Impact of a TV-based Assistive Technology on Older People's Ability to Self-manage Their Own Health

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Abstract: Nowadays, special emphasis is being focused on involving people on their own health and care. The use of digital technologies in the home-care management process is increasingly contributing to the maintenance of quality of life and preservation of functional independence in older adults. There is a huge number of available m-health applications for self-tracking health parameters, but the majority of them are inconsistent with the needs of older adults who do not currently use technologies such as computers, smartphones or tablets. The aim of this work is to present a pilot study, which included 19 older adults, that was conducted to objectively measure the effect of a TV-based assistive system on the improvement of older adults' activation levels about self-management of health. The correlation with the usage of specific digital services provided by the system was also investigated. The results reveal how the impact is limited by the aspecific nature of the intervention with respect to the participants' health condition. At the same time, they are encouraging and indicate that there is the potential for the system to impact on older people' self-management skills.

1 INTRODUCTION

Encouraging people to take an active role in the management of their health condition provides several advantages: it helps achieving quality goals and improved clinical outcomes, enhances people's experience in the care process and, consequently, their quality of life, and contributes to the reduction of the costs of the healthcare systems (Greene and Hibbard, 2012). The concept of being an informed and activated patient refers to people's knowledge, ability, willingness and confidence to exercise independent choices to manage their health and care (Hibbard et al., 2004). Self-management skills include interaction with healthcare providers, self-monitoring of own health conditions, dietary restrictions and healthy choices, medication adherence, as well as managing stress and frustration which may come from living with diseases and may impact on physical functioning, psychological well-being and social relationships. Self-management practices and skills offer people an increased level of autonomy in their health, especially in those facing age-related conditions such as diabetes, renal and cardiac dysfunctions, hypertension, cardiovascular diseases (Young et al., 2017), (Johnson et al., 2015). Several studies have recently shown that the use of information and communication technology (ICT) tools in the home-care management process can help in improving patients' activation and in influencing their attitudes and behaviours (Kim et al., 2016), (Whitehead and Seaton, 2016). During the last decade, there has been a trend in developing telehealth services and telemonitoring technologies to empower ordinary people to have more knowledge and control over their own personal health data. These technologies allow to remotely monitor key physiological parameters such as blood sugar levels, blood pressure and oxygenation levels, heart rate and weight, as well as physical activity levels, opening up new opportunities for self-care and self-management. Typically, telemonitoring services are accessible by users through PCs, smartphones and tablets devices (Anderson et al., 2016), (Morrison et al., 2014). An overwhelming volume of health-related smartphone apps are available for download today and new connected health devices are released all the time from manufacturers such as A&D Medical, Fitbit, iHealth, Medisana and Withings. How-

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ever, mobile interface are often unsuitable for older people with limited experience or confidence in using new technologies, then missing the main target. The use of a much more familiar and convenient interface such as the TV, can help to address the usability needs of the older users (Costa et al., 2017), (Raffaeli et al., 2014).

This paper presents the results of a four-month pilot study aimed at investigating the effect of a TV-based assisted living system on older people's activation and on their self-care behaviors. The system has been developed in the framework of the HEREiAM European project, financed by the Active and Assisted Living (AAL) Programme (www.aal-europe.eu, call 5). The system has been designed specifically for older people and exploits an Android set-top-box, a smart card and a simplified remote control device, to offer a combination of health, social, comfort and safety services (Macis et al., 2017). The assessment was mainly based on the different services usage and on the patient activation measure (PAM) questionnaire, adopted to measure the level of activation of participants toward their care management. In particular, the expected outcomes were an improved PAM score over time and a significant correlation with the use of the different services provided by the system.

2 MATERIALS AND METHODS

This section provides information on the technology adopted and on the methodologies followed in the study for the evaluation of its impact on the users. It includes a description of the system architecture, an overview of the population study and of the experimental setup, and an outline of the tools and methods used for data collection and analysis.

2.1 System architecture

The system in its entirety consists of three main components:

- a *Home based kit* (Figure 1), which includes an Android set-top-box with installed a set of applications reflecting the interests and the needs of each user, a personal smart card, a custom remote control, a portable webcam, some proximity infrared sensors and two personal self-care devices (body scale and non-invasive blood pressure meter);
- a cloud-based infrastructure, called *Remote Services Platform*, that centralizes both the user profile management and access control (authentication, authorization, user's relationships) and the interoperability services (data and information sharing, messages exchanging, resources planning);
- a *Web Portal*, available for external individuals such as family members, informal and professional caregivers, that allows accessing shared information (health status data, room presence, usage statistics), according to user authorization rules.

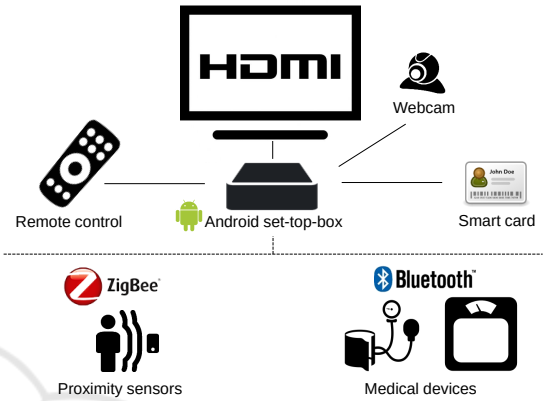

Figure 1: Home based kit.

2.1.1 Supported Services

The system basically assists older adults in their daily life activities by offering a combination of different digital home-based care services. Using the system through their own television, older adults are able to:

- Make or receive video calls from a personalized network of caregivers (Videocall service);
- Get notifications for upcoming appointments or events that are scheduled for a specific time of the day (Agenda service);
- Access a grocery shopping service from home and get products delivered right to the door (Shopping service);
- See the latest news and events happening around their city, insert events in their Agenda or share them with friends (News & Events service);
- Receive health coaching and reminder messages for medication intake, and register how they feel or behave in relation to a health condition and its therapy (Coaching service);
- Self-monitor their health status by measuring blood pressure, heart rate and body weight using the integrated Bluetooth medical devices with the TV interface (Health service);
- Be monitored by pre-authorized caregivers in their day-time and night-time mobility trends

around the house through the integrated network of motion sensors (Tracking service).

All these services were offered with the purpose of motivating older adults to be more involved in their health care and to remain independent and socially active for as long as possible.

2.2 Population Study

A group of 19 older adults (8 males, 11 females) was recruited for the study by the local Municipality of Cagliari among the subjects enrolled in the social services department activities. Inclusion criteria were: participant's age of 65 years or over, ability to live independently and engage in normal verbal communication, and familiarity with basic TV functionalities. Exclusion criteria were: participant's age less than 65 years, any kind of cognitive impairments or serious visual or hearing impairments, any severely limited dexterity in one or both hands. The study was performed following the principles outlined in the Helsinki Declaration of 1975, as revised in 2000. Subjects were asked to read and sign an informed consent form prior to their participation in the study and to complete a pre-participation questionnaire, which inquired about basic demographic aspects, background information and medical history. Sociodemographic and clinical characteristics of the selected sample can be summarized as follows:

- Age, years (range): 73.15 ± 6.36, $(65-87)$;
- Marital status: 65% married, 30% widowers and 5% separated;
- Educational level: 15% completed a primary school, 40% completed middle school, 30% had a high school diploma and 15% graduation;
- Health problems in the last 6 months: 80% suffered from some disease;
- Drugs assumptions: 75% reported regular intake of drugs for conditions such as type 2 diabetes, hypertension, heart problems, musculoskeletal problems.

2.3 Study Design

Subjects who consented to the study were contacted by the research team to schedule a home installation appointment. The Home based kit was installed in each house by a technician, assuring that everything was fully functional and properly working. All participants received a user's manual with all the necessary information for the proper use of the system. Participants with no broadband Internet connection in their homes were provided with a TP-LINK 4G Wi-Fi dongle. The Android TV-box was connected to the HDMI port of the participant's TV and to the Internet. Participants accessed all the functionalities of the system by simply inserting their personal smart card, without the need to remember and type any passwords. A dedicated remote control was entrusted to them in order to control the Android TV-box and navigate the different services. A portable webcam with built-in microphone was connected to the TV-box, to exploit videocall functionalities. The set of medical devices to monitor the participants' physical conditions was configured and the network of environmental sensors providing information about participants movements around the house was installed. The sensors were connected to the Android TV-box via Bluetooth or ZigBee. For the whole duration of the study, each TV-box collected all the different types of data gathered from the network of sensors and instruments installed at home, and transmitted them to the Remote Services Platform using the latest medical and security standards. These data were made available on the Internet through the Web portal for remote monitoring purposes. At least one informal caregiver for each older adult participant was invited to take part in the study. In total, a sample of 26 informal caregivers (9 males, 17 females, age 43 ± 7.85 years) expressed interest in participating and in accessing up-to-date information about their relatives. They received login credentials and instructions to access the Web portal.

2.4 Assessment Plan

The assessment focused on finding out if the proposed services could help in incorporating self-management support into the daily routine of older adults. The PAM questionnaire was employed to measure the level of participants' activation toward their care management. All older adult participants were asked to fill in the PAM questionnaire three times during the study period: baseline (T_0), midterm (T_1) and final evaluation (T_2). Moreover, the assessment investigated potential correlations between the PAM scores and the usage time of specific services (in minutes).

2.4.1 Activation Assessment

The PAM consists of 13 items that are related to patients' knowledge of their health condition or disease, skills and confidence in their management of health related tasks, and personal beliefs about health care (Hibbard et al., 2005). For each statement, there are four response options which are assigned scores from 1 to 4: (1) "Strongly Disagree", (2) "Disagree", (3) "Agree" and (4) "Strongly Agree". If all questions are

answered, the total raw score is calculated by adding all the responses to the 13 items. The range of PAM raw scores is 13 to 52. In the case of PAM items with missing data, the total raw score is calculated by dividing the sum of the all the responses by the number of items answered (excepting non-applicable items), and by multiplying the result by 13. The higher the PAM scores, the higher patient activation.

2.4.2 Services Usage and Trends Assessment

The system allows collecting statistics related to usage of the offered services. The following information can be obtained from each Android TV box:

- number of times each service was used;
- total time and the mean time of usage by the single participant.

This is possible thanks to a dedicated application installed in the TV box that exploits an internal database and a service running in background to save statistics of the actions performed by the older adults using the system's applications. When a system application is opened by the user, the system automatically saves the following information in the database of the monitoring application:

- name of the launched application;
- a sequence of encoded information identifying when the event occurred;
- a sequence of encoded information identifying the user logged on the platform.

The recorded information is saved in real time and a daily log file is sent, every 24 hours, to the Remote Services Platform.

2.5 Data Analysis Methods

All the daily usage information stored in the server were retrievable through the Web Portal. At the end of the study, these records were exported on a Microsoft Excel sheet for statistical analysis. False positives (applications launched by mistake and closed after no more than 30 seconds) were manually discarded and the quantitative data obtained were coded and exported from Excel into SPSS Release 18.

Data related with the system usage were analyzed with descriptive statistics, in order to identify the average time and frequency of usage. For each service, the average session duration was calculated by dividing the total duration of all the sessions performed by the population study (measured in seconds) by the total number of sessions, as shown in (1):

$$\text{Avg Session Duration} = \frac{\text{Total Duration}}{\text{Number of sessions}} \quad (1)$$

A statistical analysis was also performed on the questionnaires data to describe the psychosocial characteristics of the study population. All variables were checked about univariate and multivariate normality. Since data have shown a normal distribution, parametric analyses were used. An analysis of variance (ANOVA) on repeated measures was performed to analyze the changes of PAM scores from baseline. The significance level was set at $p < 0.05$. Pearson's correlation coefficient was used to assess the correlation between average PAM scores and average time use of the services: Videocall, Agenda, Shopping, News&Events, Health.

3 RESULTS

Descriptive statistics on the usage of the proposed services are shown in figures 2, 3 and 4.

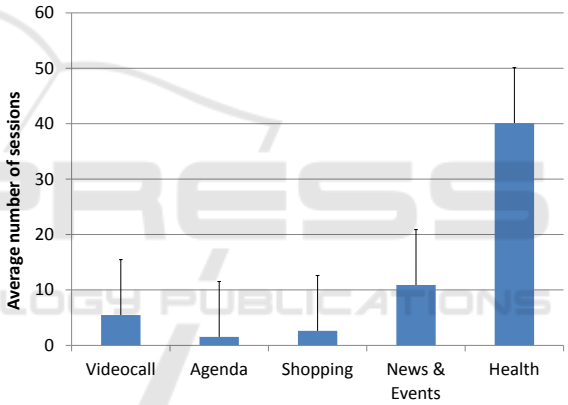

Figure 2: Average number of sessions for each service. Error bars represent one standard deviation.

Table 1 details the descriptive statistics for the PAM scores in each phase of the assessment (T_0, T_1 and T_2). The repeated measures ANOVA shows no significant differences between PAM raw scores from baseline to 4 months, $F_{2,17} = 1.55$, $p = 0.24$. This is partially due to the limited trial duration and sample size. However, it is also worth noting that the high baseline PAM levels among participants may have determined a "ceiling effect" in the reported results. Furthermore, the aspecific nature of the intervention, with respect to the participants' health condition, could have determined an underestimation of the system usefulness, with a consequent limited impact on the subject's activation. However, a general improvement in the mean values of PAM, despite the absence of statistical significance, supports the current search for eHealth solutions for patient empowerment, i.e., the delivery or enhancement of health care

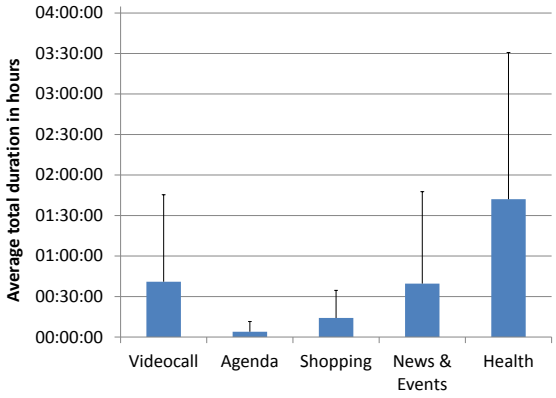

Figure 3: Average total duration in hours of all sessions. Error bars represent one standard deviation.

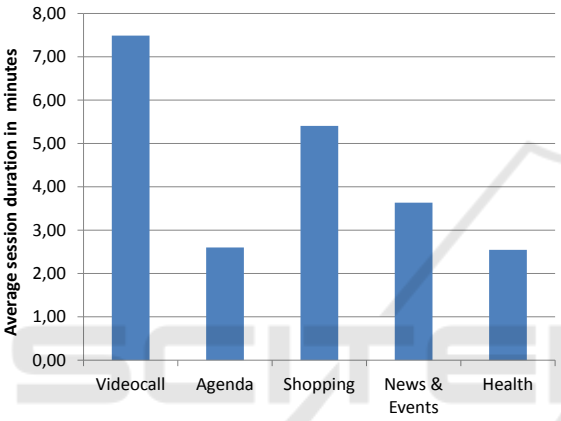

Figure 4: Average session duration in minutes for each service.

Table 1: Comparisons of PAM scores (Mean and Standard Deviation) obtained in the three phases of the study: T_0, T_1 and T_2.

	Patient Activation Measure
T_0	43 (SD 4.9)
T_1	43.1 (SD 6.9)
T_2	45.2 (SD 4.4)

services or health care information through the Internet and related technologies (Lettieri et al., 2015).

Table 2 displays the correlations between the mean PAM scores and time use (minutes) of different services. The correlations analysis showed a positive relationship between the use of the applications Videocall and News&Events. There is some evidence that participants with higher levels of activation in managing health care have spent more time using these two applications. According to these findings, greater contact and interaction with friends and relatives and higher interest in local news and city activities can be associated with higher patient activation.

4 DISCUSSION

The aim of the study was to assess the level of activation of the elderly toward their care management when using a multi-purpose TV-based assistive technology. An improved PAM score over time was expected, correlated with the use of the services embedded in the system.

However, after 4 months, there was only a slight improvement in PAM scores, not reaching statistically significant values. Main limitations of the study were: the short duration due to the project schedule, the reduced number of subjects limiting, among the other things, any gender-specific analysis, the absence of specific disease whose quantitative monitoring was perceived by the elderly as worthy of attention. Due to such study limitations, it is difficult to draw a final conclusion on the PAM changes, but the overall high scores at baseline may have limited the potential increase in participants' activation. Moreover, the aspecific nature of the intervention, with respect to the users' health condition, may have determined an underestimation of the system usefulness, with a consequent limited impact on the subject's activation. This makes the achieved results not comparable to those of studies involving chronic patients (diabetes, heart failure, etc.), where a telemonitoring is perceived as a need primarily by the patients themselves.

Descriptive statistics on the usage time highlighted that Health was the service most used by participants during the study, followed by News&Events, Videocall, Shopping and Agenda. The Health service result is particularly encouraging, taking into account that there was no supervision on the health data by professional caregivers. Over the reported period, participants spent on average a total of 1 hour and 42 minutes in self-monitoring their health data. This is not a very long amount of time, but considering that the time needed to complete a measurement session ranged from 1 to 2 minutes, this result indicates that on average each participant accessed the Health service between two and three times per week. Such regular self-monitoring of physiological parameters gave participants some degree of responsibility for their own care during the trial, and a more tangible understanding of their health status. Results also revealed that the more engaging services with longer sessions were VideoCall, News&Events and Shopping. The average amount of time a participant spent in the VideoCall service during a single session was about 7.5 minutes.

Table 2: Correlations matrix between variables.

Variables	Health	Videocall	Agenda	Shopping	News&Events
PAM	−0.23	0.60 (p <0.01)	0.25	0.17	0.43
Health		−0.17	−0.26	0.40	0.18
Videocall			0.20	0.16	0.32
Agenda				−0.02	0.18
Shopping					−0.04

5 CONCLUSIONS

In this paper, the results of a 4-month pilot study, in which a TV-based system and a set of home-care services were introduced into the daily life of 19 older adults, were presented. Assessment was carried out with the objective of evaluating how a digital system developed specifically for older people changes the PAM scores, and to understand how the PAM scores are related to the system usage. The approach, and the achived results, are important for the development of similar projects, enabling to address at the time of the study design some criticalities. Results reveal a non-intensive use of the system and negligible correlation between the access to the health service provide within the platform and the PAM score.

In the light of presented results, future investigations will be performed on people living with specific chronic conditions, including asthma, diabetes, and hypertension. These patients must have an active role in making decisions about their health, under the supervision of the family doctor or the specialist. To avoid a ceiling effect, patients whose scores at baseline are already fairly high will be excluded from the study.

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