH terms.

Table 1. Terminologies used in the technology field compared to the MeSH terms

Technical term	MesH term
Welfare technology	not found
AAL	assisted living facilities, independent living
Smart house	housing for the elderly, homes for the aged
Activity recognition	not found
Behaviour modelling	not found

5. Analysis

Studies show that older people would benefit from smart house welfare technology in the areas of health, safety and security, peace of mind (for the family), independence, mobility, and social contact [37]. Therefore, developing smart houses is important for older people.

The works related to welfare technology for the ageing usually refer to either the technical part or the healthcare part of it. It is not easy to find studies were both areas are deeply integrated.

5.1. On the Terminology Used

Section 4 defines the terms used in the technical field and compares them to the terms used in healthcare. The terms that were found in both areas fit mostly the same meaning and are used similarly. However, it is possible to notice that healthcare science emphasizes a proper definition, unlike the technology field.

Typically, most technology researchers do not accentuate the need for a single definition for the terms they use. Thus, when doing a state-of-the-art search, a significant number of keywords with synonyms need to be used. As a result, important research in the field can be left out if the correct keyword is not used. Healthcare science reduces the stress of finding keywords and synonyms by using MeSH terms.

It is worth noting that the technology field needs to find new terms if there is not any term currently available. However, welfare technology has been around for the past decades, and thus moving towards a definition of the terminology should be on the mind of the technology researchers.

5.2. On the Healthcare Focus on the Person

Welfare technology aims to help the user, which presents another difference from healthcare research that centres on the person. At USN, the healthcare research program focuses on "person-centred values and principles like respect, autonomy, participation, jus-

tice, dignity, trust and patient safety and rights" [38]. Respecting the individual is one of the main principle of person-centred research [39]. Therefore, the term "user" should be avoided when referring to the older person in the welfare technology context.

Person centred means "putting the person in the centre (not in the middle) as a necessary condition for proper care and good and efficient healthcare services" [40] and " standard of care that ensures the patient/client is at the centre of care delivery" [41].

Taking these concepts into consideration, it is here where technology researchers usually fail. Most technology researchers do not consider what the older person needs or desires, even if that is the goal of welfare technology. Previous works have pointed out that the end-user is usually forgotten because technology researchers focus merely on the technical aspects, thus neglecting the aim of helping the user in their daily life [11].

A reason for this could be that technology researchers do not always have the opportunity to work directly with older people. On the other hand, some technology researchers may not look forward to work directly with people.

Working with people is not always an easy task for technology researchers. Usually, technical education does not involve how to approach people, especially older people. Inquiring about what the older people needs are to develop welfare technology does not imply just asking "what do you need?". Instead, it takes a trained person in conducting interviews to obtain the correct information needed. This is where the healthcare researchers can help technology researchers.

In addition, healthcare science focusing on the person can make sure the older person's needs are placed before the needs of the researchers, industry, government, or any other party involved.

Special attention needs to be paid in the topic of learning the behaviour of the older person in a smart house. HBM could be invasive in many ways to the older person. Their privacy and space need to be respected. It is here where placing the older person in the centre is crucial to provide a dignified environment for the older person.

Nevertheless, healthcare and technology researchers may find difficulties to communicate with each other. Technology researchers assume many things that may be unknown to the healthcare researcher, and vice versa, which may grow into frustration from both sides.

It should not be presumed that either the technical field is more relevant than the healthcare field when developing a welfare technology. Both areas cannot be separated if the final goal is to improve the lives of older people. Therefore, there should be more collaboration between both fields.

5.3. On the Ethics and Legal challenges

The ethical part is an important aspect when developing welfare technology due to the several challenges that arise. These challenges range from cost-effectiveness, privacy, autonomy, informed consent, dignity, safety, and trust. Other concerns are the legal aspects, technology acceptance, exclusion, depression and isolation, the gap between designers and users, and technology testing and assessment [10].

At USN, these ethical issues are considered in order to provide a safe and dignified environment for older people. However, technology has limitations and thus cannot solve all the problems related to ageing [10].

The legal aspects are another essential part of welfare technology. Although countries have different laws involving welfare technology, the concerns tend to be the same

for most countries. Generally, the main concerns regarding legal issues are data privacy, data access and management, informed consent, and stakeholders' interests [42]. Some studies report that if data confidentiality and security are ensured in a smart house welfare technology, then no major legal problems should arise [43].

In Norway, the municipality is responsible for providing care services to its residents [42]. Among these services are offering home health care, practical assistance for daily tasks, and residence in nursing homes. Due to the shortage of nurses [44] and the government investment in welfare technology to cope with it, Norway is moving towards standardizing welfare technology and is called "Morgendagens omsorg" (tomorrow's care) [45].

Finally, it is important to mention that there should always be user feedback in the research and development (R&D) stage. Older people's feedback can reduce possible errors in the product [46]. In addition, rejection from older people can be avoided if their feedback is taken into account from the beginning [47].

5.4. On the Older People Struggle with Technology

Traditionally, human computer interaction (HCI) refers to how the person (user) interacts with computers. However, with the increase of technology to the personal level, this area has extended to human-centered informatics [48].

To achieve the full potential of welfare technology, HCI should be considered. Unfortunately, most researchers disregard this. As a result, the final interfaces or products do not accommodate the needs of older people [49].

It is thought that older people struggle with technology, but this claim needs to be addressed, not only stated. Indeed, a study suggested that older people struggling is only a stereotype and that older people are open to trying new technology [50]. Therefore, if technology researchers believe that older people have difficulties with technology, then more exploratory studies need to be performed to find out why older people tend to struggle with technology - instead of hoping for the newer generation to use welfare technology in the future.

Finally, it is worth noting that older people's difficulties vary according to generation and place. Nevertheless, understanding why older people struggle should not be omitted; otherwise, welfare technology will always be a challenge for current and future older people [50].

6. Recommendations

In this analysis, the connection and gaps between technology and healthcare field within welfare technology area were discussed. Technology researchers generally assume that the needs of older people are house automation or fall detection. While it is true that older people would appreciate not lying on the floor for hours, many of them think that falling is not something that would happen to them. Therefore, it is necessary to find out what other requirements older people have. Technology researchers have to consider older people's needs by making the older person a priority by placing the older person in the centre.

Technology researchers find it easier to a design welfare system that will solve their own needs, even if they do not realize it. It is harder to design for another person whose needs are not the same as the researchers' need.

Older people's needs are not always easy to know. Therefore, it is essential that researchers study older people's need according to the place where welfare technology is being developed. Through the help of the healthcare field, a major understanding of the needs and struggles of older people can be achieved.

In addition, when learning about human behaviour, the collected data contains sensitive information. Consequently, many ethical and legal issues need to be addressed. It is not possible to propose a final solution for welfare technology for older people unless the ethical and legal issues are discussed.

The technology and healthcare field should not work independently if a stronger improvement in welfare technology for older people is desired.

7. Conclusion and Future Work

Throughout this study, the gaps found between technology and healthcare were presented, analysed and discussed. Several studies point out these issues, but they have not been fully addressed and thus are still a current problem.

Four important issues found need to be addressed when developing smart houses: terminology, placing the older person in the centre, approaching the ethical and legal aspects of it, and considering the struggle older people face with welfare technology.

In the field of welfare technology for older people, these issues affect the older person directly. Therefore, stating these gaps should no longer be an option for welfare technology developers. Instead, addressing them and solving them should be the next step if improvement is wanted.

Future work should focus on reducing these gaps by doing more collaboration between the technology and the healthcare field. This can help reduce the ethical and legal issues, the struggle with technology that older people may face as well as improve their safety and respect their dignity.

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