ICT for elderly health and independent living
- opportunities & challenges

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Abstract

Introduction: Digital technologies are increasingly being used to assist older people to live more independently and better lives. The rapid increase in ageing population requires and enforces the development of adaptive technological products and services to improve the quality of life for the elderly. ICT has a huge impact on healthcare from both perspectives of delivering and providing accessibility to healthcare for elderly living independently at homes. The usability issues remain major concern for older adults as a challenge in adopting ICT solutions and services. The purpose of this study was to analyse the importance, role and impacts of ICT on elderly health, identify challenges in slow adoption of solutions and to develop a framework for better interfaces that meets the diverse requirements of older adults due to differences in physical and cognitive abilities.

Methodology: This research work presented the results of an interpretative research process that was applied to conduct literature review on relevant literature. The research work analysed the role and importance of using information and communication technology to support integrated healthcare services and independent living for the elderly population in remote, sparsely populated areas. The research work identified the importance of e-health, ambient intelligence, telemedicine, ubiquitous computing and smart homes in today’s digital world. The major constraints and challenges faced by older adults in using ICT effectively in the health sector was studied and a user adaptive interface was proposed as a solution to overcome some challenges faced by developers in developing health applications. To incorporate diverse user requirements, inclusive requirement design (for mobile interface) and universal design were discussed in the research work.

Results: The main conclusions are that ICT offers lots of potentials to support independent and healthy living for older adults. Several applications and tools already exist, however they are not user friendly and convenient for older adults. The technology has changed the paradigm of health care from general health care to self-care and prevention. Mobile, interactive TV, interactive games and Internet are utilized to improve cognitive, functional and social skills of older people. Usability problems seem to be the major issue for older people in adopting the latest technology and successfully interacting with them. The age related cognitive abilities have a huge relevance on system design especially for older people. To incorporate the diverse needs of older adults for the purpose of developing universal design is challenging to developers. User adaptive interface and inclusive requirement design model are suitable to develop more user-friendly applications and technology for older adults. Several social and legal issues are encountered when deploying health care systems. The benefits offered by technologies should be balanced with the privacy concerns of the user by utilizing strong policies for medical record storage, access and mining process. Encrypted databases, role based access control and proper authentication mechanism can be implemented to ensure privacy of patients.

Keywords
Information and communication technology, usability, eHealth, health care, population ageing, smart living environments
Foreword

Without a doubt, I remain thankful to all my teachers, family members, friends and everyone encouraging me to complete this work. It has been a very tight year due to my job commitments; pedagogy studies and thesis work all happening at the same time. Special thanks to my supervisor Adjunct Professor Raija Halonen for her kind words, supports and guidance throughout the entire research work. I would also like to express my gratitude to Mrs. Sari Hohtari, the head of degree program in Business Information Technology at Kemi-Tornio University of Applied Sciences (KTUAS), for allowing me a time frame to commence my master studies. I also express my gratitude to Juha Meriläinen, Senior Lecturer in KTUAS. He has been a wonderful person and a teacher of mine. Either it be my pedagogy studies or master studies, he has always supported and guided me. I feel lucky and privileged to come across this people who have had a great impact in my life. Last but not the least, Professor Petri Pulli (Research Opponent) also deserves to receive sincere gratitude as his comments and feedback were valuable to increase the impact of this research work.

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“No man needs sympathy because he has to work, because he has a burden to carry. Far and away the best prize that life offers is the chance to work hard at work worth doing.”

Deepak K.C.

Oulu, September 20, 2013
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1. Introduction

This chapter describes the purpose and motivation of the study. Prior research work related to the subject chosen has been explored in Chapter 1.3. Research questions, methods and contribution are explained in the corresponding chapters. The last chapter, Chapter 1.6 describes the structure of the thesis.

1.1 Purpose of the study

The purpose of the research work was to analyse the role and importance of using Information and Communication technology to support integrated healthcare services and independent living for the elderly population in remote, sparsely populated areas. The research work focused on the importance of e-health, telemedicine and smart homes in today’s digital world. The paper also discovered the major constraints and challenges faced in using ICTs effectively in the health sector by old people. The main aim of this research work was to identify the potential of ICTs to make major impacts in improving and supporting better health for the ageing population with the aid of various technologies and tools like television, mobile phones, computers and the Internet.

1.2 Motivation

Information and communication technology (ICT) is an integral part of health care today. The number and percentage of elderly people is increasing in several European states, the USA and Japan. The population of the European Union is ageing. According to the Eurostat, the population of elderly people aged 65 and over in the European Union was around 22.5% in 2005. The elderly population in this research work refers to the age group 65 and above. The share of people over 65 will increase to 30% of the total European Union population by 2020. (Eurostat, 2008.) This demographic change will have an economical and social impact on various areas like social, political and economic structures. The health care system will be affected heavily. The ageing population will increase the ratio of people with disabilities or chronic illness. The increase in multi-morbid disease pattern is common among the old people which requires extensive care in most of the cases, therefore increasing the levels of care required, requirements for more medical devices, services and pharmaceuticals. The health care system and social care are organized on national level and will have to cope with these additional requirements and increased expenses. Due to the rapid increase in ageing populations, the resources and manpower to support elderly health are inadequate. This requires and enforces development of adaptive technological products and services to improve the quality of life for the elderly. (Hussein & Manthorpe, 2005.)

ICT today has a huge impact on healthcare from both perspectives of delivering and providing accessibility to healthcare for elderly living independently at homes. The variety of ICT tools increase accessibility to home care and lead elderly people to live with chronic illness with gaining control over their illness and promoting self care. (Gabner & Conrad, 2010.)
1.3 Prior research

The improvements in the quality of health care, better social protections, better conditions of working and living have made the old age reality and have resulted in a huge number of elderly population. Decline in fertility rate and mortality rate are key driver factors for population ageing. The population ageing is expected to pose a serious challenge to health care systems in near future. The use of information and communication technologies can assist elderly living solution by generating new methods of diagnosis, prevention, treatment and care methods. ICT can be used to provide health care across geographical distances known as telemedicine. (Comyn et al., 2006.) The comprehensive reviews done on use of ICTs to support healthy living has proved to be efficient in terms of cost reduction, reduced travel times and quality of health services (Ekeland et al., 2010). Wide range of services and products are available for the purpose of observing small sets of physiological parameters to delicate behavioral monitoring of the elderly at home (Franco et al., 2010).

Technological and socio economic innovation can mitigate the challenges faced by ageing societies in Europe. Information and communication technologies intended for older adults are believed to play a significant role in the health care domain in coming years, which is also the motivation for the present study. Digital technologies are increasingly being used to assist older people to live more independently and better lives. Today’s digital society is governed and dominated by the use of ICT. ICT plays a very important role to support daily life activities. They also play a significant role to deliver, provide and help patients, doctors and pharmacists for better health solutions. (Gabner & Conrad, 2010.)

The low birth rates and higher life expectancy in European Union has remarkably caused the increase in elderly population. The proportion of older population will increase significantly in the coming decades. The trend of ageing will pose enormous challenges to Europe. ICT can help elderly people to live independently, improve the quality of life and stay healthier. The various ICT tools, services can address various elderly needs. Social Communication with the aid of mobile phones and video conversations can lead to solve the social isolation. Using the latest technology to lock or unlock doors, to report fires using fire alarms and to remind various other incidents that are difficult for an elderly person, can ensure the safety. Telemedicine can help easy exchange of information via electronic communication to improve elderly health status. Telemedicine will also reduce the involvement of normal clinical services and will ease to serve elderly population with better health consultations even in the remote areas. ICT contributes in the reduction of high expenses required in traditional medical services. It also contributes in the independent living of elderly by providing customizable solutions to improve living standards. (Anderson, 2010.)

Senior citizens to make use of ICT applications and tools face several challenges. The research work has discovered various existing challenges and methods to mitigate them. The lack of willingness to adopt technology among elderly users, skills, and motivation are common barriers prohibiting elderly population to make the efficient use of ICT tools and applications. The increase in physical impairments like vision and hearing are some obstacle among elderly person causing difficulties in utilizing available eHealth services. The user interface is one of the key issues to be considered while designing an application for this group of elderly people (65 or above). Health related ICT applications are being developed constantly. The various health care systems already exist however the adoption of such technology and system is relatively slow in health care industry. It is extremely essential to improve productivity so as to avoid several
challenges posed by ageing population. The demand of the services will increase rapidly and at the same time the decrease in labor force emphasizes the important role of ICT to support elderly health. (Broder, 2004.)

The evolution in medical technologies and various other changes like the change in demography, culture, social and globalization has confronted the health care systems with new situations, subsequently requiring new solutions. The ultimate goal today is delivering best possible health services for anyone at any time from anywhere. This becomes realistic by applying the achievement gained in information and communication technology in civil healthcare. The ICT can support delivery of healthcare and exchange of health care information across distance. (Wotton et al., 2006.)

The use of ICT makes rapid access to remote and shared medical expertise. The investigation, management and monitoring of patients using Information Systems is required where distance is considered as the critical factor. WHO defines e-health as “delivery of health care services by all healthcare professionals using information and communication technologies where distance is a critical factor”. Therefore, e-health can be defined as medicine at distance. The huge involvement of electronic communication systems has made various organizations like WHO, European Space Agency (ESA), International Telecommunication Union (ITU) to officially adopt the denomination of eHealth which refers to the use of modern information and communication technologies to address the health care needs of citizens, patients, health care professional, health care providers as well as policy makers. (WHO, 2010.)

1.4 Research question and Research Methods

Several studies are conducted to address the problem of ageing population (Harrefors et al., 2010; Snowden et al., 2010). The prior research work mentioned in Chapter 1.3 clearly highlights to analyze the importance of ICT to support elderly health along with the challenges faced by the elderly in using available services and solutions. An elderly is under-considered in the technology and is referred as a “non technological person”. The substantial amounts of studies contend this stereotype. There is no any clear evidence that indicates the rejection of technology by older people. They accept technology like everyone else does, provided that their needs and expectations are fulfilled. (Conci et al., 2009.) The sensory and various other cognitive changes due to ageing makes an elderly to approach technology in a different way than younger people. The few researches conducted on the area of importance of ICT for elderlies, technology adoption or acceptance by elderly people demands for further research and studies on this area clearly justifying the importance and need of this research work. (Renaud & Biljon, 2008.)

To conduct this research work, the following research questions were chosen:

- How can ICT support elderly people for better health and independent living?
- What are the constraints and challenges in using current ICT health solutions?

Based on the formulated research questions, the paper analyzed the importance of ICT on elderly health, current trend in consumer health services and solutions with a focus on elderly people. A systematic literature review of health related ICT services and solutions was conducted. The specific needs of the elderly population were studied based on the various literatures and EU projects. The conducted study has helped to identify the major constrains and challenges faced by the elderly people to use the
available services and solutions. The research work projected and highlighted the importance of ICT to support elderly health. The research work analyzed the role and importance of using ICT to support integrated healthcare services and independent living for the elderly population in remote, sparsely populated areas.

1.5 Research contribution

The research work highlighted the importance of e-Health, telemedicine and smart homes in today’s digital world. The paper identified user interface as a major challenge in making effective use of ICTs by old people. To mitigate the challenges and diverse requirements of elderly people, the research work contributed user adaptive interface to support better health and independent living for elderly people. The research work justified the major impacts of ICT in improving and supporting better health for the ageing population with the aid of various technologies and tools like television, computers, mobile phones and the Internet. The major contribution of the research work is an analysis of ICT tools, services and solutions through an architectural route.

1.6 Structure of the study

The thesis is structured into sections. Chapter 2 introduces the research methodology with detailed information on research methods, literature review process and research approach. Chapter 3 presents a literature review on the core concept for studying impacts of information and communication technologies on health care. The impact of ICT on remote consultation, dissemination of public health information, smart phone applications and health services aiding for independent living for elderlies are described. Chapter 4 is focused on the study of ICT based solutions such as smart homes, telemedicine and interactive games intended for elderly to support independent and healthy living. The usability issues faced by elderly in using current technologies are explained in chapter 5. A solution to identified challenges and difficulties studied in chapter 5 are addressed by proposing a framework in Chapter 6. Chapter 7 analyzes the overall findings and discussions on the research work. The last chapter, Chapter 8 includes the conclusion of the thesis, practical implications, limitations of the study and implications for future research.
2. Research approach

This chapter explains the research topic and research methods applied in this research work. The literature review process applied in the research work and the overall research approach are explained in this chapter.

2.1 Research topic

The purpose of the research work was to analyse the role and importance of using Information and Communication technology to support integrated healthcare services and independent living for the elderly population in remote, sparsely populated areas. The research work focused on the importance of e-health, telemedicine and smart homes in today’s digital world. (see Healthcare, 2004; Cheek et al., 2005; Malanowski et al., 2008; Gatzouulis and Iakovidis, 2007.) Another purpose was to discover the major constraints and challenges faced in using ICTs effectively in the health sector by old people (see Aula, 2005; Nugent, 2007). To investigate the purpose, following research questions were built:

*How can ICT support elderly people for better health and independent living?*

To answer this research question, the following aspects were investigated based on the literature available in relevant databases mentioned in Chapter 2.2:

- The impacts of ICT on health care in general and the role of ICT in Remote consultation, dissemination of public health information and ambient assisted living for elderly people were studied. (Alvarez, 2002; Jerant et al., 2001; Nymo, 1993; Hartviksen & Rinde, 1993; Chan & Chan, 2011; Thompson & Brailer, 2004.)
- Smart phone applications for both health professionals and patients were identified to support the statement ICT for better health and independent living. (Warner, 2011; Stroud et al., 2009; Mosa et al., 2012; Gamble, 2009.)
- The study also focused on identifying ICT based solutions specially targeted to support elderly health by studying different dimensions such as interactive games for elderly people, eHealth and telemedicine, mobile applications to support health and assisted living solutions via interactive TC for elderly people. (Malanowski et al., 2008; Ruoppila, 2003; Oksman, 2006; Comeau, 2005.)

*What are the constraints and challenges in using current ICT health solutions?*

The other aspect of the research work was to identify constraints and challenges in using current ICT health solutions (Armfield et al., 2012). To achieve this goal, each of the solution mentioned in the research work was studied in depth from the usability point of view and analyze issues that was prohibiting those solutions from being user friendly to elderly. Based on the study of challenges and constraints, user adaptive interface has been proposed as a solution to overcome challenges faced by elderly people in using ICT health solution. (Vasilyeva et al., 2005; Langley & Hirsh, 1999; Jameson, 2003; Bental et al., 2000.)
2.2 Research methods

Conceptual analytical method with a detailed review of literature was applied as a research method in this research work. The conceptual analytical method provided a framework for the better understanding of the topic and to develop new themes that assisted in providing suitable analysis to the defined research questions. The current research work was built upon previous researches concerning the impact of ICT on health, challenges faced by elderly people in adopting latest technologies and adaptive framework for elderly people with different physical dis-abilities. The study of previous researches (Healthcare, 2004; Cheek, Nikpour & Nowlin, 2005; Malanowski et al., 2008; Gatzouolis & Iakovidis, 2007; Aula, 2005; Nugent, 2007; Haux et al., 2008) done on the similar topic contributed to draw rational conclusions and derive new theories and concepts. (Järvinen, 2001.) Conceptual analysis was conducted to analyze the concept, variables associated with ambient assisted living, e-health, definitions, hypotheses and theories.

To answer research questions, an interpretive approach was applied for the purpose of conducting literature review. The interpretive research process started with the existing knowledge and pre-understanding of the phenomena. Understandings are then further elaborated by gaining more knowledge on the subject area. The potentials for interpretations are expanded. The interpretations conducted helped to gain a deeper understanding of the phenomena. (Walsham, 2006.)

The interpretative research process can be explained as a hermeneutical circle. The whole process can be categorized into phases. Figure 1 (see Tamminen, 1992 for more details) exhibits different phases of hermeneutical circle. Information is acquired and interpretation potential is expanded during the absorption phase. During the theory-building phase, the most relevant research related factors are discovered and interpretations are built. (Tamminen, 1992.)

![Figure 1. Hermeneutical circle, interpretative research (Tamminen, 1992).]

The attempts were made to understand the whole theme by grasping parts of the theme and comprehending the meaning of each part to divine the whole theme. Cyclic and repetitive studies of each part or aspects of the phenomenon do the objective of gaining a growing understanding of the phenomenon. (Butler, 1998.) Using the concept of hermeneutical circle, the object of comprehension or phenomenon to understand was recognized as a whole because each separately studied part was integrated in the whole to define the theoretical and conceptual aspects of the thesis work. The overall process involved acquiring information, studying the identified research phenomenon, contextualization of each part and integrating them into the whole thesis work. (Bontekoe, 1996.)
2.3 Literature review process

The essential part of literature review is gathering and analyzing literature based on the main themes of research (Brereton et al., 2007). Conducting a broad review of each literature helped to select the relevant literature. The literature included handbooks, journals, conference papers and articles on the web that helped to gain practical and theoretical relevance. The relevant literature included information associated with the main theme of the research work that is to analyze the importance of ICT and to identify the usability issues. (Hart, 2001.) The research work was further supplemented with literature on ambient assisted living systems, e-Health, telemedicine, health information dissemination, chronic care, behavioral telemonitoring and effectiveness of telemedicine. The literature review process made easier to identify the current state of study in the selected area of research. Through literature review, the role and importance of using ICT to support integrated health care services and independent living for elderly were analyzed. The literature review along with informal discussions led to the identification of major constraints and challenges faced by elderly people in using the current service and solutions. The usability issues were identified and user adaptive interface was proposed based on the literature review. A systematic literature review is a mean to identify, interpret and evaluate all currently available research that are relevant to a specific research question, topic area or a phenomenon of interest (Kitchenham, 2004). The graphical representation of the literature review process implemented in this research work is presented in Figure 2 (see Kitchenham, 2004 for more details).

![Diagram](https://example.com/literature_review_process.png)

**Figure 2.** Literature Review Process.

The systematic review process began with the definition of a review protocol to specify the research questions as mentioned in Chapter 1.4. Relevant studies (Healthcare, 2004; Cheek, Nikpour & Nowlin, 2005; Malanowski et al., 2008; Gatzioulios & Iakovidis, 2007; Aula, 2005; Nugent, 2007; Haux et al, 2008) were identified and pilot study was conducted to include or exclude the findings. The appropriate databases/sources were
identified and searches were run on all relevant database and sources. Appropriate
citations were saved every time a new relevant literature was discovered during the
search process. The differences and theme of each literature was studied deeply to
extract data or relevant information for this research work. The collected literature and
data were interpreted and presented. (Pai et al., 2004.) Search strategies were defined to
detect as much of the relevant literature as possible. Several keywords such as E-health,
Digital technology, ageing population, telemedicine, smart-homes, ambient assisted
living and usability were used to collect relevant literature. The databases such as IEEE,
ACM, SPRINGER and ELSEVEIR were used for searching relevant journals and
articles. The process of collecting literature, analysing them to fit within the scope of
research work went through a cyclic process. Each selected relevant literature after the
retrieval from the databases was also searched in the Google Scholar to analyse its
impact. The most cited literature as recorded by Google Scholar was given more
importance in-comparison to less sited literatures. On the other hand, less cited
resources were also studied to depth and utilized whenever the literature was identified
within my research scope and subject matter studied. The same technique was applied in
filtering several retrieved articles for a particular keyword.
3. Impacts of ICT on health care

The paradigm in the health care has shifted from medical services to disease prevention and promotion of health. Health promotion and prevention help to avoid a majority of diseases, stroke and diabetes. The new paradigm in health care requires the application of ICT, which has an impact on many aspects of health care. (Chan et al., 2009; Raad & Yang, 2009.) This chapter describes the most important aspects of ICTs on health care such as remote consultation, dissemination of public health information, co-operation and collaboration among health-workers by using various ICT tools and remote monitoring.

3.1 Remote consultation

Geography plays a significant role in the future development of health systems. The majority of the population in European Countries like Finland is concentrated in a few urban areas while a significant proportion is scattered in several smaller isolated communities. These factors have posed serious challenges in the provision of high quality, accessible and equitable health care services. The effects of geographic isolation and low population densities can be reduced by utilizing ICT to provide a mechanism that offers sharing of health information and medical support, remote data access, treatment and diagnosis. (Alvarex, 2002.)

Remote consultation in this chapter refers to a method via the use of ICT tools that can be applied for the purpose of remote medical consultation to diagnose or treat patient at remote sites from the medical professionals or the patient. The consultation can be collecting diagnostic data, transmitting the diagnostic data to the remote location or communicating treatment and diagnostic information to the patient. The different types of chronic diseases that require more time to heal but need continuous monitoring and consultation to identify vital signs can be benefited by the use of ICT tools for remote consultation. Elderly monitoring is challenging due to the lack of caring to elderly by their family members. The modern automated equipment helps to monitor elderly in their homes and constantly provide vital information to their physicians. (Jerant et al., 2001.)

Nymo (1993) has described remote diagnosis as the diagnosis based on transmitted information by medical experts. Remote consultation is the extension of the concept to include treatment of patients through the telecommunication network. The invention of the telephone started the initiation of different attempts to transmit heart and lung sounds to heart specialist for the purpose of assessing the state of the organs. The poor transmission system then was a reason for failure. However, the rapid development of ICT in recent years has made remote consultation more effective. Health services in any country are divided into a hierarchical structure. The centralization in health care services delays the health care processes often involving long waiting time and long travels which eventually leads to unequal distribution of health services. In this situation, the decentralized health care services with the use of ICT tools for remote consultation can evade the geographical limitations, reduce the long waiting time and need for long travels by patients. Nymo concludes that remote consultation reduces face-to-face contact and several diagnoses can be performed via the use of ICT tools or telecommunications.
Adopting telemedicine improves health care services in the remote parts of the country. The use of software applications such as Skype provides audio-visual interaction that ameliorates the isolation of health care services in remote areas. (Hartviksen & Rinde, 1993.) The elderly seem to be more reluctant to use communication tools. According to a survey “Consumer and the communications market: 2006”, age remains to be the crucial factor influencing the use of ICT tools for communication. (Panel, 2006.) Digital televisions are seen as mainstream and accessible to elderly than the Internet. Elderly people accept video enabled communication methods well to communicate with various health professionals. Remote consultation reduces the inconvenience and discomfort of travelling to and from hospital and is found acceptable by elderly patients. A patient or the patient’s family can initiate a remote consultation to seek opinions from the health specialist or can request additional assistance to care. Remote consultation is a win-win concept for the patient, their families and health experts. (Rinde et al., 1993.)

Skype is a free application that is commercially available and used widely. The easy installation process and proper graphical user interface makes it one of the favorite tools today for voice or video calls. The compatibility of the Skype with all types of hardware and operating systems like Windows, Macintosh and Linux gives it a significant advantage over other communication tools. Skype requires a web camera and a microphone for video calls. The minimum requirements for video calls is a broadband connection with a minimum of 128 kilobits per second download and upload speed. Skype uses username and password as an authentication method. Skype also provides users with an opportunity to send photos, videos and file of any size. (Skype, 2013.) Skype can be used as a tele-consultation tool to arrange appointments at short notice without the need of traveling to the hospital for scheduling appointments. It can be ideal in situation where physical presence is not necessary such as reporting satisfactory laboratory results. The recent studies concerning the use of Skype for clinical tele-health has produced unclear risks and benefits. Many case studies done were not able to produce any firm evidence for or against the use of Skype. The poor Internet security may result in the compromise of patient confidentiality. The security concern however can be addressed by the use of secure VoIP systems. (Armfield et al., 2012.)

The wider usage of social media networks such as Facebook and Twitter provide opportunities for free and instantaneous communication to large audience. Both of these social networking tools can be used on mobile phones, laptops, tablets and PCs. These tools can effectively be used to address similar types of patients with health advices and tips for better health. Figure 3 (see Chan & Chan, 2011 for more details) describes the process for social media tools to reschedule appointments.

![Figure 3. Twitter Facebook Process. (Chan & Chan, 2011).](image-url)
All patients are notified when a message is posted in Facebook or Twitter in a group or page they are subscribed. Clinics can establish a social media presence and encourage patients to subscribe to their updates. The social platform can be used to communicate last minute availabilities offer to prospective patients to fulfill appointment vacancies, which were cancelled. The patient then can communicate to take up the offer. The platform provides an excellent opportunity to find a new replacement patient instead of rescheduling other appointments by notifying prospective patients and hence increasing the possibility to fill appointment at very short notice. (Chan & Chan, 2011.)

3.2 Dissemination of public health information

Information technology has the potential to transform health information over a public network. Web-based technologies provide a framework to disseminate healthcare related information. Various technology models are currently being assessed for better provision to exchange and disseminate health information. Clinical information systems, laboratory systems, radiology systems and administrative systems are some common health related applications. The investment in ICT solutions for healthcare purposes has increased with the evolution of technology. (Thompson & Brailer, 2004.)

Health care services require sharing data between various entities and ICT solutions within the healthcare community for better provision of health care services and quick access to previous diagnosis information. The Internet has made the proliferation of healthcare information possible that also requires providing accurate and timely information to health care consumers. Web has been widely used to search healthcare related information. The Internet and web-based technologies together can provide a framework enhancing secure and reliable dissemination of healthcare related information. The web-based solutions offer several benefits in the dissemination of healthcare information. The use of single framework eases maintenance task, provides a single access point to view information and simplifies remote access. The deployment and learning curve are easier as many people today are familiar with websites and Internet browsers. (Murray, 2002.)

Portals are built upon layers of services and component modules. The layered architecture offers flexibility to emphasize or de-emphasize various services and modules based on the need of an organization. This is extremely important as different health care organizations offer different types of health care services and the use of technology also varies within these organizations. The openness of web-based technologies allows an evolutionary approach to shift towards the new solution. The universal access to information for health workers is a prerequisite to achieve health for all. (Godlee et al., 2004.)

ICT supported tools enable co-operation and collaboration among health workers. ICT tools are used to handle information and produce them to transmit, archive or store. They reduce time, distance and the information gap increasing the scope for faster and wider interaction among health workers. The lack of access to information is a major barrier in knowledge based health care system. The effective use of ICT can change the current situation by making health related information efficiently available to health professionals. (Westbrook et al., 2009.) The content and the format of the information need to be standardized so as to present information that is compatible with different type of ICT systems used by different health related organization. Technical infrastructure should not be a challenge. The development of disease management information and care records should accommodate data from myriad databases in several formats. These data should be easily exchangeable through different
communication mechanisms such as FTP (File Transfer Protocol), fax or across the web. The cloud based computing model is an option to simplify the challenge of exchanging data. Cloud-based solutions provide faster cheaper and faster delivery of application development, images, data, security and optimized infrastructure. (Microsoft, 2010.)

The electronic networking provides a means of disseminating health related information for the purpose of learning as well as creates an opportunity for virtual conferences for health professionals who are not able to attend the conference in person at a very low cost. The forums and social networking tools can be used to attract participation of people to access basic health information that can be shared on daily basis. Electronic processes bring health information into broader forums that have influence on daily practices, wider audiences such as international organizations and policy-makers. The isolated health workers working in remote settings often work alone and have very littler or zero access to updated information. There are very little possibilities to exchange experience with colleagues. The use of latest technologies such as personal digital assistants (PDAs), smart phones and other handheld devices enable health workers in remote settings to share and retrieve health information, store and capture health data. They can also link their experiences with other co-workers that significantly improve their practices and outcomes for patients. (Godlee et al., 2004.)

3.3 Health care applications for smartphones

The rapid advancement in the technology has impacted in the size of electronic devices. The electronic devices are getting smaller and smaller but faster. These transformations have made mobile devices in the forefront of health care. Health professionals, physicians and consumers are comfortable using various technologies such as smartphones, social networking sites and various mobile devices. Health information technology is focused on providing patient-centered health care. The goal of the patient-centered health IT is to help patients communicate properly with their providers and give them access to information at any time or place. Mobile devices in current times have already offered a variety of tasks within the health care domain. The improved disease management, public health collection, dissemination of epidemic and disaster data, ad hoc access to expert consultations from remote places, booking appointments and appointment reminders are some of the services available to both consumers and health professionals. (Warner, 2011.)

Smartphones combine the functionalities of advanced mobile communications and portable computation capabilities. They are also capable of running third-party software. The adoption of smart phones by health professionals and general public has increased in recent years. (Garritty & Emam, 2006.) A number of health care applications are available for both health professionals and general public. As a health professional, one can use a smart phone application for the purpose of disease diagnosis, medical calculations, drug references, clinical communication, medical training and other various general health care purposes. Disease diagnosis applications are used to access diagnosis and treatment information on a smart phone. The printed medical references for disease diagnosis are available on smartphones that provide information on diagnosis, treatment and medications. These applications provide easy to use graphical user interface, search functionalities and easy navigating. Drug reference applications available for smartphones provide information on drug’s name, dosages, pharmacology and cost. According to a survey, drug reference applications are the most useful of all applications. (Stroud et al., 2009.)
Medical calculation applications are also available for smartphones. They are generally used to calculate clinical scores and indices like body mass index (BMI). The application provides an interface to input required parameters to calculate scores by using a standard formula without the need for a practitioner to know the actual formula for calculating a score or index. Health care professionals can use literature search applications to search biomedical literature database to find relevant medical reference information. Databases such as PubMed/Medline and Essie are searchable with the help of smartphone applications. (Mosa et al., 2012.)

Smartphones support different types of communication methods such as voice calling, text messaging, video calling, multimedia messaging, email messaging and conferencing through the mobile phone service provider. In addition to these normal communicating tools, various applications such as Vooalte One and Amcorm Mobile Connect combines the features of phone calls, alarm alerts and text messaging. These applications have the capabilities of separating critical messages from less important ones. Specialized applications such as mVisum for cardiology that receives alarms, ECGs, monitor data and lab results are also available for smart phones. (Gamble, 2009.)

The mobile-based system such as LAMECS (Location Aware Medical Care Services) provides possibilities to inform about the situation to the health service providers quickly and efficiently in the mobile-based networking environment. The system uses GPS technology to provide location-based service that helps patient to receive treatment. The system processes the request received and identifies the nearest available mobile doctor who is then assigned to the affected person. (Vogel et al., 2013.)

Some useful smart phone applications described in various scientific papers and journals with their functionalities are listed in the Appendix A. As in the Appendix A, there is a diversity of applications available and also the platform supported. Most of the applications listed are free and some of them cost 1 dollar to 100 dollars. Several other applications for the purpose of training, retrieving electronic health records and monitoring food calories are also available for smartphones. The use of various applications in smartphones eases communication in critical care environments and provide access to clinical resources for better health care. The mobility of these devices allows health professionals to use them for patient care. (Lottridge et al., 2007.)

Application for smartphones such as pill reminder, VizWiz, Read2Go, and Dragon Dictation are listed as important applications for older people by Guardian news. Pill reminder, an application for iOS helps older people to take their medications in appropriate time and proper dosage by sending messages through PUSH alert. Dragon dictation is a voice-recognition application allowing users to dictate email and text messages. (Guardian, 2013.) The VizWiz another application for iOS is intended to help people with poor vision (partially sighted users). This particular application allows taking a picture with their mobile phone and receives multiple spoken answers. The application is intended for people with visual problems and is nearly real time. (Bigham et al., 2010.)

Mobile applications assist older people and their families in lost situations by using standard mobile terminals with GPS and compass device. This solution is based on the use of a mobile social network where caregivers and other family members are informed about their current location and if needed the device is capable of initiating a communication. (Calvo et al., 2009.)
The usage of mobile phones among people aged over 65 is increasing rapidly in the recent years. Several studies have proved this statement. According to a survey, 58.5% of the people between 65 & 74 years old in Italy use mobile phones (Conci et al., 2009) while another study suggests 60% of the people of the same age group use mobile phones in the United Kingdom (Kurniawan, 2008). In Finland, 70% of Finns aged between 60 & 70 own a mobile phone (Oksman, 2006). For older people, mobile should support personal communication, act as a means for social integration and provide a sense of safety that empowers old people to remain at home. It helps them to maintain quality of life and independence. (Plaza et al., 2011)

3.4 Summary

ICT has a huge impact on health care and plays important role in disease prevention and promotion of health. Remote consultation helps to improve health care services in the remote parts of the country. Use of applications such as Skype provide easy audio/video interaction and has been proved to be an ideal solution to deliver successful lab results or other health related information where physical presence is not required. Social media networks such as Facebook and Twitter reach large audience and provides opportunity for free and instantaneous communication. Health care providers can use social media to provide general health care advices, last minute availabilities and other health related information. The ICT provides a platform to deliver health information over a public network. Various tools and technologies are under consideration and assessed for exchanging and disseminating health information. Use of technologies also assist health care providers in delivering health care services as well as acquiring information about patients. The increase trend of using mobile phones among elderlies makes mobile phone as a medium to support elderly health. Several mobile applications are available for both health professionals and patients. Mobile phones provide the feeling of safety and act as a communication tool for elderly people. The ambient assisted living systems and latest technologies are important aspect in creating a cohesive and inclusive society.
4. ICT based Solutions for elderly health

Chapter 3 explained the impacts of ICT on general health care. This chapter is focused in identifying the major ICT based solutions mainly targeted for old people to support independent living and better health. The chapter describes major terminologies such as eHealth and telemedicine, smart home as a solution for older people to achieve independent living, interactive games for the purpose of maintaining healthy life and assisted living solutions via interactive TV for old people.

4.1 Independent living for elderly

Ambient assisted living allows elderly people to live independently. The ambient assisted living systems monitor elderly who wish to live alone and independently. The development of innovative ICT products, systems and services provides opportunities to improve the quality of life, social life participation and autonomy. They also reduce the cost of social and health care. The activity patterns change with age. The levels of activities drop in elderslies and the mobility is reduced. Elderly becomes more concerned of their personal care and limit their activities to their homes. The technology-assisted systems such as automated heating regulation, automated light in entrance area and motion detectors have eased the life of elderly. (Malanowski et al., 2008.)

The European Commission-funded MOBILATE project investigated technology based solutions to simplify the life of elderly people at home. The ICT based products and services, multimedia applications, games, e-newspapers are currently being developed and provided to meet the need for leisure activities of elderly people. Visual and hearing impairments are developed in many elderly people that demand for the devices or technologies to compensate such sensory impairments. Reading lenses, intelligent electric magnifiers and electronic assisted IT systems are currently available to assist elderly living. (Ruoppila, 2003.)

Living independently demands high level of safety at home for elderly people. The decreases in certain mental and physical abilities demand the provision of technologies within homes to prevent accidents and make elderly people feel safe. To ensure the high level of security, several security applications such as locking systems, alarm systems and surveillance systems are deployed. These systems should be capable of detecting falls and similar problems on elderly persons. The domestic accidents can even result the death of elderly people when supporting personals become un-aware of these types of situations for a longer period of time. Ubiquitous computing and context awareness is practiced in recent times by means of sensor networks with distributed data processing to acquire data regarding elderly home activity. The context aware techniques process sensor data and continuously analyze the context an elderly is involved in. (Botia et al., 2012.)

Mobile applications and tools are implied to improve the quality of life for the elderly. Mobile phones are accepted as an integral part of everyday life. The significance of the mobile phone as observed by Oksman (2006) in the early stages of mobile usage is increasing security. Elderly people perceive mobile phones as memory aids and as tools to provide a sense of safety and security. (Oksman, 2006.)
According to Sorri and Leinonen (2008), elderly consider ICT positively when they support every day activities; matches elderly’s needs and are easy to use. Older people prefer to live independently. The assistive technology (AT) enables them to live independently. Assistive devices such as telephone, smoke detector, social alarm, walking stick and door entry phones are used in older people’s home for assisting elderly to live healthily and independently. (McCreadie & Tinker, 2005)

Assistive technology can be defined as any device or system that eases or allows an individual to do certain task that they would not be able to do. AT are supportive, preventive and responsive. (Beech & Roberts, 2008.) The artificial intelligence can help elderly, particularly with the cognitive decline (Pollack, 2005). Bodine (2007) found that ICT could help isolated elderly to connect with the world around them, easy access to health, information, entertainment and social interaction. It enables elderly to contribute via websites, email and chat rooms. It also offers the possibility of life long leaning. (Bodine, 2007.)

The AT slows the physical decline of the elderly people (O’Brien & Mac, 2009). According to O’Brien and Mac Ruairi (2009), ATs can be divided into three categories: event driven, continuous and trend analysis. Event driven ATs act in reaction to events, continuous systems are used if a person decides to use on his own will and trend analysis solutions are used to monitor the person. Table 1 explains AT categories.

Table 1. AT categories (O’Brien & Mac Ruairi, 2009).

<table>
<thead>
<tr>
<th>Categories</th>
<th>Application Types</th>
</tr>
</thead>
<tbody>
<tr>
<td>Event Driven</td>
<td>Fire sensors, Fall detection, Security alarms</td>
</tr>
<tr>
<td>Continuous</td>
<td>Hearing aids, walking aids, object locator</td>
</tr>
<tr>
<td>Trend Analysis</td>
<td>Location tracking, monitoring,</td>
</tr>
</tbody>
</table>

Event driven assistive systems start to react only when an event/accident has occurred. The smoke detector starts to produce alarm right after detecting smoke in the room. Fall detection and fire detection are event driven systems. Continuous systems help elderly people to carry out normal routine. Walking aids with the aid of robot suit helps elderly to walk. Hearing aids, walking aids and object locators are continuous assistive systems. Trend analysis assistive systems monitor elderly people’s activities and vital signs. The observed or the input results are stored in databases that are accessed by the required professional to provide quick support and services. General monitoring, health monitoring and medication monitoring assistive technology fall under the trend analysis category. (O’Brien & Mac, 2009)

ICT is considered as an important tool to create cohesive and inclusive society. New terms such as “Gerontechnology” has been introduced in the recent times that refers to the technology intended to meet the needs of an aging society. The specific research areas in gerontechnology include the home and independent living, home care, health care and support to caregivers. The technology usage should ensure safety and security to the elderly people. (Comeau, 2005.) Health related issues such as sensory impairment, falls, isolation, medication management and diminished mobility can be solved by utilizing ICT solutions that ultimately promotes safe and healthy living of elderly people. (Demiris & Hensel, 2008.)
4.2 eHealth & telemedicine

The introduction and proliferations of e-terms during the 1990s brought new dimensions in the field of communication (email), business (e-commerce) and health (eHealth). eHealth promised the use of information and communication technologies for better health and health care systems. (Alvarez, 2002.) eHealth includes Internet and other technologies to provide health care services. The main purpose of eHealth is to make effective use of technologies in providing health care services, maintain the patient’s record electronically and effective user interaction with the health care system. eHealth is not restricted only to the usage of computers and other technological devices by health care professionals. (Wilson, 2005.)

The European Commission is focusing on using ICT to support the life of ageing people, improve health services and provide better public health services for more than two decades. The main focus is on sustainable healthcare and ICT based solutions for independent living. The European Commission defines “eHealth as a mean to provide quality health services and information to individual’s own health records online from anywhere in Europe”. (Health-EU, 2013.) The purpose is to build secure health networks that give secure access to vital health related information for health professionals in any member state. Peer-to-peer communication between patients’ and/or health professionals, improved and efficient data transmission between health service providers are significant features eHealth brings into the dimension of health care services. The European Commission also defines eHealth as health information systems, electronic health records, any wearable equipment, telemedicine services, portable and communicable systems and any other equipment that monitors and helps patients. (Oh et al., 2005.)

eHealth refers to the use of variety of tools, applications, devices, health information databases, availability of health related information to people over the Internet and the implantation of devices in the human body to get complex bio-signal data. It also refers to the health care practices that are supported by health information technology, electronic devices, processes and communication and exchanges of health information. (Wilson, 2005.)

Telemedicine can be defined on the basis of four different contexts: medical, technological, spatial and benefits (Sood et al., 2007).

1. Medical context: The medical perspective of telemedicine is providing health care services.
2. Technological context: This context explains the use of technology in delivering health care services. The use of technological tools such as interactive audio-video tools for communication verifies the technological perspectives of telemedicine.
3. Spatial context: Telemedicine is meant to address the geographical distance between patients and doctor, hence highlighting the geographical separation between health care service providers and patients that indicates the spatial perspective of telemedicine.
4. Telemedicine provides access to medical care at remote places where people cannot get to medical care, thus addressing the uneven distribution and shortages of medical resources that justifies the perspective of benefits.

Telemedicine involves wide scope of technologies ranging from simple email services to complex remote surgical technologies, employing robots. It is a modality of
healthcare delivery that uses technology as its prime component. It is intended to bridge the geographical gaps by using tools such as communication technologies, Internet, GSM (Global System for Mobile Communications), computer networks and satellite communications. The main goal of telemedicine is to deliver healthcare services and medical education to different locations that addresses challenges like uneven distribution of health facilities and lack of health professionals. (Sood et al., 2007.)

eHealth tools and services are for citizens, health care professionals and health care providers. They support several tasks such as information sharing, administrating, monitoring and reporting. The wide range of eHealth tools supports efficient delivery of health care services to citizens. A report by WHO, global observatory for eHealth has identified important eHealth tools for citizens. They are: patient information systems (PIS), hospital information systems (HIS), general practitioner information systems, national electronic registries, national drug registries, directories of healthcare professionals and institutions, decision support system (DSS), geographical information systems (GIS) and picture archiving and communication systems (PACS). Appendix B explains each of these systems briefly. (WHO, 2005.)

EHealth tools can encourage people to adopt healthy habits and have the potential to promote health, disease prevention and early detection of various diseases. Various eHealth services with the aid of technology can provide consumers with relevant motivational information reinforcing people to adopt healthy habits and get rid of key behavioral factors such as improper dieting habits, drug use, alcohol use, tobacco use and many other problematic life styles. (Kreps, 2010.) Services such as e-Prescription, health cards, health portals, patient identifiers, portable communication systems, personal wearable, online health information services, online diagnosis and telephone consultation offers lots of potentials and opportunities for older people to live their live healthily and independently. e-Prescription system helps old people with a possibility to accessible pharmacy twenty four hours a day. Health card such as the kela card in Finland is an alternative to health insurance vouchers. The use of various health portals helps elderly to seek information about health care. Patient identifiers make accurate identification of patients and provide fast paced medical care as in some situations identification of patients become challenging. Patient’s wristbands for older people help health professionals to check their medical records and proceed with further treatment and medication. (Sahar & Asim, 2009.)

The ambient intelligent technologies support every day activities for older people. In many cases, elderly require emergency services and rapid health assistance. Delayed calls and late medical services can lead to hospitalization forcing elderly people to move into nursing homes, thus affecting their independent living style. Personal wearable and portable communicable system can send the real time information and situation of an elderly for fast medical helps and treatment. (Sahar & Asim, 2009.) Wearable systems include different types of miniature sensors and are also implantable. The biosensors used in the wearable systems can measure various physiological parameters such as blood pressure, heart rate, body-temperature and respiration rate. The obtained measurements are then transferred to the medical center via personal digital assistant (PDA) or any other technical devices and enables better health and quick health services for older people. The wearable technologies are able to detect the early signs of health deterioration, notify critical situations to health care providers, provide health care services to remote locations and assist elderly people to live independent life. (Pantelopoulos & Bourbakis, 2010.)
The technological advancements have made telemedicine services accessible outside the clinic and hospital and provide the freedom for patients to be anywhere at home or at work. The telemedicine services allow physicians for remote diagnosis. The health care websites enable people to access information on food and diets, vaccinations, health promotion, detection and prevention. Low potent medicines can be ordered via online pharmacies thus reducing the travel time for older people to pharmacy for buying some low potent drugs. The eHealth and telemedicine cover a wide range of accessible health care services and information to the citizens. They play significant role in maintaining, reporting and monitoring elderly health. (Sahar & Asim, 2009.)

4.3 Smart Homes for elderly people

An ageing world demands good health and independent living (see 4.1) for as long as possible. The elderly people can be assisted twenty-four hours with the aid of numerous smart devices in their own homes instead of hospitalization. Smart home is a promising concept that has potentials to improve home care for elderly in a non-obtrusive way. Smart homes allow greater independence, prevent social isolation and maintain good health for elderly people. Various sensors, monitors and actuators are included in a smart home. These devices are connected to remote health care center via network and collect data for processing to initiate remote diagnosis or provide quick health services to the patient. The wearable or implantable technology helps to monitor people twenty-four hours a day both inside and outside the house. Smart home is a residence that is equipped with technology and is able to monitor its inhabitants for better as well as to maintain independence during old age. (Chan et al., 2009.)

The home care technologies play a major role in home-based care approach. The performance improvement and drop in cost of embedded systems has resulted significant growth in the number of Internet enabled appliances, mobile devices, smart phones, PDAs and various other devices. The pervasive computing explored methods to install smart devices that function without the intervention of the user. Ubiquitous systems are designed to be everywhere: smart homes, smart offices and others. Numerous sensors embedded inside the wall or under the floor enable an elderly to adjust the light level, room temperature and monitor the home safety. The intelligent devices in a networked smart home allow the access to a variety of controls from a remote location using a browser or other appliances. (Raad & Yang, 2009.)

An ‘aware home’ based on ubiquitous computing is a smart home built in the United States. Aware home is capable of recognizing potential crises and assist elderly people with declining memory. Smart homes developed today such as “Gator Tech Smart House” are based on sensors. They are for the purpose of elderly comfort, security and safety, fall detection of an elderly, reducing social isolation and physical monitoring such as weight and temperature. Smart homes are also equipped with features that monitor and control energy expenditure, provide entertainment, help in learning and communication. The environmental control technologies help to control locking of doors, windows and curtains. In case of emergencies, the sensor sound alarms and reports the incident to the support center. The infrared sensors that are embedded in the ceiling of a smart house can monitor the mobility and activity of an elderly. The various assistive technologies aim to use information technology to facilitate communication between health service provider and elderly people. (Kidd et al., 1999; Intille et al., 2006; Demongeot et al., 2002.)

Home intelligence combines automation service, home network service, and Internet service. It also includes various devices and is further extended to include situation
aware automation and context aware automation by utilizing ubiquitous technologies. The emphasis is to offer personalized services in smart homes that require offering people with varieties of needs affecting various aspects such as security, monitoring, home automation, entertainment and health care. The ubiquitous technologies used in smart homes are required to be context aware to adapt them to rapidly changing circumstances and situations. The advancement made in the sensor technology has made it possible to develop eHealth systems and services to serve the elderly and disable people. Smart homes offer a smart environment that continuously monitors elderly during the movement around home and sends an emergency call in case of a severe fall, accident or major health problem. (Raad & Yang, 2009; Park et al., 2009.)

Smart homes adopt the concept of ubiquitous sensoring. The sensory data collected by sensors used in smart homes are analyzed to recognize the normal pattern of activities performed by the elderly. The activities analyzed are daily life activities such as preparing a meal, dressing, bathing and taking medication. The recognized patterns of activities reflecting physical and cognitive health conditions are captured and whenever the recorded pattern deviates from the normal, the situation might indicate problems which is then reported to make necessary intervention and solve the issues faced by elderly. Video cameras and RFID technology are simple binary sensors used throughout the home for the purpose of direct environmental sensing to provide valuable insight about actual activities and contexts. Binary sensors are the most common types of sensors used in smart homes. They detect the movement or state of an object in single digit either ‘0’ or ‘1’. Motion detectors or pressure sensors help to discover the presence or absence of an individual at home. (Ding et al., 2011.)

Video cameras used in smart homes produce rich source of information for both human observation and computer interpretation. The video surveillance however raises privacy issues. To maintain the privacy, Tabar et al. (2006) employed a wearable accelerometer that is capable of detecting falls. Based on the accelerometer signal, the video recording is triggered and real time image processing is used to analyze the data and estimate the position of an occupant. This helped to conserve the privacy of an elderly as it did not transmit visual data and also reduced the number of false alarms produced by sensitive accelerometer signals. (Tabar et al., 2006.)

The different sensor technologies mentioned by Ding et al. (2011) were demonstrated in the laboratory settings. It is essentially important for the sensor technology to address actual and diverse needs of all stake holders including elderly people, their family members, care givers and physicians. There are not enough evidences to prove the use of sensor technology in smart homes that are effective to detect changes in daily routines. The sensor technology requires a series of further study to address clinical, technical and ethical aspects before being integrated into people’s actual homes and clinical environments. (Ding et al., 2011.)

The objective of the smart home is to monitor elderly whereabouts at home for their relatives to make sure they are all right and to report to health care service providers incase of trouble. Another objective is to continuously capture vital signs of an elderly and allow physicians or caregivers to interact with the smart home. They should also allow monitoring and controlling certain functions in the home like lights, room temperature, locking doors and security to provide comfort and safety for the elderly at home, initiate emergency calls in critical cases and permit video or audio communication. The smart objects, sensors, actuators and various other technologies assist elderly people to live in their homes by monitoring and delivering remote care services. The model of a smart home as described by Raad and Yang (2009) is
mentioned in Appendix C that demonstrates the use of sensors, devices such as camera and other appliances in a smart home. (Raad & Yang, 2009.)

4.4 Interactive games to support quality living for elderly

The use of interactive games in the existing health system by incorporating technologies such as the Nintendo Wii games console can support elderly people to stay physically and mentally active. The remote care system in addition to monitoring their vital sign health parameters should also help them to engage in a series of interactive games. The interactive technology should enforce an elderly to directly interact with the technology. The system should also keep track of vital sign thresholds such as blood pressure, heart rate, pulse rate and respiration rate. It should create historical record of elderly people’s fitness level. This information should then be accessible to health care providers. (Gamberini et al., 2008.)

The Wii console, Nintendo Wii is a video game console that consists a wireless controller, the Wii Remote. The Wii Remote is used as a handheld pointing device and detects movement in three dimensions. There are over thousands of Wii games that can be installed on the Wii console. This provides possibilities for seniors to select their favorite sport and play on the Wii console under a nurse’s instruction. Sports like baseball and golf games with the use of Wii Remote can help seniors to exercise their waists and arms. Several game controllers like dancing carpet available in the market as the game controller are other possibilities. The elderly people can use dancing carpet as the game controller and dance on the carpet to exercise their knees, toe muscles and calf. The Nintendo balance board also called the Wii Fit is another game controller for the feet. Seniors can use these games and play Yoga or any other games of their choice to improve their physical and mental health. (Nintendo, 2013; BJHCIM, 2008.)

The Wii Remote resembles a TV remote; therefore it makes it easy for elderly to control the Wii Remote, as they are familiar with a TV remote. It also enables elderly to participate sports they once used to play which can help to keep their minds active. Various researches have stated that mental stimulation postpones the onset of dementia and may reverse the process. (Lawrence et al., 2010.)

The Nintendo Wii is an ideal tool for an elderly that allows playing games with normal human movements. The use of interactive technology to the existing system offers huge amount of mental and physical training benefits. Besides, interactive technology contributing on the physical health, they also help seniors to improve their mental health. Playing games help seniors to release their mental stress, forget their loneliness and depression. Playing games together could help lonely elders to make new friends. The nature of Wii makes it suitable for care homes, as they can be adapted to suit users of varying abilities. The opportunity offered to play as individual or in groups can help them being active socially and compete against each other. The game based applications can also be used for therapy and rehabilitation of elderly people. The interactive ICT solutions like the Wii game console are proved to improve elderly people’s cognitive abilities. They take care of psychological problems illness and social isolation. (Gamberini et al., 2008; Gamberini et al., 2006.)

Declined lower limb functionality in an elderly has adverse effects on elderly people. It prohibits an elderly to perform various leisure activities, increases the rate of falls and leads to an overall decline in the quality of life. Lower limb muscle training is a method of rehabilitation. An interactive video game based rehabilitation device (LLPR) is used to train lower limb muscle power in the elderly. The LLPR system has a computer
system and a uniaxial force plate (Appendix D). The power training includes a video game, which is controlled by single click of the left mouse button. The subject, an elderly stands in the middle of the force plate and starts to complete continuous squat movements as the game progresses. The threshold for each elderly is set up in the beginning of the training and is increased on regular basis based on the progress made. This exercise improved muscle power and balance in elderly that allowed them to perform various activities requiring movements and balance. It also reduced the rate of falls. (Chen et al., 2012.)

The advanced visualization and interaction interfaces in video games help to improve the functional, cognitive and social skills of older people. The mixed-reality platform offered by the interactive games has shown positive impact in health outcomes for older people. Eldergames is a EU funded project that aims to develop interactive games and tools for elderly to preserve cognitive function impaired due to ageing. Ageing causes various physical and psychological problems. The loss of memory, linguistic impairment and cognitive deficits are common problems among elderly. These problems result social isolation, loneliness and depression. The latest advancement in the technology and interactive games provide an opportunity to help elderly to rehabilitate and improve cognitive, mental and physical strength. (Gamberini et al., 2009.)

4.5 Assisted living solutions via interactive TV for elderlies

Elderly people have access to information and communication technologies and use them. TV is one of the major tools used for the purpose of leisure activity by elderly people. A large proportion of elderly people spend their time watching TV. Therefore, TV sets are very well suited platform to improve the quality of life of elderly people. (Eizmendi, 2007.) The tailored interactive contents and services allow active ageing of elderly. TV can be used as an alternative to deliver complex ICT services to elderly people, as elderly people are more comfortable using TV in comparison to computer smart phones and other intelligent devices. (Stojmenova et al., 2007.)

Philips Motiva is an example of interactive TV based telemedicine platform. Motiva is a remote patient management technology that monitors patient’s progress outside the hospital. It promotes self-management and also facilitates two-way communication between patients and their care providers. TV based systems deliver personalized healthcare content and help care providers reach to more patients. They enable behavioral change of patients via daily-personalized interactions and engaging contents, which are delivered via broadband connection to the television set. (Philips, 2005.)

Social isolation in elderly has negative impacts on their general health. Lack of social relationship is one of the cause and risk of mortality in ageing. TV based services can foster social interactions among elders to promote better health and longevity. TV is more acceptable to elderly people than any other medium of interactions like computer. TV is used frequently and gives the feeling of not being alone to elderly people. Several social TV systems exist today but they are still in beta versions, on a conceptual stage or are limited to lab prototypes. Interactive TV systems such as Social TV, Windows Media Center, NDS Social TV, Collabora TV, ConnecTV are capable of voice communication, texting, chatting, video conferencing, context awareness, TV recommendations and ratings with the television set. (Alaoui et al., 2012.)

Smart TVs available today are becoming more interactive. They perform like a computer and availability of several applications for TV have enriched functionality.
beyond the normal watching paradigm. TV is used for web browsing, sharing data, social communication and watching personalized content. (Vatavu, 2013.) Smart TV is the combination of traditional TV and personal computer. The new trends in TV have opened an alternative to provide elderly people with various services enabling them to improve their quality of life. Smart TV services include information service, healthcare service, learning service and social network service. The better-designed TV services are more acceptable to elderly people, thus TV assisted solutions can be efficient and more user friendly to elderly people. (Trinh et al., 2012.)

4.6 Summary

This chapter concludes that the various ICT related solutions such as eHealth, telemedicine, smart homes, interactive games and interactive TV are beneficial and supportive media to support independent living for elderly. TV is the most common device used by elderly among others. The functionalities of smart TV provide an opportunity to shift the normal watching paradigm of TV to offering various health related customized services, browsing and communicating. Smart homes reduce the hospitalization of elderly by offering twenty-four hours monitoring services and emergency help whenever needed. Interactive games help to improve cognitive, functional and social skills of older people.
5. **Constraints & challenges**

This chapter is intended to discover challenges faced by elderly people in using current information systems and technologies. Usability issues are addressed in the Chapter 5.1. Chapter 5.2 describes challenges encountered by elderly in adopting different health care services, applications and mobile technology.

5.1 **Usability issues**

As mentioned in the Chapter 3 and Chapter 4, ICT and related technologies play important role in monitoring, managing and delivering health care services. Smart devices, applications and various other appliances are used to motivate or remind people to take medication, adhere to diets or to exercise. Technology has transformed the normal health care paradigm to emerging eHealth services. Smart home health technologies provide family members and care providers the capability to remotely monitor the wellbeing of an older adult living independently in their homes. (Chan et al., 2009; Raad & Yang, 2009.)

Despite the availability of several applications and tools for elderly to support health, the adoption rate of technology among elderly people in many countries is not as expected. The perceived value of technology-enabled tools and applications are not meeting elderly requirements. Usability remains a major issue in adoption. The user friendliness remains a challenge for older people to find this technology helpful and usable. The digital divide among older adults and the lack of proper technical efficacy is also a barrier to adoption. (Coughlin et al., 2007.) Therefore, in-order to fully exploit the potentials of eHealth applications and services, the acceptance and usability issues of eHealth applications need consideration (Arning & Ziefle, 2009).

**Usability**

Usability is a quality attribute that defines the level of easiness to use an interface. It also refers to methods that are applied to improve ease-of-use during design process. Usability is an important aspect to produce quality application and interfaces that are easy to use, learn, remember and provide customer satisfaction with no or minimal errors. (Nielsen, 2003.) The five-quality components that define usability are:

1. **Learnability:** The level of easiness to learn an interface when encountered for the first time.
2. **Efficiency:** It defines how quickly a user can perform tasks once he has learned to use an interface.
3. **Memorability:** It explains easy to remember design. When users return to the design after a certain gap, it is about how easily they can regain proficiency in using the interface.
4. **Errors:** The number of errors encountered when performing a certain task, severeness of the error and ways to recover from the errors.
5. **Satisfaction:** The satisfaction level when using an interface.

The decline in intellectual skills, memory impairment and deteriorating visual activity due to ageing affect ability of an older people to make proper use of standard graphical
user interface. The deteriorating visual ability in old people makes the graphical user interface difficult or impossible to use it. Most of the interfaces available today rely on conceptual models that force an older adult to remember sequences of actions to perform a task or sets of tasks. The memory impairment in elderly people affects remembering ability and they become unable to build conceptual models for performing a task. (Zajicek, 2001.) Therefore, special attention and several important factors are to be considered when designing an interface for older adults with various physical impairments. The interface should support related difficulties or physical impairments of an elderly. (Arning & Ziefle, 2009.)

Lehoux (2004) explains the user friendliness of a technology depends on the proper settings between human and technical features, the context and various variables. The technical dimensions such as physical properties (size, appearance, weight), functionality (usefulness, complexity, how well it fits with the task), “systemness” (power source, supplies) and safety (when using it) affect the use of technology. These dimensions are co-related with human dimensions such as skills, knowledge, autonomy, attitudes and social values that decide the user-friendliness of a technology. The better adaption and consideration of both technical and human dimensions result in the production of interfaces that are acceptable and user friendly to all. Figure 4 represents the relationship between technical and human dimensions that influences user acceptance. (Lehoux, 2004.)

![Figure 4: Technical and human dimension shaping the user-friendliness of a technology (Lehoux, 2004).](image)

The technical and human dimensions affect the user friendliness of any system or application. The user friendliness defines user acceptance. Many users accept better interface. The proper settings and balance between technical and human dimensions define the user friendliness of a system. Human dimensions such as skills and knowledge of user, self image and social values are to be considered when designing an application or system so that users are able to perform required tasks in a system with out any complexes. (Lehoux, 2004.)

The “assistive technology” and “universal design for all” are two type of design concept that address some of the issues faced by elderly due to various physical and mental impairments. Assistive technology can enhance the functional abilities of older people and help them perform their daily activities and routines. (Hirsch et al., 2000.) The computer aided assistive technology provides a wide array of opportunities for an elderly to bridge gap caused by the decrease in functional ability (Zajicek, 2001).
Universal design or design for all is a concept to design (computer) technology that meets the global requirements of individuals with different requirements, preferences and abilities. The designs are adaptable in a variety of contexts. The HCI universal design recognizes social values and abilities. It tries to accommodate the possible range of human requirements, abilities and preferences in the design of all computer and technology related products or services. This paradigm of design is not about a single interface for all, rather it is a design solution that suits the broadest possible end users. The design can be used to design computer technology for elderly to address the diverse needs in this group of people. (Stephandis et al., 1998.)

Demiribilek and Demirkan (2004) suggest an USAP design model (Appendix E) to design and develop safe and effective products to promote and maintain independent living of the elderly. The USAP (Use-ability, Safety, Attractiveness Participatory) design model consists of five phases of design model to transform the concept into an artifact with determined functions. The conceptual phase involves both designers and elderly participants. They work together to produce ideas and define their exact needs and preferences. The elderly users are motivated to propose a design in various design sessions that are recorded in videotapes. (Demirbilek & Demirkan, 2004.)

Designers analyse the problem in the second stage of the concept development phase and prepares a feasibility study. Designers then try to discover an optimal solution to the problem that satisfies requirements and proposals of the elderly users. The next phase is the concept refinement phase. During the concept refinement phase, conceptual design solutions are presented to the elderly users. They are asked to express their opinions and necessary changes are made based on the feedback to refine the design. The third phase is intended to develop a prototype and in the fourth phase, the elderly users conduct the trial of the prototype of the designed artifact. Comments, new ideas and suggestions are noted to create knowledge domain for similar projects. In the production phase, the artifact is manufactured and provided to the consumers. (Demirbilek & Demirkan, 2004.)

5.2 Privacy issues

Technologies provide several benefits in the health care domain. Remote monitoring and video surveillance is technically feasible however several social and legal issues are encountered when deploying health care systems. The benefits of these technologies should be balanced with the privacy concerns of the user. (Davies & Gellersen, 2002.) The mobile-based system LAMECS (Location Aware Medical Care Services) explained in Chapter 3.3 utilizes GPS technology and informs where about of individuals to provide location-based health care services (Vogel et al., 2013). Data being transmitted from in-home sensors and medical records through the Internet poses several risks of compromising the privacy of individuals. The sharing of personal health care information between health care professionals over the public network exposes confidential data to more hostile attacks. The health information being available in electronic form open the door for attackers and hackers that increases the possibility of unauthorized access to personal information. (Meingast et al., 2006.)

Personal medical records stored in medical databases can be stolen, altered, intercepted and misused. Data being easily accessible is more vulnerable to attack. Security of health data is crucial. They are closely connected to ensure the reliability, integrity and confidentiality of the data produced and used. Standards for medical databases, explicit definition of ownership, detailed security and privacy rules are to be enforced when implementing medical systems to ensure the privacy of user. Health authorities are
trying their best to improve security and privacy of health care records through data standards while many are struggling to meet these requirements. This requires a detailed privacy and security rule that are to be implemented in all health related systems and applications. The enforcing mechanism is also required to monitor the implementation of these rules and standards. (Zineddine, 2011.)

In addition to following the standards, to ensure the security and privacy of health related information, there should also be clear policy concerning data access, storage and data mining. The data ownership should be clearly defined and data edition permissions should be allowed to limited health care professionals such as the doctor in charge of a patient. In case of remote monitoring, aggregated data can be utilized for the purpose of diagnosis while the raw data can be stored locally at the patient’s residence. The aggregated data can be transferred to the monitoring center for further diagnosis and health care assistance. The raw data or extra information is of less relevance on patient care and also may compromise the individual’s privacy. The collected data and information should have clear policy about storing this information. Information can be stored in centralized or decentralized databases. Further research work is required to identify the proper database type for storing data obtained from remote monitoring sites and other health records. (Meingast et al., 2006.)

Data mining raises privacy and security constraints as in the data mining process, several data is analyzed to identify a pattern or relationship. Thousand of electronically stored medical data exists currently. The data mining done on this information has security and privacy concern however the different formats of data and the scattered data all over different databases in several medical care systems restricts the proper analysis or mining process. The increases in medical records require a proper governing body to explicitly define the mining process. Rules and regulations are to be enforced to maximize the benefits from readily available medical data but at the same time respecting the privacy of individuals from whom the data is collected. Role based access control that is one gets access to medical data and records based on their role, encrypted databases, proper authentication mechanism, proper policies of data storage, policies on patients privacy at home and data mining rules are to be developed and practiced in order to respect the privacy and security of medical records. (Meingast et al., 2006.)

**Role based access control**

Role based access control can be used to prevent unauthorized access of data and information. This mechanism regulates access to computer, network or resources based on the individual’s role in an organization. Roles are defined according to the authority, responsibilities and job competency within an organization. Roles are easily created, modified or deleted depending on the organizational need. (Ferraiolo et al., 1995.)

**Encryption**

Encryption is the process of converting data from a readable form to “chiphertext” that cannot easily be read or understood by unauthorized people while decryption is the process of converting cipher text back into its original form. The use of encryption methods while transmitting and storing medical records ensures the security of data and prevents eavesdropping and skimming. Encryption is extremely important when sending or receiving critical information over public and wireless networks. To achieve high level of security in health care information systems, encryption can be applied in hardware as well as in software. Symmetric and asymmetric key algorithms can be utilized to provide encryption in software. (Diffie & Hellman, 2006.)
Proper authentication mechanism

Proper authentication mechanisms are required to ensure the data being originated from an authentic source it is claiming to come from. Authentication algorithms such as passwords and digital signatures are designed for information systems. The sensor network utilizes more energy efficient authentication algorithm such as the hash function for the purpose of authentication. (Meingast et al., 2006.)

5.3 Challenges

Elderly people differ from each other by age, sex, degree of impairment, income, education, religion and culture. The users’ awareness, expectations and practical experiences are to be considered when designing and developing new solutions that are supporting independent living for elderly people. The technology has to be accessible and usable by older population as well as people with various disabilities. Elderly people have particular user requirements due the various impairments like hearing, seeing or controlling ICT equipment. This characteristic of elderly people prohibits from defining a standard technological solutions, which has to be more customizable and adaptable to the particular needs of different people. (Gaßner & Conrad, 2010.)

The interactive games mentioned in Chapter 4.3 faces several challenges in incorporating into remote care, as they do not provide the elderly person with patient specific information. They are not able to capture the physiological parameters such as heart rate and blood pressure and report to the systems in remote care settings. These kinds of interactive games are to be integrated into the overall health monitoring system so as while the senior is playing a game like golf, there should be a possibility to capture the heart rate and report to the system. In case of his heart rate being increased over a certain threshold, the game should pop up a warning and produce an alarm to notify caregiver. Special user interfaces designed for elderly people must support an easy-to-use user experience. As not every elderly people are acquainted with computer systems and playing games, the interaction is to be made as intuitive as possible. The users’ lack of computer knowledge or possible mental impairments enforces to an account management system that is intelligent enough to recognize users automatically and informs their exercise program. The face recognition technology can be integrated in the gaming system to provide automatic sign-in. The usability of the system is the major challenges and the system becomes successful only if the elderly can handle these interactive games with ease. (Lawrence et al., 2010.)

Despite numerous mobile applications intended for elderly as mentioned in Chapter 3.3, elderly people use mobile phones for limited purposes like calling and texting. On average, they make five calls and send or receive two text messages per week. Small screens, problems related to displays, too small buttons and characters causing them to select wrong characters frequently, difficult menu options, unclear instructions and too many functions are major hindrances faced by elderly in using mobile phones. Mobile phone designers focus on physical disabilities mainly visual but often seem to ignore other disabilities in elderly people due to reduced cognition. (Kurniawan, 2008.)

The limited knowledge about interfaces among adult users is another major problem prohibiting the use of mobile phones by elderly people. The interfaces are complex due to rapid updates and upgrades as well as new features. Young users easily adopt the new interfaces based on their prior knowledge while older adults need to apply more effort to learn a new interface. (Pattison & Stedmon, 2006.)
The user adaptive interface and framework mentioned in Chapter 6.1 has been implemented only in some systems (Paymans et al., 2004). HCI researchers are skeptical to the concept of utilizing intelligent user interfaces in the ICTs supporting health. The previous failures of artificial intelligence, the lack of transparency and predictability are some major reasons for researcher to be skeptical concerning the whole concept. (Jameson, 2003.)

The perceived usefulness and ease of using a system are major components of technology acceptance (Davis, 1993; Venkatesh et al., 2003; Van der Heijden, 2004; Arning & Ziefle, 2009). Technology acceptance depends on several factors (experience, cognitive abilities, demographic variables, personality factors), especially for the older people (Saadé et al., 2005; Wilkowska & Ziefle, 2009; Turner et al., 2007). The learning history and experience with technology among older people is a crucial factor. The positive or negative experience affects the technology acceptance when encountering a new technology. Older adults perceive technology less useful as they weight the perceived usefulness against the time required to learn to operate a system. (Wilkowska & Ziefle, 2009.)

The individual parameters is not only the factor affecting technology acceptance among older adults, the usage context (compulsory, optional, medical reasons) and usage motives (health related reasons) of eHealth applications also determine the technical acceptance. The elderly acceptance of eHealth applications in comparison to common ICT tool is different, thus demanding research work to explore the complex picture of acceptance factors. (Wilkowska & Ziefle, 2009.)

A recent study found that older people perceive Internet as a useful source of health related information. The study indicated the readiness of elderly to use web services to seek health related information however the usability problems in health related website is a major hindrance for them to adopt web technology. The older adults made more errors and were unable to recover from these errors. Usability problems are related to input device design, operating procedures, screen design and complex commands. (Czaja & Chin, 2007.)

Elderly people with decline cognitive abilities (memory and spatial abilities), less technological expertise and experience (computer knowledge) face even more challenges in accepting and using technology (Chappell, 1999; Ziefle, 2011). Seniors are more critical concerning usability issues. Seniors accept technologies: when the benefits of system usage are clear and transparent and they are provided with clear guidelines or comprehensive support such as tutorials, manuals or help systems. (Melenhorst et al., 2001; Ziefle, 2009.)

Elderly use computers for very specific tasks like emailing, contacting others, writing and self-learning. They consider ICT non-relevant to their lives. An elderly does not recognize ICT as a universal need nor an attraction. (Selwyn, 2004.) They even perceive ICT as non-sense (Mikkola & Halonen, 2011). Elderly consider technologies more relevant when they support safety and independence. Technologies such as system monitoring the house and control access, embedded technologies providing real-time information, devices supporting long term and short term memory and devices promoting physical activities are desired by older adults. They however do not want technology to isolate them and the technology should allow older adults to express themselves. (Sorri & Leinonen, 2008.)
5.4 Summary

The advancement made in technology has not been able to build the gap between old and young users. The digital divide exists due to age differences. Usability problems often prevent older people from successfully interacting with technologies. The age related cognitive abilities have a huge relevance on system design. The lack of proper technical efficacy is a barrier to the adoption of technology. The technical dimensions and human dimensions are influencing user acceptance of any system or design. Assistive technology and universal design for all try to address some usability hindrances to design technology meeting all types of requirements. The USAP design model can be implemented to design ICT products and services that are targeted for older adults.

To maintain the privacy and security of health information and various medical data, several policies and standard practices are required. The policies should clearly define the data storage process, ownership and the data mining process. Role based access control, encryption, proper authentication mechanism and several polices are needed to ensure the privacy of patients.

Despite the opportunities offered by ICT to promote independent living and health of an elderly there are several challenges encountered. The cognitive abilities of an old user are major hindrances to accept technology. The usability issues force them to avoid the use of technology. The interactive games as explained in Chapter 4.3 is proved to be useful however is challenging when it has to be integrated into the health monitoring system. Mobile applications are used for limited purpose only. Seniors accept technologies when the benefits of system usage are clear and transparent. Proper guidelines and tutorials help elderly to learn a new system. The acceptance of eHealth applications in comparison to other applications is different and requires research work to explore the acceptance factors.
6. Framework for better ICT solutions

This chapter aims to mitigate challenges faced by elderly in using ICT solutions. It also aims to discover methods that are best suitable, user friendly and acceptable solutions for elderly people. The adaptive user interface described in Chapter 6.1 tries to address challenges faced when developing ICT solutions for old people due to diverse needs and requirements of elderlies. Sensor nodes, artificial intelligence and speech control are identified as alternatives to normal human computer interaction process to avoid various problems caused due to physical impairments in elderlies. The user centered mobile interface is present as a solution to develop mobile interface for elderly people.

6.1 Adaptive user interfaces for eHealth

The different individual abilities, interest and needs are major challenges in developing eHealth Information Systems. The adaptive user interface approach can be utilized to address this challenge. The health service providers need to make sure the information systems are not only up to date and accurate but also easy to understand and use by heterogeneous group of patients. The medical experts and patients have different demographical, psychological and cognitive characteristics. This enforces personalization of the content and representation of providing information. The information needs to be in various forms like text, graphics, audio and video to communicate with different users having different characteristics. This diversity of users utilizing eHealth points out to the necessity of user interface adaption. (Vasilyeva et al., 2005.)

According to Langley and Hirsh (1999) adaptive user interface is defined as “a software artifact that improves its ability to interact with a user by constructing a user model based on partial experience with that user” (Langley and Hirsh, 1999). The physical impairments of individual users are taken into account so as to allow them to use an information system more efficiently with less errors and frustration. Adaptive systems can be categorized into adaptive and adaptable. Adaptable user interfaces provide users with an opportunity to customize, hence making it more user friendly. The adaptive interfaces on the other hand personalize the system automatically without explicit user commands. The system in this case is dynamically generating individual user interface. (Jameson, 2003.)

The existing medical systems are supporting mainly content and navigation adaption. According to Bental et al. (2000), an adaptive medical system uses both content and navigation adaption. Depending on the patient’s situation, the process of illness and treatment, the content of the presented information is adapted. The system decides itself the required contents and the design to present the information. The additional information or hyperlinks (to describe the term used in the presented texts) are generated according to the patient’s profile. (Bental et al., 2000.)

The user interface adaption for any eHealth information system should at least provide the content customization for two main groups of users: patients and medical staffs whose knowledge in the health area is considerably different. The major issue here is to reduce the misinterpretation of information provided by medical systems to patients. Therefore, the content delivery in eHealth is peculiar in comparison to other systems.
like eLearning. The eHealth system should include users’ goals and tasks, psychological and cognitive peculiarities along with a feature that indexes interaction parameters like the last visited pages and links used. (Vasilyeva et al., 2005.) The users’ cognitive changes are detected by using proper user interface adaption (UIA). The major idea is to develop a relatively unobtrusive and automatic procedure to track certain measures of patient’s health. (Jimison and Pavel, 2003.)

The framework of UIA consists of three major groups of components: participants, data repositories and different engines. Participants can be categorized into two major groups: patient-oriented (that includes patients, family and other persons receiving eHealth services but are not medical experts) and medicine oriented (hospital staff, general practitioners and doctors). The other participants involved in the eHealth system are usability engineers, system developers, administrators, psychologists and knowledge engineers. Various eHealth related materials, log data consisting the information about user-computer communication, management data that includes repository of user profiles and constructed user model and information about potentially adaptable interface parameters. Different engines in an eHealth system are responsible for the overall functionality. The system should include at least one adaption engine, a user profile engine, a content deliver engine and an administrative engine. This framework focuses on the adaption engine consisting three major parts: a model (user, task and environment) generator, an adaptation effect (to present, to navigate and to contents) and a knowledge base. Figure 5 explains the framework in which the arrows emphasize information flows that are crucial to the UAI process. (Vasilyeva et al., 2005.)

![Figure 5. General framework of adaptive e-Health system (Vasilyeva et al., 2005).](image)

For each type of participants, the system has an adaption engine. In Figure 5, patients oriented and medicine oriented participants have an adaption engine that generates user model, task model and environment model. The engine is connected to the data repository such as eHealth materials repository, user models repository and repository of adaptable parameters. Depending on the requests and queries made by a user, the system first analyzes the suitable adaption engine and then connects to the relevant
database to generate the adaptable user and task model to present the content in an effective way. (Vasilyeva et al., 2005.)

eHealth applications with user adaptable interface such as the “Homey” project where dynamic UIA is used to learn patient habits to motivate them to change certain habits for better health. The system in this case is a dialogue system based on automated speech recognition to provide easier and efficient communication between patients and health centers. This significantly improves the flow and availability of health related information at any times. The architecture of the homey system assures simplicity and adaptability that demands patients to use a normal phone or a mobile device. The automatic dialogue system was applied in medical domain of hypertension and has supported patients to develop their treatment at home. The system has been accepted and the effectiveness on the health outcome has been proven. (Giorginoll et al., 2005.)

The content personalization and easy navigation still remains a challenging process due to large differences that exist in different users. The user adaptive interface approach can be considered as the key opportunity to address challenging and diverse needs of various users in eHealth services. (Vasilyeva et al., 2005.)

6.2 Mobile interface for elderly

Mobile devices definitely improve and support the lives of elderly people. Touch screens are considered adult friendly however touch screens on mobile devices are extremely difficult for elderly people due to smaller size of the icons (targets) and difficulties in handling the interfaces. Elderly find difficulties to make accurate clicks, touches and fast movements with finger. Thumb dial can be solution when touch screens are used in small devices. Elderly prefer to use finger than the pointing devices. (Ziefle et at., 2005.)

The inclusive requirement design model can be implemented in developing and designing mobile interfaces for elderly. This model caters as many users as possible to incorporate diverse user requirements. The goal of the design is to support more users by developing generic solutions meeting specific needs. The model identifies users needs by specifying problems to be solved. Problem definitions are verified. The user perception is considered and verified. After the verification of the user understanding, the interaction is structured by considering motor function of adult users. The model also focuses on the users’ comfort to produce a solution that is usable and accessible. Figure 6 (see Keates, 2003 for more details) illustrates the inclusive design model. (Keates, 2003.)

![Inclusive design model](image)

**Figure 6.** Inclusive design model (Keates, 2003).

According to Keates, the inclusive design process begins with the identification of
problems. The problems to be solved are identified and each problem is defined. After
the verification of problems, the user perception of the problems and the user
representation of the system are verified. Based on the analysis of user perception and
problems identified, the structure of the interface is prepared and verified. For better
quality of control and input, the user motor functions are studied and user comfort is
verified. Finally the produced design is evaluated and validated. (Keates, 2003.)

Elderly face several physical and cognitive challenges in using current tools and
applications. Challenges of the elderly can be categorized into motivation, cognition,
physical, force control and perception. Technological applications usages require a
certain level of procedural knowledge. Human computer interaction requires users to
remember a certain procedure for a certain situation or a specific task. Cognitive load is
involved in using a system, as the end users are required to learn and remember how to
use a system for accomplishing a particular task. (Kirschner, 2002.) The cognitive
performance slows down with age and poses a challenge for elderly to remember how a
system works. Reducing the complexity of an interface is a vital factor for design and
development of applications and other technological solutions targeted for elderly users.
Implicit learning ability is not reduced with age however the complexity of an interface
is a greater disadvantage older people face to perform accurately when complex steps
are repeated in a process. (Midford & Kirsner, 2005.)

Motivation is a psychological construct and is essential for learning. Beliefs, anxiety,
fear, computer literacy and attitudes come under motivational issues. Older adults are
more reluctant to modern technology. (Hertzog & Bleckley, 2001.) The poor
understanding of the benefits offered by mobile applications and solutions among older
adults make them feel uncomfortable in using current technological solutions and
services. Older adults are often considered to loose concentration easily and get bored
with the subject that prevents older adults to learn to use a new technology. Developers
and designers need to understand the attitudes of the elderly towards the technology to
achieve elderly friendly design. (Lines & Hone, 2004.)

The physical impairments of the elderly hinder the use of technological solutions. A
slower response time, loss of flexibility and co-ordination reduction is noticed in many
elderly people. The partial loss of vision, memory, visibility and mobility affect the
confidence level of older users that affect the acceptance of modern technology. These
losses also affect the learning time, performance speed, error rate and subjective
satisfaction among older users. Developer and designer should consider physical
impairments to make the modern technology acceptable to older users. Table 2 lists
common factors among older user in using mobile technology with potential design
solution. (Holzinger et al., 2007.)
<table>
<thead>
<tr>
<th>Factor</th>
<th>General effects on older users</th>
<th>Potential design solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vision</td>
<td>• More light required&lt;br&gt;• Ability to focus deteriorates&lt;br&gt;• Ability to deal with glare diminishes</td>
<td>• Improve illumination&lt;br&gt;• Provide user interface options&lt;br&gt;• If a display is required, use anti-glare coatings to display</td>
</tr>
<tr>
<td>Hearing</td>
<td>• Loss of sensitivity to higher frequencies&lt;br&gt;• General threshold deteriorates&lt;br&gt;• Complex sounds more difficult to process</td>
<td>• Do not use high frequency audio feedback&lt;br&gt;• Couple auditory feedback with visual or tactile feedback&lt;br&gt;• Keep auditory feedback as simple as possible</td>
</tr>
<tr>
<td>Hand Function</td>
<td>• General weakness (strength &amp; grip)&lt;br&gt;• Dexterity often impaired&lt;br&gt;• Range of movement is more limited</td>
<td>• Design casings that are easy to hold and keys so they are easy to press&lt;br&gt;• Group keys by use and function</td>
</tr>
<tr>
<td>Cognitive process</td>
<td>• Processing time – with working memory&lt;br&gt;• Long term memory (episodic)&lt;br&gt;• Reaction time&lt;br&gt;• Learning time required&lt;br&gt;• Problem solving capacity</td>
<td>• Keep menu structures intuitive and consistent&lt;br&gt;• Make user interfaces as simple as possible</td>
</tr>
</tbody>
</table>

The common factors affecting the efficient use of technology among older users are declining vision, hearing, hand function and cognitive process. Elderly people require more lights when using mobile phones. Their ability to focus deteriorates and the ability to deal with glare also diminishes with ages. To solve the vision issue, designers and developers can improve illumination, provide options for user interfaces and to use anti-glare coatings to displays. Hearing impairments is another obstacle in using technology among elderly people. Therefore designers should keep the auditory feedback as simple as possible and should avoid using high frequency feedback as older people lose their sensitivity to higher frequencies. Old age also deteriorates hand function. Older people are not able to properly grip the devices. The devices should be easy to hold. Older people require more processing time and reacting time. Their problem solving capacity is declined. In order to address cognitive decline in older people, designers should keep menu structure consistent, intuitive and as simple as possible that requires less cognitive load. (Holzineger et al., 2007.)
According to Kurniawan (2008), the physical design of a mobile phone that is senior friendly should have the following physical design elements:

**Table 3. Physical design elements for older people (Kurniawan, 2008).**

<table>
<thead>
<tr>
<th>Physical design elements</th>
<th>Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buttons: Square large metallic buttons</td>
<td>The metallic button provides the impression of being clicked when pressed, therefore making sure the number associated with the button is dialed successfully. This is useful for older adults with reduced vision.</td>
</tr>
<tr>
<td>Display: Large text and screen backlight does not turn off when idling</td>
<td>The automatic backlight dimming is too fast for older adults, as they require extra cognitive processing time when texting or dialing a number.</td>
</tr>
<tr>
<td>Shape: Flip phone</td>
<td>Flip phones are more comfortable when picking up and ending calls. They have comfortable length and angle when opened.</td>
</tr>
<tr>
<td>Color: Bright</td>
<td>Bright color phones are easy to spot however some older adults disliked it for the fear of being the phone too visible.</td>
</tr>
<tr>
<td>Size: Bulky</td>
<td>Joint stiffness makes smaller phones difficult to grab and hold, therefore bulky phones are more comfortable and easy to grab for older adults.</td>
</tr>
<tr>
<td>Hardwired functions</td>
<td>Functions such as button for emergencies, a button to lock and unlock phone to prevent accidental dialing etc. are convenient for older adults.</td>
</tr>
</tbody>
</table>

LG8380 is a phone that matches most of the criterias explained in Table 4. It is a flip phone and has square metallic buttons that clicked when pressed. It also has large display and uses bright colors. The size is bulky enough for an older person to properly grab and hold. (Kurniawan, 2008.)

Mobile phones if designed carefully can be used effectively by older people. Design choices appropriate for younger people may be unacceptable and inappropriate to older people. In the context of mobile systems, the design or interface should (i) meet diverse needs of older people, (ii) compatible with various physical and cognitive conditions of older people, (iii) contain proper guidelines and (iv) require less cognitive load. (Godman et al., 2004.)
6.3 Ambient intelligence for elderly

Most of the commercially available applications, devices and systems in the health care domain today are closed and stand alone systems with limited capabilities to describe the actual situation. The available products are often too difficult for the elderly people to use. Ambient intelligence offers a huge potential for elderly people. The ambient intelligence technology enables novel ways of integrating into the life of elderly people. The unobtrusive sensing of ambient intelligence technology allows embedding of the monitoring and other assistive technology invisibly. Ambient intelligence is recognized as an approach to tackle the physical impairments and disabilities in the domain of health care and assisted living. (Kleinberger et al., 2007.)

Ambient intelligence in a system is defined as the capabilities of system that can render the service in a sensitive and responsive way. The system responds to the actions of persons and objects. This approach includes every possible objects and the entire environment to associate the system with the human interaction. Extended and intuitive interaction is possible due to ambient intelligence that result to produce systems that are highly efficient with increased creativity and greater personal well being. (Aarts & Wichert, 2009.) According to Pena et al. (2002), ambient intelligent systems show the following characteristics:

- Ambient intelligent systems are invisible. They can be embedded in clothes, glasses and watches.
- The can be easily carried with (Mobile).
- Spontaneous communication is possible with different nodes.
- They include different types of system nodes with different rendered functionalities.
- The systems are context-aware that is they are aware of their local environment and continuously exchange information with similar nodes.
- They are able to act on their own without explicit requests.
- They offer natural interaction methods such as voice and gestures instead of keyboard and mouse.
- They are adaptive in nature and are capable of reacting to abnormal and exceptional situations.

The ambient intelligence technologies can be embedded in elderly people in their clothes, watches or glasses. Sensors used in the ambient intelligence systems are integrated in our living environment that helps to detect specific situations. The sensor technology and ambient intelligence provide an accurate automated system that has clear benefits in remote monitoring activity at elderly people’s home, thus allowing them to live independently. Early detection of upcoming and existing problems is possible via the use of sensor and ambient intelligence. Ambient intelligent systems can assist elderly people to prevent problems and in case of emergencies the system reports the circumstances to service providers, thus enabling quick and timely assistance for elderly people. (Kleinberger et al., 2007.)

6.4 Summary

Adaptive user interface can be utilized to develop a software artifact that improves the interaction between systems and elderly people. The adaptive user interface considers physical impairments of individual users to develop applications and technologies that are more usable to elderly people. Adaptive interfaces provide user the possibility to
customize the interface as per their preferences. The inclusive requirement design model can be implemented in designing mobile interfaces for elderly. Inclusive design process tries to incorporate diverse user requirements. It leads to the development of generic solutions that are meeting specific needs. The physical impairments of the elderly people hinder the use of technological solutions. Developer and designer should consider physical impairments such as loss of vision, memory and hearing capabilities to make the modern technology acceptable for elderly people. Ambient intelligent systems are embeddable, invisible and are portable. They are able to detect specific situations and report to the concerned service provider for further assistance. Natural interaction methods such as voice and gestures are possible by deploying ambient intelligence and sensors.
7. Findings & Discussions

The rapid increase in older adults has demanded to adapt technological products and services to improve the quality of life of the elderly (Hussein & Manthrope, 2005). ICT has a huge impact on health from both perspectives of delivering and providing accessibility to healthcare for elderly living independently at homes (Gabner & Conrad, 2010). The use of ICT to support health has proved to be efficient in terms of cost reduction, reduced travel times and quality of health services (Ekeland et al., 2010).

Health care paradigm today is not limited to medical services but has changed to disease prevention and promotion of health. The new paradigms in health care services require the use of ICT. Remote consultation, dissemination of public health information, cooperation and collaboration among health-workers are important aspects offered by ICT in the health sector. Social media tools such as Facebook and Twitter can be used for instantaneous communication to large audience. Social platforms can be used to communicate last minute availabilities to prospective patients to fulfill appointment vacancies. (Chan & Chan, 2011.)

On the other hand, elderly are more reluctant to use communication tools (Panel, 2006). Digital televisions are identified as mainstream and accessible to elderly than the Internet. Web based technologies provide a framework to disseminate healthcare related information over a public network. The evolution of technology has increased the investment in healthcare ICT solutions. (Thompson & Brailer, 2004.)

The advancement in technology has impacted the size of electronic devices and has made them more portable and faster. Health information technology is focused on providing patient-centered health care. The improved disease management, public health collection, dissemination of epidemic and disaster data, ad hoc access to expert consultations from remote places, booking appointments, appointment reminders and many other services are available to both consumers and health professionals. (Warner, 2011.) Moreover, the use of mobile phone by elderly people is increasing. For older people, mobile should support personal communication, act as a means for social integration and provide a sense of safety empowering older people to remain at home and maintain quality of life. (Plaza et al, 2011.) Ambient assisted living allows older people to live independently. Technology assisted solutions such as automated light in an entrance area, motion detectors and automated heating regulation have eased the life of elderly people. (Malanowski et al., 2008.) ICT driven solutions such as eHealth, telemedicine, smart homes, interactive games and Interactive TV are beneficial. They are also supportive media to support independent living for elderly.

Elderly consider technologies more relevant when they support safety and independence. Technologies such as system monitoring the house and control access, embedded technologies providing real-time information, devices supporting long term and short term memory and devices promoting physical activities are desired by older adults. They however do not want technology to isolate them and the technology should allow older adults to express themselves. (Sorri & Leinonen, 2008.) On the other hand, elderly people face several challenges in using current information systems and technologies. The cognitive abilities of an old user are major hindrances to accept technology. The usability issues force them to avoid ICT products and services. Inclusive requirement design and user adaptive interface try to address diverse needs of
older adults. Technology acceptance depends on several factors: experience, cognitive abilities, demographic variables and personality factors especially for older people. (Saadé et al., 2005; Wilkowska & Ziefle, 2009; Turner et al., 2007.) Older adults perceive technology less useful as they weight the perceived usefulness against the time required to learn to operate a system. The elderly acceptance of eHealth applications in comparison to common ICT tool is different, thus demanding research work to explore the complex picture of acceptance factors. (Wilkowska & Ziefle, 2009.) Table 4 lists the overall findings of the research work.

Table 4. Findings of the research work.

<table>
<thead>
<tr>
<th>Opportunities</th>
<th>Challenges</th>
<th>Possible Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remote consultation, social platforms and web platform to disseminate public</td>
<td>Usability issues</td>
<td>Universal design for all.</td>
</tr>
<tr>
<td>health information, social platforms for free and instantaneous communication</td>
<td>• Learnability</td>
<td>User adaptive interface framework.</td>
</tr>
<tr>
<td>to large audience, web based technology and framework for secure and reliable</td>
<td>• Efficiency</td>
<td>Inclusive design model.</td>
</tr>
<tr>
<td>dissemination of health information among health care providers, ICT</td>
<td>• Memorability</td>
<td>Use of artificial intelligence and sensors.</td>
</tr>
<tr>
<td>supported tools for co-operation and collaboration among health workers, cloud</td>
<td>• Errors</td>
<td>Encryption, role based access control and</td>
</tr>
<tr>
<td>based cheaper solutions for exchanging data, health care applications for</td>
<td>• Satisfaction</td>
<td>proper authentication mechanisms</td>
</tr>
<tr>
<td>smart phones, ambient assisted solutions, assistive technology, eHealth and</td>
<td></td>
<td></td>
</tr>
<tr>
<td>telemedicine, smart homes, interactive games and interactive TV.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Physical impairments, cognitive decline, partial</td>
<td></td>
</tr>
<tr>
<td></td>
<td>loss of vision, memory, visibility and mobility.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Diverse requirements.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Privacy issues</td>
<td></td>
</tr>
</tbody>
</table>

As presented in Table 4, ICT offers a wide range of opportunities for elderly people in the health care domain. Opportunities are diverse and include remote consultation to the dissemination of health information. Web based technology and cloud based cheaper solutions can be utilized for disseminating information over public networks. Ambient assisted solutions, assistive technology, telemedicine, smart homes, interactive games and interactive TV offer possibilities for an elderly to live healthy and independent life. However, several challenges were identified as factors affecting the adoption of technology among elderly people. Usability issue is a crucial factor. Physical impairments, cognitive decline, partial loss of vision and mobility are hindrances for older people to make efficient use of technology. On the other hand, only few possible solutions to address divers needs and physical impairments of elderly people were discussed in the literature review. Universal design for all, user adaptive interface framework and inclusive design model can be implemented to address diverse needs and physical impairments of elderly people. Artificial intelligence and sensor nodes can be used as an alternative to normal human computer interaction that address problems caused due to physical impairments in elderly people. Several social and legal issues are encountered when deploying health care systems. The benefits offered by technologies
should be balanced with the privacy concerns of the user by utilizing strong policies for medical record storage, access and mining process. Encrypted databases, role based access control and proper authentication mechanism can be implemented to ensure privacy of patients.
8. Conclusion

This research work has focused on analyzing the role and importance of using Information and Communication Technology (ICT) to support integrated health care services and independent living for the elderly population in remote and sparsely populated areas. Several challenges faced by older adults in adopting the latest technology are effectively researched and a user adaptive interface is proposed as a solution to meet diverse needs of elderly population. Conceptual analytical method with a detailed review of literature was used to understand the topic and develop new themes that assisted in providing suitable analysis to the defined research questions. Older people have high health care demands due to disability, chronic illness and various diseases. Technology can help to maintain a secure, safe and healthy environment for older people.

The health care sector will be facing major challenges in the upcoming decades. Ageing population will demand more health care and social services in parallel to decreased labor force. (Border, 2004.) The evolution of medical technologies, change in demography, culture and globalization has confronted the health care systems with new situation, subsequently requiring new solutions (Wotton et al., 2006). ICT offers a lot of potentials for health sector. The latest technology enables remote monitoring, remote consultation and real time communication to support independent and quality living for elderly. (Gabner & Conrad, 2010.) Social media networks provide the framework to reach larger audience and provide opportunity for instantaneous communication (Chan & Chan, 2011). The increase trend of using mobile solutions among older adults makes mobile phone as a medium to support elderly health (Conci et al., 2009; Kurniawan, 2008; Oksman, 2006; Plaza et al., 2011). eHealth, telemedicine, smart homes, interactive games and interactive TV are beneficial and supportive media to support independent living for elderly. Smart homes reduce hospitalization of elderly by offering twenty-four hours monitoring services and emergency help whenever needed. (Chan et al., 2009.) Interactive games improve cognitive, functional and social skills of older people. The ambient assisted living systems and latest technologies are important aspect in creating a cohesive and inclusive society. (Comeau, 2005.)

Despite several potentials offered by ICT in health care domain, the adoption of health ICT among older adults faces several challenges. The advancement in technology has not been able to build the digital gap. (Aula, 2005; Nugent, 2007.) Many technological solutions are already available but are not fully utilized due to poor design for ease of use, proper guidelines and privacy issues. Usability problems seem to be the major issue for older people in adopting the latest technology and successfully interacting with them. (Coughlin et al.; 2007.) Technical and human dimensions influence user acceptance of any interface or design. The age related cognitive abilities have a huge relevance on system design especially for older people. (Lehoux, 2004.) Seniors accept technology when the benefits of system usage are clear and transparent. The acceptance of eHealth applications in comparison to other application is different and requires further research to explore the acceptance factors.

The adaptive user interface approach can be utilized to address different individual abilities, interest and needs of older adults. The adaptive interface for any eHealth information system or application should at least support content customization for two
main groups of users: patients and medical staffs. (Vasilyeva et al., 2005.) The existing medical systems are supporting mainly content and navigation adaption (Bental et al., 2000). The inclusive requirement design model can be applied in developing mobile interface for older adults (Keates, 2003).

Several social and legal issues are encountered when deploying health care systems. The benefits offered by technologies should be balanced with the privacy concerns of the user by utilizing strong policies for medical record storage, access and mining process. Encrypted databases, role based access control and proper authentication mechanism can be implemented to ensure privacy of patients.

In conclusion, the advancement in technology offers a wide range of solutions from remote consultation to remote monitoring of elderly health allowing them to live their lives healthily and independently. Mobile, interactive TV, interactive games and Internet can be utilized to improve cognitive, functional and social skills of older people. User adaptive interface and inclusive requirement design model can be used to develop more user-friendly applications and technology for older adults.

Economical aspects and challenges to integrate several ICT solutions (see Chapter 4) were not covered in the current study. Therefore, economical analysis and integration of several ICT solutions into a single health system require further research work. In addition, future research work is also required to cover the detailed privacy aspects of utilizing ICT in health care domain.
References


### Appendix A. List of smart phone applications

<table>
<thead>
<tr>
<th>Application</th>
<th>Platform</th>
<th>Description</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sanford Guide to Antimicrobial</td>
<td>Palm OS, iOS, Windows phone, Blackberry</td>
<td>The guide to antimicrobial therapy.</td>
<td>Disease Diagnosis application</td>
</tr>
<tr>
<td>Normal Lab values</td>
<td>iOS</td>
<td>This application helps to interpret test results.</td>
<td>Disease Diagnosis application</td>
</tr>
<tr>
<td>Pocket Guide to Diagnostic Tests</td>
<td>Android, Blackberry, iOS, Plam OS, Windows phone</td>
<td>This application is a laboratory test reference for medical, nursing and health professionals.</td>
<td>Disease Diagnosis application</td>
</tr>
<tr>
<td>Epocrates</td>
<td>Android, Blackberry, iOS, Plam OS, Windows phone</td>
<td>This application is a drug database application.</td>
<td>Drug reference application</td>
</tr>
<tr>
<td>FDA Drugs</td>
<td>iOS</td>
<td>This application provides authoritative information for FDA drug approvals</td>
<td>Drug reference application</td>
</tr>
<tr>
<td>SafeMed Pocket</td>
<td>Windows phone</td>
<td>This application provides access to data on all pharmaceuticals sold in Sweden</td>
<td>Drug reference application</td>
</tr>
<tr>
<td>Medical Calculator</td>
<td>iOS</td>
<td>This application calculates useful medical formulas and equations</td>
<td>Medical Calculator</td>
</tr>
<tr>
<td>uBurn Lite</td>
<td>iOS</td>
<td>This application calculates percent burn of body surface area</td>
<td>Medical Calculator</td>
</tr>
<tr>
<td>Calculate</td>
<td>iOS, Blackberry, Android</td>
<td>This application calculates various medical equations and formulas.</td>
<td>Medical Calculator</td>
</tr>
<tr>
<td>Disease associations</td>
<td>Web enabled smartphones</td>
<td>This application is search interface for case reports and review on cases in PubMed/MEDLINE</td>
<td>Literature Search</td>
</tr>
<tr>
<td>mVisum</td>
<td>Android, Blackberry, iOS, Windows phone</td>
<td>Receives patient data on smartphone. It is a cardiology communication application</td>
<td>Clinical communication</td>
</tr>
</tbody>
</table>
## Appendix B. Brief explanations of eHealth tools

<table>
<thead>
<tr>
<th>S.N.</th>
<th>eHealth System</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Patient Information Systems (PIS)</td>
<td>PIS contain textual and numerical data about hospitalized patients to support both administrative and clinical activities.</td>
</tr>
<tr>
<td>2.</td>
<td>Hospital Information Systems (HIS)</td>
<td>HIS is a computer based information system for the purpose of information processing inside a hospital in areas like planning, administration, appointments, billing and budgeting.</td>
</tr>
<tr>
<td>3.</td>
<td>General Practitioner Information Systems (GPIS)</td>
<td>GPIS is an ICT based system to support the functionality of a general practitioner. The major function is to share and manage medical data by connecting to other health systems like laboratory results and billing systems.</td>
</tr>
<tr>
<td>8.</td>
<td>Geographical Information Systems (GIS)</td>
<td>GIS is a computer-based application to support capturing, integrating, displaying and analyzing data related to geographical co-ordinates.</td>
</tr>
<tr>
<td>9.</td>
<td>Picture Archiving &amp; Communication Systems (PACS)</td>
<td>PACS are capable of sharing patient records, images and diagnostic resources.</td>
</tr>
</tbody>
</table>
Appendix C. A model of smart home for elderly
Appendix D. LLPR System
Appendix E. The phases of the USAP design model