



Mobile applications in an aging society: Status and trends

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ABSTRACT

Today, many countries, including several European states, the USA, and Japan, are aging; both the number and the percentage of elderly people are increasing. To create a cohesive and inclusive intergenerational society, technological products and services must be adapted to the needs and preferences of these citizens. Mobile phones are promising tools to improve the quality of life for the elderly. This work presents a review of the status of mobile functionalities and applications that can satisfy the requirements and needs of older people and improve their quality of life. This analysis of the state of the art enables us to identify the strengths and weaknesses of the current systems as well as discover trends and promising future lines of research. This paper outlines several needs that should be met to improve the quality of research in this area. This work provides a basis for researchers, designers, and mobile phone service providers to think about the existing needs of the elderly, the developing trends in the field and the opportunities that mobile applications offer to improve the quality of life of the elderly and to support a cohesive and inclusive society.

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1. Introduction

New social protections, improvements in the quality of health care and better conditions of living and working lead to people living longer than in the past, and old age is becoming a reality for an ever-increasing number of people. Together with the decrease in mortality, the decline in fertility rates is a key driver of population aging. At the same time, the lifestyle, potential and expectations of older people are changing together with their increasing life expectancy. People are living healthier and more active lives (Ministry, 2008).

The population of the European Union (EU) is aging, and indeed, it is already the world's oldest region. In 2000, there were 61 million people aged 65 and over in the EU – 16% of the total population – compared with 34 million in 1960 (Walter, 2004). In Spain, the average age of the population in 2010 is 40 years; in 2025, it will be 45.9, and in 2049, the average age will be 48.2 years (Qualitas, 2010). Fig. 1 shows the age pyramid in the EU. The share of population of 65 and over was around 22.5% in 2005 (Eurostat, 2008). According to Eurostat, in 2050, the share of those of 65 and over is projected to increase to a 30% of the EU population. Today, 17% of the total population in Spain is over 65 years old. According to data from the Spanish National Statistics Institute (INE) the percentage will be 32% in 2049 (INE, 2010).

Products and services must be adapted to the needs and preferences of this increasing number of elderly people as well as to the requirements of the new economic context. At the same time, a strategy addressing population aging should take advantage of the potential of older people and help to create a cohesive and inclusive intergenerational society (Ministry, 2008).

In this context, Information and Communications Technology (ICT) has been considered an important tool to help in creating this cohesive and inclusive society. New terms have been coined, such as “Gerontechnology,” which refers to technology that meets the needs of an aging society (i.e., research, development, and design in the engineering disciplines based on scientific knowledge about the aging process). More formally, gerontechnology is defined as the study of technology for ensuring good health, full social participation, and independent living throughout the entire life span, as long as it may extend (Harrington and Harrington, 2000). Some of the specific areas of research in gerontechnology include the workplace, the home and independent living, health care and home health care, and caregiver support (Comeau, 2005).

Among the ICTs, it is worth noting the developments in mobile communications spearheaded by the rapid penetration of the mobile devices, including 3G technology, mobile applications, data and video, voice, storage capacity, downloadable ring tones and music, mobile clips, and personalization.

This article analyzes if current mobile communications, devices and applications can be considered important tools to support an inclusive society. With this objective in mind, this work presents a review of the status of mobile functionalities and applications

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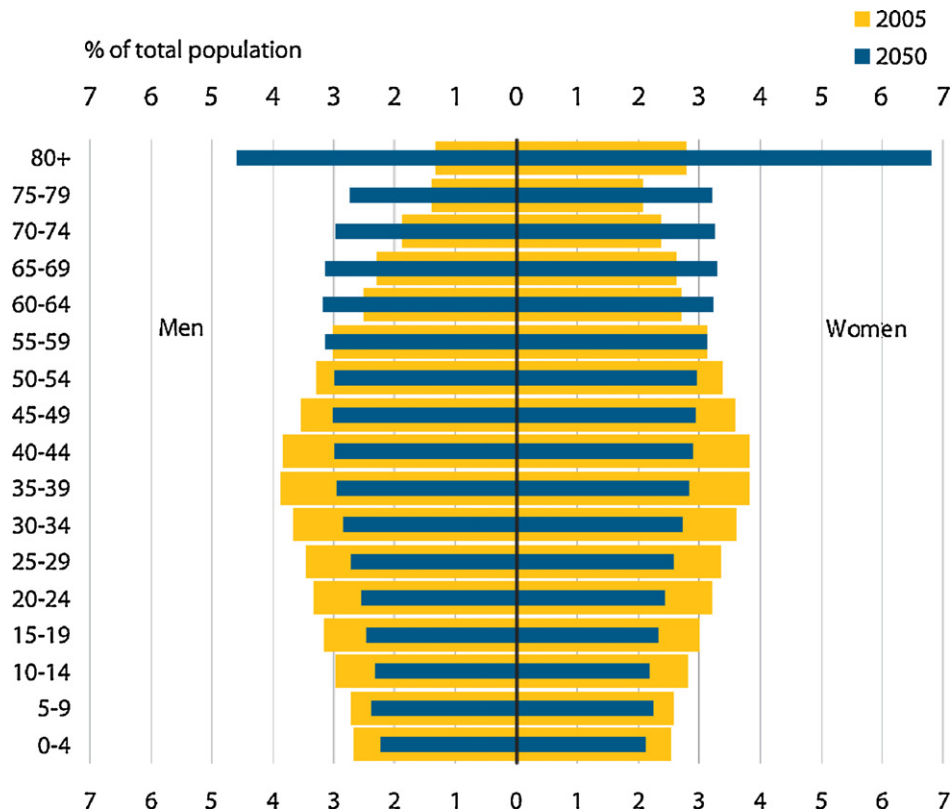


Fig. 1. Age pyramid in the EU-25, 2005 and 2050 (Eurostat, 2008).

that can satisfy the requirements and needs of older people and improve their quality of life (QoL). The concept of QoL allows us to select the relevant aspects when analyzing the impact of mobile functionalities. This work also studies the present and future roles of mobile applications in an aging society, as well as the future trends. This article provides a global vision of the status and trends of mobile applications in an aging society.

The paper is structured as follows. The following section explains the methodology used to outline the status of mobile applications in an aging society. The third section presents the results. These results enable us to deduce the conclusions and to define the recommendations and the trends presented in section four. Finally, section five presents the final conclusions.

2. Methodology

This section is aimed to define the methodology of the article. The study of the role that mobile applications can play in an aging society requires the identification of the needs and the requirements of this new social situation.

The first stage of the study is to analyze the aspects with implications for the concept of “the quality of life”. In Section 3.1, this concept is briefly analyzed and dissected into key components.

The second stage is aimed to analyze how mobile applications can improve the quality of life of older people and to examine the acceptance of mobile phones by older people: use, needs, preferences and barriers in relation to mobile applications. Section 3.2 deals with this topic. Within this framework, the current status of mobile devices and applications for older people is examined. Research papers (from scientific and technical journals and proceedings of conferences) and Internet sources (web sites of mobile phone providers, web sites of research projects, etc.) are the main source of information. Section 3.3 analyzes the current status of mobile devices and applications for older people.

The third stage is aimed to analyze whether the current mobile applications can satisfy the requirements of older people in order to improve their quality of life or not. The discussion section develops this stage and also explores the future trends.

The fourth stage is aimed to extract conclusions from the results. This stage study strengths and areas where the research is well developed, to discover trends and future lines of work and to identify holes and weaknesses in the current literature. This stage is mainly developed in the discussion and conclusions sections. These sections help researchers and developers to consider the status and trends of mobile applications as an important tool in an aging society.

3. Results

3.1. Quality of life in old age

Quality of life research has emerged as a concept with intense scientific and political interest in the last few decades. According to the historic introduction developed by Smith, early notions of quality of life can be dated to Aristotle's (384–322 B.C.) written concepts of ‘the good life’ and ‘living well’. However, the popularization of the term ‘quality of life’ (QoL) evolved in the second half of the twentieth century. Over the last fifty years, a plethora of definitions of quality of life have emerged within the health and social science disciplines. However, as yet, there exists no generic definition satisfying all proponents of quality of life research (Smith, 2000). There is no consensus on a definition of quality of life in older age, whether among the younger, more fit elderly population or among the frailer elderly population (Brown et al., 2004). As a consequence, there is no consensus on how to measure quality of life (Bowling and Stennen, 2010; Xavier et al., 2003).

Despite this variety, Melander stresses that there is an emerging consensus that physical, mental and social aspects should be

Table 1

Comparison of quality of life components identified by older people and expectations and needs of elderly people in relation to mobile applications found in the literature.

QoL components identified by older people (Brown et al., 2004)	Needs of older persons with Alzheimer's disease (Armstrong et al., 2010)	Needs of older persons in our review (Section 3.2, Table 2).
Family and other relationships/contact with others	Maintain social contact	Communication device
Emotional well-being	Enhance their feelings of safety	Feeling safe and secure
Religion/spirituality	To help patients remember	Freedom of movement
Independence/mobility/autonomy	Perform daily life activities	Memory and daily life activity aids
Social/leisure activities	Perform daily life activities	Enjoyment, self-actualization
Finances/standard of living		Memory and daily life activity aids
Own health/health of others		Healthier independent life

included in QoL, and there is now also recognition that spiritual aspects should be included as well (Melander, 2008). Brown et al. (2004) provide a taxonomy, overview and systematic review of the literature. Through this review, they determine the components of quality of life that older people themselves have deemed to be important and compare them with the components identified in the literature. The literature reveals that quality of life can theoretically encompass a wide ranging array of domains, including the individual's physical health and functioning, psycho-social well-being, psychological outlook, psychological and social role functioning, social support and resources, independence, autonomy and perceived control over life, material and financial circumstances, community social capital and the external environment, including the political fabric of society (Brown et al., 2004). Table 1 shows the components that older people have identified as being important.

These components should be taken into account in defining the current and future roles of mobile applications in an aging society.

3.2. Mobile phone adoption by older people

It is usually thought that older people do not use mobile phones or their technology; they are considered "non technological persons". Abascal and Civit stress that people trying to introduce technological advancements to help older citizens have to overcome some extended stereotypes: the lack of ability of the hypothetical users to handle complex devices and their unwillingness to accept them ("older people reject technology", "technological devices are too difficult for older people to use") (Abascal and Civit, 2001).

Several recent studies refute these stereotypes. For instance, Conci points out that in the last few years, mobile phone usage by people over 60 has been growing rapidly. According to a survey, 58.5% of the people in Italy between 65 and 74 years old and 26.6% of those over 75 use a mobile phone, with a much higher growth trend in this age group than in others (Igarria et al., 1997; Conci et al., 2009). In her work, Kurniawan (2007) explains that just like computers and the Internet, mobile phones are becoming common personal items for older persons. She refers to two studies with the following data: in early 2006, 60% of people aged 65–74 years old and 36% of people aged 75 years and over owned and used mobile phones in the UK. Actually, older people have

a much higher adoption rate of mobile phones than of Internet usage. Many older persons use mobile phones in both leisure and work contexts (Kurniawan, 2007). Melander et al. (2007) found that elderly people tested in her study felt positive about the use of mobile services for safety; all of them had experience using mobile phones, and most of them used personal computers in their daily life, which might be the reason for their positive attitude. Oksman remarks that previously, seniors had many negative opinions on mobile communication, but lately, the attitudes have changed, and mobile usage has become a daily occurrence (for instance, in 2002, about 70% of Finns aged between 60 and 70 owned a mobile phone) (Oksman, 2006). Venkatesh concludes that the elderly, like anyone else, accept and adopt technology when it meets their needs and expectations (Venkatesh et al., 2003; Conci et al., 2009). Thus, the next step is to identify their needs and expectations.

Oksman observed that seniors, at least in the early stages of mobile usage, appreciated the significance of the mobile phone as a tool to increase security. However, the significance of the mobile phone as a personal communication device has also increased. Usage immediately after purchasing a mobile phone is characterized by caution (only carrying it on special occasions). Later, the mobile phone is accepted in the activities of everyday life, and people are more inclined to take it with them as they leave the house. After the pressures of working life, contacts with friends and family often become more frequent. With the increased leisure time in retirement, hobbies and hobby related relationships may also increase communication (Oksman, 2006). In a similar way, Ling concludes that the primary reason for mobile telephone adoption includes its function as a safety link to others; indeed, this is often seen as its most useful function (Ling, 2008). According to the same author, mobile communication is also an appropriate tool for the development and maintenance of friendships. In fact, the pressure to have a phone often comes from social interactions.

Focusing on the safety functionality, Melander studied the experiences of elderly people in testing a mobile safety alarm and their reasoning about safety, privacy and mobility. She found that safety and mobility were considered more important than privacy. Informants focused on feeling safe and secure, and they feared falling and not being noticed and not being able to take care of themselves. Safety and security were connected to the usability of the technology. The concept of mobility or freedom of movement seemed to involve both self-determination and empowerment (Melander et al., 2007).

In the same line, Conci summarizes in her experimental thesis that, in accordance with results reported in the literature, feeling safe is a crucial issue for older people. Although safety concerns do not directly affect their intention to use a mobile phone, they increase its utilitarian value. Conci (2007) demonstrates the importance of utilitarian considerations and extrinsic motivations (usefulness). Intrinsic motivations, such as enjoyment and self-actualization, influence the intention to use only through the mediation of usefulness—that is, by affecting the utilitarian value of the mobile phone. It has been argued that perceived ease of use is important because, despite its frequent usage, the mobile phone remains an alien technology. This is also reflected in the need for support while using it. In conclusion, older people perceive the mobile phone as a useful device for communication and safety. For all these reasons, the reported use is high. However, the ease of use is still an issue, and the subjects are aware of needing special support (Conci, 2007).

The results of the study of Kurniawan (2007) clearly reveal that for older persons, mobile phones are perceived as memory aids to mediate aging-related memory decline and as tools that provide a sense of safety and security.

Armstrong et al. (2010) focus on older persons with Alzheimer's disease, and they conclude that the key unmet needs still remain

Table 2
Needs and expectations related with mobile functionalities found in our literature review (Section 3.2).

Needs and expectations	Note
Feeling safe and secure	Crucial issue. Connected to the usability of the technology.
Memory and daily life activity aids	For example: appointment reminder, alarm, address book, diary, medication reminder, and caller ID complemented.
Communication device	Enables contacts with friends and family.
Freedom of movement	Involves both self-determination and empowerment.
Enjoyment, self-actualization, healthier independent life	Intrinsic motivations. Services that promote their physical and mental well-being.

(1) to help patients remember, (2) to maintain social contact, (3) to help perform daily life activities, and (4) to enhance their feelings of safety. These needs can also be found in other older people. Table 1 presents a comparison between these needs and the components of quality of life defined by older people. In their research, Armstrong et al. (2010) propose to develop and test the following mobile phone applications: a 1-h reminder system, a geofencing application, reminder messages, and medication reminders. Considering a more general target group, Mikkonen et al. (2002) tried to identify the service needs of elderly people using different mobile communication service concepts:

- Mobile WristCare (mobile phone functions as the base station of a security bracelet that automatically sends an alarm).
- Traveling by bus (a mobile informs the user when the right bus arrives at the bus stop).
- Service center (when a user contacts the service center, a positioning service is activated that shows the service center where the person is located).
- Reminder (broader service, for example, information about medication and reminders to take medication).

Based on the results, the needs could be prioritized as follows. Mobile WristCare was the most popular and the most necessary of all of the services presented, and Traveling by bus was the least important service concept. Reminder and Service care were evaluated evenly. The authors concluded that the Mobile Wrist Care must also have equipment capable of relaying position information. Based on the study, it appears that elderly people are willing to pay for the use of the service concepts presented (Mikkonen et al., 2002).

As a complementary point of view, it is possible to find studies where older people demand mobile services compatible with the modern image of the 'active senior': people who remain capable of managing their affairs and pursuing an independent life long after retirement from working life. Instead, seniors are interested in services that promote their physical and mental well-being, thus providing opportunities for a longer and healthier independent life (Oksman, 2006). Kurniawan (2008) suggests that mobile phone design for older persons is not necessarily limited to or centered around old-style, out-of-date models supporting only very basic calling functions.

Table 2 summarizes the needs and expectations found in the bibliography analyzed in the present section. Table 1 relates them to the quality of life components nominated by elderly people.

Specific barriers: It is impossible to forget that the mobile phone is a relatively recent development. For people who have organized their lives without the mobile phone, the adoption of the device often involves a readjustment of well-established routines (Ling, 2008). It is also necessary to consider memory decline (or in general, cognitive decline), which causes problems for older persons

in using and learning to use mobile phones (Kurniawan, 2007), and the limitations of mobility, visual and hearing impairments and high disease susceptibility, especially for chronic diseases (Gaßner and Conrad, 2010).

Thus, the need for support is an important motivating factor for mobile phone acceptance according to Conci (2007), and the design of mobile phone terminals should be improved to be fully accessible for older people (Goodman et al., 2004). Kurniawan (2007) conducted a study seeking to identify problems older people (aged 60 years and over) may experience when using mobile phone technology. The results from the study identified the following problems.

- Buttons:* Some are too small, rubbery, do not click when pressed and therefore provide no feedback regarding whether the associated number had been dialed.
- Menus:* Too many, and most of them are unnecessary and difficult to understand and recall.
- Devices:* Too small to hold comfortably.
- Text size:* Too small to read even with corrective lenses.

In general, the desired features can be classified into the following categories (Kurniawan, 2008).

- Memory aids:* These include appointment reminders, alarm, address book, diary, and caller ID. Another set of features is not strictly memory aids but would help older persons with reduced cognition. These include a personalized interface that only displays a limited number of essential menus and a design that is easy to learn and navigate.
- Visual aids:* These include stronger backlight, larger text, bold color, and differently shaped, colored or located keys for important functions.
- Haptic aids:* These include rubber grips, easy-to-hold phones, big buttons, and antenna (easy to pick-up).
- Features to minimize user error:* These features are related to the fear of consequences of unintended actions and include mechanisms to prevent accidental dialing, alert the user when the battery is almost empty, and provide feedback indicating whether a call has gone through or a button has been pressed.
- Safety features:* These include a panic button and a button to blacklist a caller.

Once, the most common needs and requirements of older people regarding their mobile phones have been identified, the next section analyses if the current mobile applications fulfill these needs, expectations and desired features.

3.3. Current status of mobile devices and applications for older people

To analyze the state of the art of mobile applications devoted to improving the quality of life of older people, it is necessary to consider two aspects:

- Current mobile applications for older people (Section 3.3.1).
- Mobile devices (Section 3.3.2).

3.3.1. Mobile applications for older people

Most of the studies developed to investigate mobile applications for older people share the same starting point: the important premise that "elderly people want to stay and live in their homes as independently and as long as possible". The problem of supporting independent living using ICT calls for holistic concepts focusing on the individuals' quality of life.

To improve the quality of life of older people and strengthen the industrial base in Europe through the use of ICT, the German com-

Table 3

Comparison between QoL components identified by older people, needs found in this review and the AAL model.

QoL components identified by older people (Brown et al., 2004)	Needs of older people in our review (Section 3.2, Table 2).	VDI/VDE-IT and AAL model (Gaßner and Conrad, 2010).
Family and other relationships/contact with others	Communication device	- Social Interaction
Emotional well-being	Feeling safe and secure	- Safety, Security and Privacy – Peace of Mind
Religion/spirituality		
Independence/mobility/autonomy	Freedom of movement, Enjoyment, self-actualization	- Mobility
Social/leisure activities	Enjoyment, self-actualization	- Hobbies - Information, Learning and education - Working life
Finances/standard of living		
Own health, health of others	Healthier independent life	- Health and wellness - Home care - Chores and Supply with goods

pany VDI/VDE-IT, together with the AAL Association (AAL, 2011), developed a model that classifies the needs of elderly people for their well-being. They considered the following factors (Gaßner and Conrad, 2010): Health and Wellness, Home Care, Chores and Supply with Goods, Safety, Security and Privacy – Peace of Mind – Mobility – Information, Learning and Education – Social Interaction – Hobbies and Working life.

Obviously, there are overlaps and relationships among the different aspects. The classification into nine factors is close to the results of the previous literature review, as shown in Table 3.

This model will be the starting point used in this paper to review different kinds of mobile applications for older people.

- Health and wellness and home care

As a result of the aging of society, it is possible to observe an overall trend toward a more personalized model of health care. Intelligent applications have been developed to guarantee independent living for the elderly. Thus, new concepts such as Telehealth, Tele-care and Tele-rehabilitation or E-Health have been coined. The Doctoral Thesis of Anita Melander helps to understand these concepts: Telehealth can be defined as the delivery of health related services and information via telecommunications technologies. Telehealth consists of Tele-care and Tele-rehabilitation. Tele-care and Tele-rehabilitation provide services directly to the end-users, as distinct from telemedicine, which uses ICT systems for diagnosis. E-Health describes the combined use of electronic communication and information technology in the health care sector: the use of digital data in the health care sector – data transmitted, stored and retrieved electronically – for clinical, educational and administrative purposes, both at the local site and at a distance (Melander et al., 2007; Curri et al., 2003).

In this context, the role of mobile devices and applications has been reviewed by Blake (2008). She developed a model of the state of the art in “Health promotion” (programs conducted mostly in Japan, the US, New Zealand and the UK) and “Health monitoring” (programs predominantly conducted in Europe: Italy, Denmark, Norway, Spain, UK, Korea and the USA). She concludes that both the text message and the voice response functions of the mobile phone are used, for instance, in monitoring wandering in dementia, monitoring blood glucose in diabetes or promoting health. She

found that the mobile phone is used either as a stand-alone tool or in combination with other technologies.

A review of the literature enables us to conclude that the desirable frameworks combine conventional health care and new assistive technologies with home care solutions. After an extensive review of the state of the art, Gaßner and Conrad found that the scientific contributions regarding this aspect are mostly related to the subcategories “Assistance” and “Therapy”. Many projects address the development of home platforms that integrate different devices and allow for automatic communication by external persons (e.g., to receive help, advice or support) (Gaßner and Conrad, 2010). In this kind of solutions and projects, the mobile phone is usually one component of the global system. For instance, Tamburini and Pagetti (2005) presents integrated home care services in the DGHome platform where the mobile phone is used to provide reminders to take medication. As another concrete example, the work of Sasaki et al. (2007) proposes a network that incorporates a safety confirmation system, a remote health care system, an emergency information system and other useful daily network services in the closed life area. The elderly person’s mobile phone is used to send text messages to a remote family member’s phone. In the same line, Kamel et al. (2007) introduces CAALYX—Complete Ambient Assisted Living Experiment, an EU-funded project that aims at increasing older people’s autonomy and self-confidence by developing a light, wearable device capable of measuring specific vital signs of the elderly, detecting falls and location, and communicating automatically in real-time with the individual’s care provider in case of an emergency, wherever the older person happens to be, at home or outside. Focusing on mobile phones, communication and mobile GPS (Global Positioning System) tracking functionalities are used. However, the authors advise that the system should use a more comprehensive and robust geo-positioning solution for older people, combining multiple geo-positioning technologies to cover locations where conventional GPS alone would fail.

Obviously, these frameworks are entirely related to other aspects of the model, mainly “Safety, Security and Privacy” and “Mobility”.

- Safety, security and privacy—mobility

User location and tracking devices, telemonitoring systems and alarm systems are the most common products and services found in the analysis of the state of the art about safety, security and mobility.

Since the mid-1980s, mobile telephone services have been considered key technology for user location and tracking (Clarke, 2001). Several patents reflect the importance that mobile telephone services have acquired in location and tracking. Yacenda et al. (1996) presented a telephone communication with a locator system for locating telephone users and generating location information. More recently, Toubia et al. (2001) described a system and method for locating missing persons, animals and objects that can be incorporated into a cellular mobile phone.

Today, mobile applications are usually combined with other elements. The proposal of Calvo et al. (2009) is a recent example of integration: they try to assist elderly people and their families in situations where they can be lost in outdoor environments using standard mobile terminals (Android G1) equipped with GPS and compass devices. Their solution is based on the use of a mobile social network to create a virtual community to allow caregivers to communicate with the elder individual. In their follow-up work, they have begun integrating vital sign devices in the architecture, collecting data from the Android device and keeping the caregivers informed through the mobile social network (Calvo et al., 2009).

In telemonitoring systems, mobile phones are also combined with other devices (like accelerometers), and SMS and GPS-enabled

functionalities are mainly used. For instance, [Scanaill et al. \(2006\)](#) designed a telemonitoring system based on the mobile phone short message service (SMS) to remotely monitor the long-term mobility levels of elderly people in their everyday life. Mobility is measured by an accelerometer-based portable unit worn by each monitored subject. Mobility level summaries are transmitted hourly, as an SMS message, directly from the portable unit to a remote server for long-term analysis. Each subject's mobility levels are monitored using custom-designed mobility alert software, and the appropriate medical personnel are alerted by SMS if the subject's mobility levels decrease. [Miskelly \(2005\)](#) describes the use of global positioning system (GPS-enabled mobile telephone) technology to locate missing persons anywhere in the country, except inside buildings and on public transport, with an accuracy of approximately 5 m. [Dalton \(2007\)](#) evaluates the accuracy and viability of a mobility telemonitoring system, based on the short message service (SMS), to monitor the functional mobility of elderly subjects in an unsupervised environment.

Finally, the situation is similar in alarm systems. It is possible to find systems based on mobile functionalities or their integration in the platforms cited in the "Health and Wellness and Home Care" point. As an example in the first category, [Riisgaard et al. \(2005\)](#) used the embedded camera of the phone and smart sensors to detect and verify the falls of elderly people. In the second category, following the previous examples, the DGHome platform integrates environmental, telecare and smart living alarms ([Tamburini and Paggetti, 2005](#)).

- Chores and supply with goods

Several studies have reported the use of mobile phones for dietary programs (see, for instance, [Kikunaga et al., 2007](#); [Blake, 2008](#)), but these programs are not specifically designed for older people. Nevertheless, [Mattila et al. \(2006\)](#), who developed a Mobile Diary for Personal Wellness Management based on mobile phones, stressed that the positive results indicate that their system is suitable not only for technically oriented young people, but also for middle-aged and older users who are not accustomed to using this kind of technology. Based on the results, simplicity and ease of use were important factors in promoting the use of their mobile diary ([Mattila et al., 2006](#)).

In contrast, the work of [Lee et al.](#) presents a mobile phone application for monitoring caloric balance as a part of weight management. They tested it with six participants: six working professionals and a retiree, ages 32–78, who were regular cell-phone users. The retiree stopped using the application after the first day upon becoming frustrated with the user interface ([Lee et al., 2006](#)).

When users take an active part in the design of the prototype, this type of problem can be avoided. [Arsand et al. \(2008\)](#) designed a mobile self-help tool for people with diabetes (the "Easy Health Diary"), with a target user group typically aged 50 or over and with a design focused on usability. As a relevant point in this review, we must emphasize that users preferred a mobile phone or both the PC and the mobile phone as platforms. None of the informants chose the PC as the unique terminal.

- Information, learning and education

[Gaßner](#) has observed that modern devices such as mobile phones, handhelds or e-newspapers allow elderly people to stay informed. Information is essential for individual development, maintaining contact with the outer world and preserving and exercising mental abilities. Conversely, services are needed to enable people to handle the new technologies ([Gaßner and Conrad, 2010](#)).

E-learning plays an important role. According to the work of [Ileana Hamburg \(Hamburg et al., 2005\)](#), distance education enables

people to find a new social identity by giving them access to work or helping them to maintain a job. Distance education can help the elderly and the disabled to feel less isolated. In most cases, access to ICTs is an additional means of communication and a way of breaking their isolation. [Hamburg](#) summarizes several international projects devoted to improving the quality of life and work of elderly and disabled people using distance learning and virtual applications.

Many international projects can be found devoted to developing cognitive training applications in the literature. Training improves cognitive abilities in healthy elderly people ([Buiza, 2009](#)). As an example, the Hermes project is a project in the realm of cognitive care. The Hermes system is built around a mobile phone and a computer that work together automatically, and both can record what is being said in a room ([Hermes, 2010](#)).

The analysis of the state of the art suggests that most of the projects refer to PC applications. The mobile phone remains under-employed.

- Religion/spirituality

Findings from previous studies show that religious involvement is associated with longer life. For instance, [Buono](#) found that centenarians consider themselves religious ([Buono et al., 1998](#)). [Phillips](#) remarked that health care literature demonstrates an accelerated proclivity toward wellness and holistic care: Authors repeatedly contend that for treatment to be most effective, clients' faith, beliefs, religion, and/or spirituality must be considered ([Phillips, 2003](#)). More specifically, [Ferriss](#) explored the relationship between religion and the quality of life and concluded that happiness and satisfaction with life come from a complex set of influences. Religious involvement is one such factor ([Ferriss, 2002](#)).

Nowadays it is possible to find many examples of different ways in which mobile applications can deliver religious experiences. [Bell](#) offers a survey of emerging and emergent techno-spiritual practices ([Bell, 2006](#)). For instance, we can find: prayer books, religious calendars, healing videos, daily audio podcasts, news updates, holy books (Bible, the Koran, etc.) recitations, religious ringtones, etc. (see for instance ([Getjar, 2011](#))). However we have not found studies about the use of this kind of applications by the elderly in our revision. In her Thesis, [Susan Wyche](#) remarks that a worthwhile future research endeavor would be to investigate systematically the result of the application of ICT concerning religious matters ([Wyche, 2010](#)).

- Social interaction

Communications are an important aspect of our social interactions. The landline phone is often the primary conduit through which the elderly communicate to maintain family and social relations. The elderly are often most likely to see a mobile phone as a type of safety device or lifeline as opposed to seeing it as a social communications device ([Ling, 2008](#)). However, the significance of the mobile phone as a personal communication device has increased, and different communications functionalities are considered. [Quadrello et al. \(2005\)](#) examined the pattern of use of different forms of contact between grandparents and grandchildren with a specific focus on the use of new technologies (SMS, e-mail). He found that the SMS service was considered equally important for all users (young and elderly), which is most notable for older participants ([Quadrello et al., 2005](#)). Perhaps the reason is that phone services such as voice communication and SMS have low complexity and low certainty, whereas personalized or position-based information services have high complexity and high certainty ([Anderson et al., 2004](#)). Today, elderly people are learning to send text messages to communicate with their friends, or children and

grandchildren, but they are not generally interested in ringtones and wallpapers (Kaasinen, 2005).

- Hobbies

Digital games hold significant positive potential for elderly users. In addition to their entertainment value, there can be substantial therapeutic value in playing digital games. Digital games allow elderly people, like other users, to bond socially, both with online and physically co-located others, thereby enhancing their social connectedness and potentially enlarging their social support structure (Ijsselstein et al., 2007).

PopCap Games® conducted a survey involving more than 2000 casual game players and found that 47% of all casual game players are 50 or older, and nearly 20% are 60 or older; of players 50 or older, 74% cited cognitive exercise (mental workouts), 86% noted stress relief, and 62% chose memory strengthening as benefits they experience from playing casual games, a full 32% of respondents 50 or older said the games distract them from chronic pain/fatigue, and nearly one in ten said they derive actual relief from chronic pain/fatigue when playing. A total of 86% of older survey respondents said that they felt playing casual games offered them physical and/or mental health benefits, compared to 74% of under-50 respondents (PopCap, 2010). PopCap's games are played on the Web, desktop computers, a myriad of mobile devices (cell phones, Smartphones, PDAs, Pocket PCs, iPod, iPhone) and other popular game consoles.

Focusing on mobile devices, Omar Mubin and her colleagues describe a user-centered approach to designing and evaluating a socially interactive mobile game for the elderly. They analyzed the requirements and identified three key design principles (Mubin et al., 2008): to design a game that encourages senior citizens to be more active in participation (both active and passive involvement), that requires them to interact with each other during game play and that has simple rules yet provides fun.

They found that the following attributes can be valuable to incorporate in game design for the elderly (Mubin et al., 2008).

- First, the game should include a natural tendency of audience building. The game should try to involve as many elderly players as possible. The game can have both active and passive participation, as not every senior citizen can play a certain game due to physical or cognitive limitations.
- Second, the target for any game for the elderly should be Minimum Rules and Maximum Fun. The elderly are very comfortable with uncomplicated rules, and they find simple games to be the most exciting.
- Third, the user experience of the elderly can be enhanced by playing known games with add-on's such as technology and new rules. This can make conventional and boring games more fun, interesting and enjoyable.
- To ensure maximum involvement of the community center, the participation of both males and females should be encouraged. Finally, the game environment needs to be customizable.

The socially interactive mobile games enhance social interaction and ensure fun and enjoyment. However, it is necessary to make sure that there are substantial perceived benefits for elderly users so that they are willing to invest their valuable time and energy in what could potentially be a rich and rewarding experience (Ijsselstein et al., 2007).

Although there are other projects devoted to developing games for the elderly (see, for instance Al Mahmud et al., 2010; Gamberini et al., 2007; Khoo and Cheok, 2006), the authors express the view that mobile phone games for older adults remain relatively understudied (Chu-Yew-Yee et al., 2010). This opinion is not specific to

Table 4

Example of the economic activity rates of older men in the UK (1951–2000%) (Duncan, 2003).

Men aged:	1951	1961	1971	1981	1990	2000
65+	31.1	25.0	23.5	10.3	8.8	7.9

mobile phones but can also be found about ICT: apart from these rather conventional leisure activities, ICT may also help elderly people to maintain their hobbies or even find new ones, especially if they are suffering from typical ailments that constitute hindrances. This is an opportunity that has not yet been explored (Gaßner and Conrad, 2010).

- Working life

As observed by Duncan, the decline in economic activity among older men represents one of the most remarkable labor market transformations in modern times, an international trend that has affected most OECD (Organisation for Economic Co-operation and Development (OECD)) countries over the last 20–30 years (Duncan, 2003). For several years, countries have experienced a trend toward early retirement. In parallel, ageism is found to be prevalent in employment. Table 4 shows an example of the decline in the economic activity of older men in the UK (1951–2000).

There are three major reasons why employers have not been more proactive in taking steps to retain their mature employees: many employers continue to hold negative stereotypical views of mature workers, resulting in age bias and age discrimination; we know relatively little about the retention of mature workers and what employment practices would encourage them to remain in the labor force; and there is also a lack of knowledge about how to develop and implement specific human resources practices relevant to mature workers (Armstrong-Stassen, 2008).

However, with the demographic change, older people are emerging as a major untapped labor source that could limit potential worker shortages and offset declines in Social Security. They typically bring maturity, dependability, and years of relevant experience to the workplace. Many people report in surveys that they wish to continue working after traditional retirement ages, their health status at older ages is generally better now than in the past, and many jobs are less physically demanding (Eyster et al., 2008; Munnell et al., 2006).

Several studies show that there are two types of cognitive abilities: one that involves the ability to master new material quickly and one that relates to accumulated knowledge, vocabulary and verbal skills. Laboratory and other evidence show a clear decline as people age in the first set of skills – the ability to master new material quickly – but no decline in the second. In fact, older workers have often accumulated substantial knowledge and devised efficient ways to do their work. Thus, older workers might be viewed as more productive (Munnell et al., 2006). Creativity also remains independent of age when given positive stimuli. Kristjuhan stresses that in 2009, the average age of the 10 world's richest billionaires was 70.5 years. Most of them were intensively working and rapidly increasing their wealth despite their age. Many of the billionaires are investors, an occupation that requires a great deal of experience. Entrepreneurs make up 85% of the working population over 90 years old in the United States (Kristjuhan, 2009).

On the other hand, the exclusion of elderly people from work due to their retirement often causes grave psychological and even medical problems, as they lose a central part of their earlier everyday life. Feelings of senseless, boredom or emptiness are possible consequences arising from this transition from working life to retirement. Moreover, the drop-out from working life may also cause severe social problems (Gaßner and Conrad, 2010).

Table 5
Comparison between “Human resource strategies” (Armstrong-Stassen, 2008), “Current Employer Strategies to Hire and Retain Older Workers and Strategies by Government and Other Service Providers to Boost Older Adults’ Employment” (Eyster et al., 2008) and “Older Worker Retention Strategies” (Rice, 2009).

Armstrong-Stassen (2008)	Eyster et al. (2008)	Rice (2009)
1 <i>Flexible work options</i> : providing flexible work schedules, a reduced work week, job sharing or providing options to work from home.	- <i>Flexible Work Arrangements</i> : part-time employment; job sharing; flexible work schedules, including flextime and compressed work schedules; telework arrangements; snowbird programs.	- Flex Time - Job Sharing - Shift Selection and Special Shift Schedules - Dual Worksite Programs - Telework - Job Redesign - New Positions - Work Reduction - Contract Work
2 <i>Job design</i> : providing challenging and meaningful assignments, creating new roles for mature employees, redesigning jobs or providing opportunities to transfer to a less stressful/strenuous job.		
3 <i>Mature employee training</i> : targeting mature employees for training to update their job skills or for training to acquire new skills, providing access to new technology that will assist mature employees in performing their job.	- <i>Training Opportunities for Older Workers</i> : Publicly funded training programs; Community colleges.	- Training
4 <i>Manager training</i> : providing age awareness training programs for managers or educating managers about effective ways to utilize mature employees.	- <i>Educating Employers on the Value of Older Workers</i> .	-
5 <i>Performance evaluation</i> : ensuring that mature employees have input in setting performance standards or providing mature employees with useful feedback about their job performance.	-	-
6 <i>Compensation</i> : offering incentives for continued employment, increasing financial compensation or improving benefits by providing more vacation time and additional time off.	-	- Customized benefits
7 <i>Recognition and respect</i> : recognizing the accomplishments of mature employees, the experience, knowledge, skills and expertise of mature employees, the role that mature employees can play or showing appreciation for a job well done.	-	-
-	- <i>Phased Retirement Options</i> : Deferred Retirement Option Plans; transition to part-time employment for older workers or hiring former employees as independent contractors.	- Pre-retirement Leave and Vacations
-	- <i>Helping Older Workers Find Employment</i> : Job and Career Centers; Employment Web Sites; Job Fairs; Job Counseling.	-
-	-	- Changing Legislation

A review of the literature enables us to analyze different strategies to retain older workers. Table 5 summarizes a comparison of different proposals.

Flexible Work Arrangements appear in all of the proposals. Among the recommended actions, telework is one of the most commonly mentioned strategies to enable older workers to work from home and to retain older workers. It enables flexible work options and job design strategies.

Working from home is suitable for older persons. It saves a great deal of time and stress. Most people can save several hours each day, allowing them time to be with their family. They will be less tired in the evening. These workers can thereby avoid the impact of negative social changes on their personal well-being in later life and therefore maintain their health better. Thus, many older individuals may be attracted to teleworking by the opportunity to supplement retirement income, others by health limitations, and still others by the opportunity to perpetuate their contribution to the economic fabric of society (Kristjuhan, 2009; Patrickson, 2002).

Previous studies reported that though many older workers recorded a more negative emotional reaction to errors, they also seemed more able to address these problems and more likely to

attempt to rectify by themselves rather than relying on co-workers. Such self-reliance is likely to stand them in good stead if working alone in a home-based environment (Patrickson, 2002).

Telework usage depends on the age of the user. The research showed that personnel younger than 30 years were using teleworking less, about 8 h a week. Personnel in other age groups teleworked almost twice as much. 50-year-old personnel seemed to be the most active teleworkers (15 h a week). Telework usage did not vary significantly between the ages of 40 and 70. Attitudes toward teleworking varied somewhat depending on age. Tired eyes were an overall problem, but it was more widespread in non-teleworkers. Fifty-eight percent of non-teleworkers complained of tired eyes (Kristjuhan, 2009).

Competent older individuals have the potential to become ideal teleworkers, although they may need to complete specialized training (Patrickson, 2002). As Gaßner emphasizes, it is crucial to develop concepts for a working life of elderly people that take into account social, medical and psychological aspects, as elderly people may suffer from a loss of earlier mental and physiological capabilities. Technological solutions to meet these needs and deficits, such as applications supporting or enabling work at home, may therefore be preferable (Gaßner and Conrad, 2010).

Mobile applications should be a technological solution to prepare and enable this new working framework, but to the best of our knowledge, they remain understudied.

- Final remarks

Although a single classification has been employed, most of the mobile applications apply to several categories; for instance, hobbies are related to health and wellness. Thus, in this study, it is necessary to apply a holistic point of view.

3.3.2. Mobile phone terminals

Some manufacturers design devices especially for older people; see, for instance [Auro-Mobile \(2011\)](#) and [Emporia \(2011\)](#). These devices are designed to facilitate their use to people with visual ([Owasys, 2011](#)), hearing or memory difficulties. The buttons of the keypad are usually large, and the volume can be adjusted to meet user needs (+30 dB) ([Doro, 2011](#)). Some models incorporate a flashlight to help users with visual difficulties ([Funker, 2011](#)). These phones usually offer an SOS button that automatically makes an emergency call to some predefined telephone numbers. A programmable reminder and task list help users to remember to do important tasks.

Other phones detect fallen and motionless states and make an automatic emergency call ([Doro, 2011](#)). These devices use motion sensors to indicate possible unconsciousness of the carrier if no movement has been detected in 5 s. In this situation, the alarm is triggered, making an emergency call to a number from the emergency list. Other relevant contributions from the use of mobile phones are more related to the possibility of using the location and motion sensors embedded in the device (as has been explained in Section 3.3.1).

Despite all of the features offered by these phones, these are closed devices that do not allow customization or the addition of new features. These are proprietary devices that are not created over an operating system (e.g., Android, iPhone, RIM). Thus, no external applications can be installed in them, and their functionalities cannot be improved.

According to [Armstrong](#), the use of Smartphones could eliminate some of the problems experienced by older users ([Armstrong et al., 2010](#)). Operating system-based Smartphones (i.e., iPhone and Android) allows the creation of customized applications that meet the users' needs and improve their quality of life. [Armstrong](#) enumerated some of the contributions related to the use of Smartphones with elderly people:

- Smartphone handsets now provide a large touch screen interface, allowing users to select preferred options; when these options are selected, feedback will then be given to the user via vibration or sound (user choice).
- Smartphone applications may be tailored or designed to meet specific user needs; if a patient wishes to have only a small number of functions available, an application may be created to facilitate this.
- Smartphone handsets are now the ideal size (not too big or too small) for users to hold comfortably and operate all functions.
- Smartphone applications may be created to increase the text size on mobile phones.

4. Discussion: status and trends

In the literature, there is a tendency to view the elderly as a homogeneous group, but the concept of "older people" refers to a diverse group: native people and immigrants, individuals with a university degree and those who have no specific training, and

healthy people and frail individuals. Thus, their needs and requirements to define "the good life" or "living well" can be diverse.

It is difficult to define the term "quality of life" for older people. Currently, there is no consensus on its definition or its measurement. However, after an analysis of the state of the art, it is possible to define a list of components that should be included. In fact, there is an emerging trend to consider physical, mental and social aspects. With this common framework, it is possible to analyze the role of mobile applications as a tool to improve the quality of life of the elderly ([Lee et al., 2008](#)).

There are several stereotypes about older people and ICT. For instance, "the elderly reject ICT" or "technological devices cannot be used by the elderly". An analysis of the existing data and the research works allows us to refute these fixed ideas. Specifically, elderly people think that mobile phones are more accessible than PCs and the Internet. In the early stages of mobile use, they appreciate the safety and security possibilities offered by the technology. Later, its use as a communication device increases, and the mobile phone is accepted into daily life.

There are different studies on the needs of elderly people using mobile services. From their review, it is possible to obtain a list of requirements and expectations related to feelings of safety and security, aids for memory and activities of daily living, communication functionalities, freedom of movement and enjoyment of a healthier independent life. Physical and mental decline involves specific barriers that should be considered in the design of the terminals.

Physical and mental decline is a cause for concern: within the "health-wellness" and "home care" domains, older adults are frequent users of technological solutions. There is an overall trend toward more personalized care. Several projects address the development of platforms that combine conventional health care and new supporting assistive technologies with home care solutions. Mobile phones are used either as a stand-alone tool or in combination with other technologies. This review of the state of the art allows us to conclude that the most commonly utilized functionalities are communication-based (phone call, SMS, etc.). However, a large number of solutions include standard mobile terminals that are not adapted to the needs of the elderly. Modifying this aspect could be an important improvement. In a similar way, the papers analyzed in the "Chores and Supply with Goods" domain show that the prototypes developed with standard interfaces can become frustrating. This is one of the points of improvement that we propose.

Mobile phones play a crucial role in the "safety-security" and "mobility" domains. Person location, tracking, tele-monitoring and alarm systems can be based on mobile functionalities or through integration with other devices. GPS-enabled functionalities and SMS are usually used in these applications. The authors exhibit a tendency toward combining multiple geo-positioning technologies to cover locations where conventional GPS alone would fail.

On the other hand, the use of mobile applications in the "hobbies" and "working life" domains has been understudied. These gaps should be filled. Data found in the literature indicate the benefits that games offer to the elderly (therapeutic, social, physical, cognitive, etc.). Moreover, the state of the art reveals the trend toward retaining older workers and facilitating the work of the elderly. Mobile applications could contribute to flexible work options and to support new job redesign strategies. Mobile applications for both hobbies and working life should be considered as future fields of research.

The "Information – learning – education" domain should be considered in designing solutions for older people. For instance, mobile phones can allow elderly people to stay informed or to use cognitive training applications. In previous works, studies were mainly restricted to PC applications. However, recall that the elderly con-

Table 6
Examples of mobile applications and functionalities that could improve the components of quality of life.

QoL components identified by older people (Brown et al., 2004)	Needs of older persons in our review (Section 3.2, Table 2).	Examples of mobile functionalities or mobile applications.	Notes: Status and Trends
Relationships/contact with others	Communication device	Communication functionalities: call, SMS, etc.	Their use can increase
Emotional well-being Independence/mobility/autonomy	Feeling safe and secure	Person location, tracking services, tele-monitoring systems, alarm systems, etc.	Currently mobile applications play an important role
Religion/spirituality		Prayer books, religious calendars, healing videos, daily audio podcasts, news updates, holy books recitations, religious ringtones, etc.	Future line of research
Social/leisure activities	Enjoyment, self-actualization	Games, e-Learning and training applications, etc.	Future line of research
Finances/standard of living		Mobile applications to facilitate or support flexible work options and new job redesign strategies.	Future line of research
Own health, health of others	Healthier independent life	Medication reminder, dietary, home platforms, e-health systems, ambient assisted living projects, etc.	Mobile phone is used either as a stand-alone tool, or in combination with other technologies

sider mobile phones more accessible than PCs. There are several research works showing that older people prioritize mobile phones over the PC option. Thus, mobile applications for “Information – learning – education” are interesting fields of work for researchers and manufacturers.

Although a single classification has been employed in this paper to analyze the role of mobile phones in the quality of life of the elderly, most of the mobile applications apply to several domains; thus, a holistic point of view should be applied to develop new applications. As conclusion, mobile applications are a powerful tool to improve the quality of life of the elderly, but they have not been sufficiently investigated. Table 6 shows the components of quality of life considered, together with examples of mobile applications that could improve them.

As a result of this analysis of the state of the art, several additional shortcomings have been detected.

- Although many authors try to promote the early user involvement in the development of information technology-related products for older people (Eisma et al., 2004; Gregor et al., 2002; Zajicek, 2004), they often do not participate in the R&D. Gaßner points to several reasons for this lack of participation: it is difficult to integrate the users into R&D projects because of their poor health; because they often are single, private persons who cannot be easily participate in projects; and because non-governmental organizations such as senior associations are often too far away from research orientation. Thus, ideas have to be generated about how to integrate users more effectively (Gaßner and Conrad, 2010).
- There are products tailored for elderly people in the market. They offer various specialized aspects or functionalities, giving rise to an improvement over the present default state. However, they use proprietary software. Thus, it is not possible to customize or widen their functionalities.
- The need for support and the need for training are two important motivating factors for mobile phone acceptance by older people. However, most technological research works do not deal with the need for training or support for older users. Both aspects should be considered.
- It should be necessary to provide evidence of the impact of mobile phones. Usually the methodology to assess prototypes is a questionnaire or interview. There are no standard established methods to evaluate the prototypes or the applications. The QoL measurement tools should also be applied in technological projects to provide objective and statistical evidence of the usefulness of mobile applications.

- According to the results found in this review, price and cost factors are relevant in the adoption of mobile applications by elderly people. Nevertheless, these data are missing in many research works. Similarly, it is not yet sufficiently clear how to turn research results into marketable products (Gaßner and Conrad, 2010). This point is particularly important to create an age-inclusive society.
- Mobile applications are promising tools to improve the quality of life for the elderly, but they can also lead to social and ethical risks that should be analyzed. For instance, Abascal summarizes the most critical of these risks: social isolation, lost of personal autonomy (services may lead to an invasion of their decision making capacity), loss of privacy and economic barriers (Abascal and Civit, 2001). Beckwith (2003) explains that reliable, inconspicuous sensing of personal information is problematic because users do not always understand the extent or methods of data collection. This fact becomes important when dealing with the elderly. For instance, in their work, Sixsmith and Johnson (2004) noticed a lack of understanding about the way technology works between people aged 65 and 82. In a complementary paper, Melander, Fältholm and Gard describe the experiences of elderly persons through testing a mobile safety alarm and their reasoning about safety, privacy and mobility. They found that the fact that the informants were located by means of the positioning device was not experienced as violating privacy as long as they could decide how to use the alarm [Melander, 2007]. At the same time, Beckwith (2003) points out that many people assume that sharing personal data such as location is only a problem for those involved in wrongdoing. Sixsmith and Johnson (2004) conclude that technologies should be used only where end users or their caregivers understand the technology and can provide informed consent.

5. Conclusions

Today, many different countries, including European states, the USA, and Japan, are aging rapidly; both the number and the percentage of elderly individuals are increasing. The creation of a cohesive and inclusive intergenerational society requires that technological products and services must be adapted to the needs and preferences of these citizens.

Mobile phones can be considered promising tools to improve the quality of life for elderly people. This work presents a review of the status of mobile functionalities and applications that can satisfy the requirements and needs of older people and improve their quality of life. The product and application groups that can be found most frequently are related to the “Health – wellness – and home care”

and “Safety – security – mobility” domains. Several authors conclude that the most beneficial services for the elderly in the future will be those that allow them to maintain their social relationships and health and give them the ability to live at home (Mikkonen et al., 2002). The trends point to the design of holistic frameworks that provide users with global solutions related to different components of the QoL models. Mobile phones are used either as a stand-alone tool or in combination with other technologies.

Current trends suggest that the society of the future will have more active and healthier older adults who will be physically able to work. In addition, the younger elderly who have had experience with mobiles in earlier phases of their lives will continue to use the mobile applications as they become retirees. Thus, the use of mobile applications will increase, and different utilities should be considered. Domains such as “Religion/spirituality”, “Hobbies”, “Information – learning and education” and “Working life” are likely to have a great impact in the future.

Despite the substantial body of research, there are still several needs to be met, for instance, the need to incorporate older users in the design of the products and services, the lack of customized phone terminals with open software, the need to consider support and training actions, the lack of standard methods to evaluate the impact of mobile applications, or the inclusion of price and cost aspects in the research. Social and ethical risks should also be analyzed and technologies should be used only when end users or their caregivers understand the technology and can provide informed consent.

This work will help developers, researchers, and manufacturers think about the unmet needs, developing trends and opportunities that mobile applications offer to improve the quality of life of the elderly and to support a cohesive and inclusive society.

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