Bournemouth University

# Impact of Assistive Technologies in Supporting People with Dementia

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**Abstract**

In recent decades, many Assistive Technologies (ATs) have been developed to promote independence among people with dementia (PWD). Although there is a high rate of AT abandonment, only a handful of studies have focused on AT usability evaluation from the user point of view. The aim of this thesis is to empirically investigate the usability of ATs from the PWD and to measure its impacts on their lives.

Following the Multi-methods research approach, the first part of the thesis uses secondary research methods including literature review and systematic mapping studies. The second part uses primary research methods including interviews (N=20) and questionnaire (N=327) based surveys for data collection and requirements elicitation. The third part is based on the design, development, and testing of an assistive software application through case studies (N=8).

The first mapping study categorised existing general ATs into five major categories: robotics, monitoring, reminders, communication, and software. The second mapping study categorised software-based ATs into nine categories: cognitive help, reminders, health/activity monitoring, socialization, leisure, travel help, dementia detection, dementia prevention, and rehabilitation.

The qualitative results showed that most of the PWD use ATs for socialization, and highlighted user interface efficacy, tailoring individual needs, and simplified functions as the major limitations of existing ATs. The quantitative results identified eleven factors for ATs usage: operational support, physical support, psychological support, social support, cultural match, reduced external help, affordability, travel help, compatibility, effectiveness, and retention. The statistical analysis showed that improved (social, psychological and travel) support and reduced need of external help for operating ATs, greatly impact AT effectiveness and retention.

Based on PWD requirements, an assistive software application named E-Community for Dementia (ECD) was developed and tested through case studies involving 8 PWD and 40 volunteers. The participants were able to get their daily needed items in less time and with a friendlier manner through the help of their neighbours. The involvement of the caregivers for medication, meals, prayers etc. reduced significantly. The painting function helped evoke their memories, and encouraged them to perform activities from their youth. The news and weather functions kept them updated about the world around them. The travel tutor guided them in safe travel outside home and made sure that they

got back home independently. The enhanced interaction between the PWD and their neighbours significantly reduced their social isolation. The results support the idea to create dementia-friendly communities at street levels, which is a cost-effective and reliable solution.

The major outcomes from this thesis are AT categorization, evaluation of user experiences, factor identification and ranking, user requirements elicitation, assistive software application development, and case studies. This thesis helps considerably towards empirical investigation of the impact of ATs in supporting the PWD. The implementation of the ECD contributes towards the wellbeing of the PWD and saves costs spent on caregivers and carer companies. In future, the same study could be conducted in other settings to analyse the role of culture in AT acceptance.

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## Glossary of Terms Used

| **Term** | **Meaning** |
|---|---|
| ADI | Alzheimer's Disease International |
| ADL | Assisted Daily Living |
| AI | Artifical Intelligence |
| AMOS | Analysis of a Moment Structures |
| AT | Assistive Technology |
| ATE | Assistive Technology Effectiveness |
| ATF | Assistive Technology Factor |
| ATR | Assistive Technology Retention |
| ATU | Assistive Technology User |
| CPS | Cyber-Physical Systems |
| DLA | Daily Living Activities |
| EC | Exclusion Criteria |
| ECD | E-Community for Dementia |
| EFA | Exploratory Factor Analysis |
| EMA | Electronic Memory Aid |
| GDP | Gross Domestic Product |
| GPS | Global Positioning System |
| HCI | Human Computer Interaction |
| IC | Inclusion Criteria |
| ICT | Information and Communication Technology |
| KMO | Kaiser-Meyer-Olkin |
| MMSE | Mini Mental Scale Examination |
| NGO | Non-Governmental Organization |
| PDA | Personal Digital Assistant |
| PNCA | Pakistan National Centre for Ageing |
| QoL | Quality of Life |
| RE | Requirements Engineering |
| SAR | Socially Assistive Robot |
| S.D | Standard Deviation |
| SE | Software Engineering |
| SPSS | Statistical Package for the Social Sciences |
| SWAT | Software based Assistive Technology |
| UCD | User-Centred Design |
| WBAN | Wireless Body Area Networks |

## Nomenclature for Symbols

| Symbols | Meaning |
|---|---|
| $\bar{x} \pm S$ | Values Above and Lower the Mean |
| C | Citations |
| $C_{ov}$ | Covariance Between Scale Items |
| C/P | Citations per Paper |
| P | Number of Publications |
| $s^2$ | Unique Variance Within Variables |
| $S_{ig}$. | Significance of Result |
| SS | Sample Size |
| $u_{ij}$ | Partial Covariance Matrix |
| $\lambda$ | Wilk's Lambd |
| $R^2$ | Vraiability Explained |
| $r_{ij}$ | Correlation Matrix |

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Last but not the least, bundle of thanks to all my friends and people who helped me in data collection from Pakistan.

## Dedication

"Acquire the knowledge and impart it to the people"

*- The Prophet Muhammad (P.B.U.H) -*

This dissertation is dedicated

To the dream of my

FAMILY

To my parents, brothers, sisters and little champions of my family

To my teachers for being source of inspiration

To my wife for her continuous care

To my friends for their support

**Publications from this Thesis**

1. Asghar, I., Cang, S. and Yu, H., 2017a. Assistive technology for people with dementia: an overview and bibliometric study. *Health Information & Libraries Journal,* 34**,** 5-19. (**IF:3.44**)
2. Asghar, I., Cang, S. and Yu, H., 2017b. Usability Evaluation of Assistive Technologies through Qualitative Research Focusing on People with Mild Dementia. *Computers in Human Behavior,* 79**,** 192-201. (**IF:0.88**)
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**Book Chapter from this Thesis**

1. Asghar, I., Cang, S. and Yu, H., 2017. Dementia Friendly Assistive Brotherhood Communities, *"Novel Aspects on Dementia"*, 978-953-51-5902-5. (Accepted)

## Poster Presentations from this Thesis

1. Asghar, I., Cang, S. and Yu, H., 2015. Impact of Assistive Technologies in Supporting People with Dementia, *8th Annual PGR Poster Conference*, Bournemouth University, 19-May-2015.
2. Asghar, I., Cang, S. and Yu, H., 2015. The Potential of Assistive Technologies in helping the People with Dementia, *Annual Assistive Technology Exhibition*, Dorset County Council, Dorchester, 16-Nov-2015.

# CHAPTER ONE

## Introduction

Chapter one presents background and motivation for this research. The concepts of ageing, dementia and assistive technology (AT) are defined and explained; their relationship with this research is also clarified. The challenges associated with AT are identified and discussed. The thesis aim and objectives are outlined, followed by research questions and work novelty. Introduction of the research process used for this thesis is briefly described as well. Finally, the thesis structure is presented by chapter wise contents.

### 1.1 Background and Importance

#### 1.1.1 Ageing and Dementia

From recent statistics, it is evident that the world population is ageing (Figure 1.1). According to the United Nations survey, the world population aged 60 years or above stands at 11.7% (841 million people). This figure is expected to rise to 21.1% (2 billion people) till 2050 (Au et al. 2015a).

The worldwide demographic ageing process represent the achievements of health care in recent years; people are living healthier and longer life which is resulting into greater proportion of aged people. On the other hand, as dementia usually affects older people, resultantly this ageing population is contributing significantly to the number of the people with dementia (PWD).

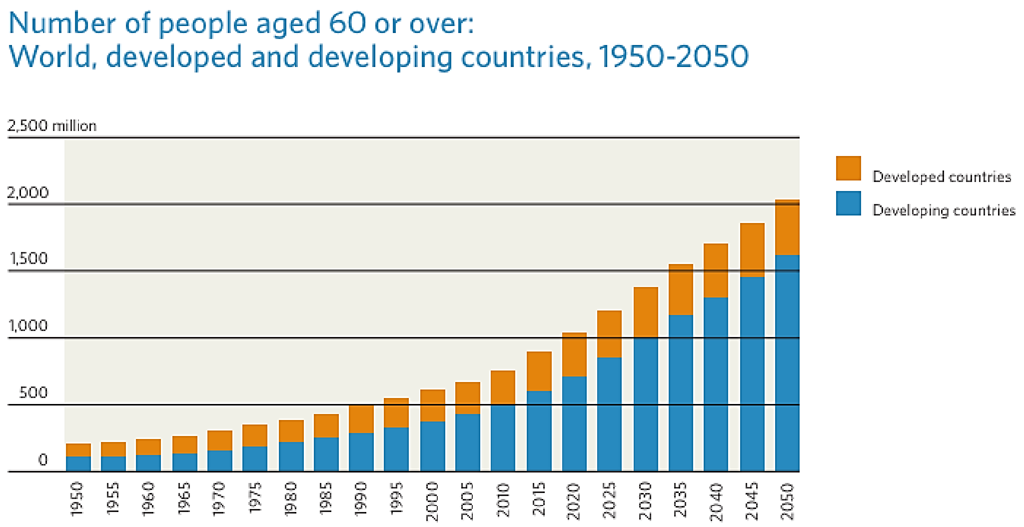


Figure 1.1: The United Nations Survey for Elderly Population (Au et al. 2015a)

Right from the start of the 21st century, dementia is recognized as one of the most serious challenges around the world. Dementia has over 100 symptoms, which makes it a complex disease. It is a comprehensive class of *"brain diseases that includes any disease that causes loss of cognitive ability (the ability to think and reason clearly) that is severe enough to affect a person's daily functioning"* (Span et al. 2013). The PWD often have difficulties in accomplishing activities of daily living without the help of a caregiver. This leads to a loss of independence, and an increase in burden on the caregivers and the family members.

### 1.1.2 Dementia Worldwide Statistics and Economic Impact

In every three seconds, someone develops dementia, which is contributing to dementia population in the form of 9.9 million new cases every year. According to 2017 estimates there are 50 million PWD around the world, which is more than the individual population of 123 countries (Prince 2015). This figure is expected to rise up to 131.5 million by 2050.

Furthermore the governments around the world are investing more than 818$ billion annually for the wellbeing of the PWD (Pratchett 2015). These annual costs are more than the annual GDP of 178 individual countries. For many developed countries the cost spent on the wellbeing of the PWD is greater than the combined costs on cancer and heart diseases (Prince et al. 2014). In the present circumstances, taking all financial figures into account if we consider worldwide dementia costs as a country, it will be the 18th largest economy of the world (Prince 2015).

### 1.1.3 Dementia Statistics in South Asia and Pakistan

The South Asia is one of the most important regions of the world as it holds 25% of Worlds' population (Rasul 2014). The ageing phenomenon has started to affect South Asia and this region along with China is expected to have fastest ageing growth in the coming years. Delphi consensus study reports that there is an annual 1.9% increase in dementia population for this region. According to a recent statistics, the South Asia has over 4.5 million PWD (Prince et al. 2013).

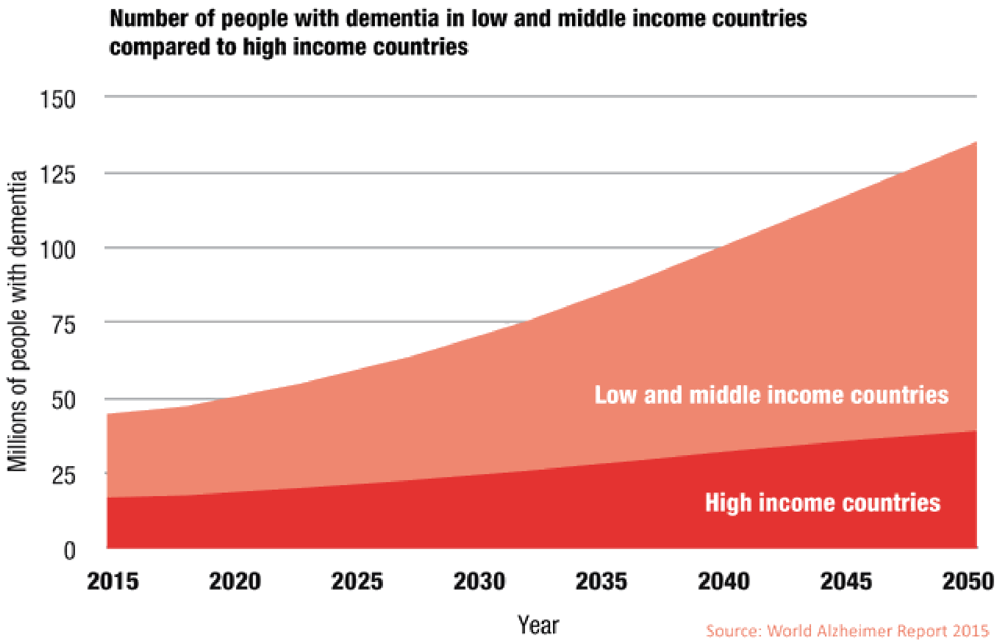


Figure 1.2: Number of PWD in Low and Middle Income Countries (Prince 2015)

Another study reports that almost 58% of PWD live in low and middle-income countries. These figures are expected to rise to 68% by 2050, as depicted in figure 1.2

(Prince 2015). Pakistan is also believed to be amongst the low and middle level income countries, which will have higher population of dementia in the coming years. Some unofficial statistics reports that currently there are over one million PWD in Pakistan (Wasay 2015). The recent official statistics states that there are 150,000 PWD in Pakistan. The dementia population in the country is increasing steadily at 1.9% annually (Ahmad et al. 2013). The fast growing rate of dementia population is creating new challenges for the already weak economy of Pakistan.

## 1.2 The Research Context

Pakistan is situated in the heart of Asia. Geographically it is situated in an important region of the world surrounded by China, India, Iran and Afghanistan (See figure 1.3). According to recent statistics Pakistan has population of over 199 million, which make it the 6th most populated country in the world, Pakistan constitute 2.6% of the world total population (Malik 2015). With a Gross Domestic Product (GDP) of 930$ billion, it is ranked as 26th largest economy in the world. Pakistan has a semi-industrialized economy with well-established agricultural sector (Arshad et al. 2015).


Figure 1.3: Geographical Location of Pakistan

Due to industrialization and life span increase around the world, Pakistan is also experiencing the rise in elderly population. Currently Pakistan has over 11.6 million people ages over 60 years which is 6.5% of the population. According to population estimates this elderly population will rise to 43 million by the year 2015, which will be 15.8% of the population (Sabzwari and Azhar 2011).

Although the dementia situation in the country is going to be challenging, but still there are no efforts at Government level for handling this issue so far. The literature indicates that there are many challenges for active aging in Pakistan. According to Pakistan National Centre for Ageing (PNCA) almost 47% elderly population in the country cannot afford safe housing, healthcare and care home expenditures (Vertejee and Karamali 2014). Resultantly all these people are dependent on Government or community help.

As Pakistan is a welfare state according to its constitution, the situation for active aging will improve significantly in coming years due to more awareness and resources (Vertejee and Karamali 2014). There are many private and Non-Governmental Organizations (NGO) working for the welfare of the elderly people. Especially the Pakistan Alzheimer Society is working hard and running day care homes for the people with dementia. Researchers have started investing their efforts into this critical area of research as well. There is much scope in this society for using AT as cheap solution for the wellbeing of the PWD.

## 1.3 How Assistive Technology Can Help the People with Dementia

The AT can help governments and individuals to improve situation of the PWD. Additionally AT can also help to reduce the cost spent on human efforts (caregiver, nurses, and doctors) for the wellbeing of the PWD. Therefore in recent years the academic researchers and industry started to focus on AT as an alternate to help the PWD. AT is a broad term used to describe *"any item, object, device or system that enables a person to perform tasks that they would otherwise be unable to do, or increase the ease and safety by which certain tasks can be performed"* (Wu et al. 2013).

Currently there are a many ATs available for the PWD. These days it is common to see the PWD using ATs in their homes and outside environments. These ATs have different scopes to help the PWD, as some of these belong to very basic everyday technologies while other includes complex and modern technologies. Current ATs offer various functionalities, such as:

- ✓ Social assistance through robots (Wu et al. 2013)
- ✓ Physical mobility through smart walkers (Martins et al. 2012b)
- ✓ Health information monitoring technologies (Fischer et al. 2014)
- ✓ Communication through mobile multimedia technologies (Donnelly et al. 2010; Boman et al. 2014)
- ✓ Reminders through prompting technologies (Seelye et al. 2012)
- ✓ Activities and night time observations through monitoring technologies (Meiland et al. 2014; Rowe et al. 2009)
- ✓ Memory assistance electronic memory aids (Imbeault et al. 2014)
- ✓ Enjoyment activities through leisure technologies (Torrington 2009)
- ✓ Remote care through tele-care technologies (Leroi et al. 2013)
- ✓ Travelling through GPS enabled technologies (McCabe and Innes 2013)
- ✓ Task completion through automatic task assistance technologies (Peters et al. 2014)
- ✓ Medical assistance through patient care technologies (Tung et al. 2013)
- ✓ Socialization through software based technologies (Zhang et al. 2014)

- ✓ Independent living through assisted living homes (Aloulou et al. 2013)

## 1.4 Research Gaps

The rich literature indicates that serious efforts are being carried out on the use of AT for the PWD by academic researchers as well as industry practitioners (Doukas et al. 2011; Boman et al. 2014). Most of the studies done so far in social and medical domains are based on highlighting the symptoms, causes and effects of dementia (Saborowski and Kollak 2015; Wherton and Monk 2010). While studies done in the technological domain are usually based on presenting new ideas, designing devices and implementing technologies (Tchalla et al. 2012). The literature further indicates that although there are many researchers working on the technologies related to the wellbeing of the PWD, yet there are some major challenges left unanswered (Imbeault et al. 2014; Hoey et al. 2010). These challenges include:

**GP1:** AT Abandonment

Although the PWD who use ATs may become dependent on them, still there is high rate of AT abandonment of their part (Evans and Johnston 2005). The possible reasons for AT abandonment include: difference between user requirements and AT functionality, difficult usage and user preference (Beigel 2000).

**GP2:** Social and Economic Loss

AT abandonment is common, particularly when it does not promote better quality of life (QoL). These facts lead to high level of social and economic loss as these ATs usually involve huge investments (Carvalho et al. 2014).

**GP3:** Lack of Empirical Studies

Although there is rich amount of work available on AT related research and development for the PWD both in academic literature and professional practices. However, still there are gaps available in analysing the usability of the ATs from the PWD point of view. Therefore the literature often highlights the need of empirical studies for checking possible impacts of the ATs on the daily lives of the PWD (Span et al. 2013; Imbeault et al. 2014).

**GP4:** Lack of Software Solutions

The literature, industrial and commercial surveys show that most of the AT related work for the PWD is focused on monitoring, safety, robotics and communication. However there is there is lack of software related ATs for the PWD. The software engineers should develop user friendly assistive software applications and test them by involving the real PWD through case studies (Aloulou et al. 2013; Topo 2009).

**GP5:** Lack of Personalized ATs

Previous research studies also show that sometimes too much use of ATs may bring aggression in the PWD as either they may feel totally dependent on ATs or these are not tailored to their needs (Carrillo et al. 2009). This situation highlights the need of developing specialized ATs tailored to the individual needs of the PWD.

Figure 1.4: Untailored ATs May Confuse the PWD

**GP6:** AT and Social Isolation

Although there are many advantages of using ATs for the PWD, there are some associated negativities as well. Some studies show that the PWD believe that adopting AT may bring social isolation for them, as their family members and caregivers may reduce number of visits to them (Boman et al. 2014). Therefore, there is need of balance between AT use and human interaction with the PWD.

**GP7:** Lack of User (PWD) Involvement

It is strongly believed that technology success depend heavily on its end user perspectives. Therefore knowing the point of view of the PWD regarding the usability of existing AT becomes more important. Yet there are only few studies carried out in this domain (Span et al. 2013). Such as (Rowe et al. 2009) in USA, (Demers et al. 2001) in Canada and (Jedeloo et al. 2002) in Netherlands conducted some studies for testing AT satisfaction from the users. Further literature investigation shows that although some empirical studies have been conducted recently, but their focused population is different (schoolchildren, people with disabilities, caregivers etc.). The most comprehensive work in this domain concludes that there is still a high rate of non-acceptance of ATs, existing ATs are often unreliable and just makes little difference to practical outcomes and there is critical need of better designed empirical studies by involving the real PWD (Fleming and Sum 2014).

**GP8:** AT Usability Studies in South Asia

To the best of our knowledge, there are no AT usability evaluation studies conducted in the South Asian region with focus on the PWD. The importance of this study becomes even more significant as South Asia holds 25% of Worlds' population (Rasul 2014). The AT usability evaluation studies can also be useful for enhancing the quality of future ATs (Peterson-Karlan and Parette 2007; Karmarkar et al. 2012).

To fill these research gaps, the current research study is initiated, which empirically investigates the existing ATs against their actual support to the PWD. An assistive software application is developed based on actual requirements of the PWD gathered through semi-structured interviews and questionnaires. The questionnaires and interviews based surveys provide insights into the issues like (aggression and social isolation) due to AT use.

## 1.5 Aim of the Study and Research Questions

The overall aim of this research study is to increase knowledge about the ATs available for the PWD and its possible influences on their daily lives. This research investigates what difficulties are faced by the PWD while using existing ATs and explores their actual expectations from the ATs.

More specifically the aim of the study is to empirically investigate (by following user centric approach) the impacts of ATs to support the PWD. This study proposes a user friendly assistive software application to increase the positive impacts of AT support on the lives of the PWD. This study is undertaken to address the following research questions (RQ).

**RQ1:** What ATs are there to help the PWD?

To answer RQ1 extensive literature review is performed for synthesising information related to the ATs available in literature. The literature review involves papers based on ATs with focus on the PWD. The evidence is documented from different studies with respect to what challenges the researchers investigated, which research methods they used, what are their major findings and what future research directions they identified. RQ1 contributes in addressing GP1 and GP8.

**RQ2:** What differences do these ATs have from each other?

The answer of RQ2 is found using systematic mapping studies, which are based on the ATs listed from RQ1 and ATs available commercially for the PWD. Using the systematic mapping process we classified ATs into different categories based on their types and functionalities. For that, we developed AT evaluation criteria based on the established definitions of different ATs from literature. Furthermore AT functionality and their respective advantages and limitations are also analysed to have better understanding about their possible uses and impacts. The RQ2 contributes in addressing GP3 and GP4.

**RQ3:** What are the experiences of the PWD from the existing ATs?

To answer this research question data is collected through the semi-structured interviews and questionnaire based surveys from the PWD. These surveys are focused to understand the usability of existing ATs and to elicit the requirements of the PWD for future ATs. The RQ3 contributes in addressing GP3 and GP7.

**RQ4:** How can we help the PWD through the use of AT?

This research question is answered by the help of the qualitative, quantitative and requirements analysis. These analyses show that the ATs can help the PWD in getting social, psychological and travel support and can help them to reduce their dependence on others. The RQ4 contributes in addressing GP4, GP5 and GP8.

**RQ5:** What are the impacts of ATs on daily lives of the PWD?

This is the most important research question for this study. The answer to this research question involves data from all previous RQs. The results are validated by conducting case studies through the involvement of the PWD. In the case studies the PWD are provided an assistive software application [named E-Community for Dementia (ECD) Application] to use for daily functioning and the impacts of this software application are analysed. The RQ5 contributes in addressing GP1, GP2 and GP6.

## 1.6 Objectives of the Research

The major aim of the study is achieved by accomplishing individual objectives outlined below:

**OB1:** "To investigate different ATs available in literature for the PWD"

This objective is achieved through a comprehensive literature review of recent research studies on the design, development and implementation of ATs for the PWD.

**OB2:** "To investigate different ATs available commercially for the PWD"

For this objective an industrial survey for the existing ATs has been performed by visiting AT exhibitions.

**OB3:** "To analyze different ATs for their respective advantages and limitations"

Two systematic mapping studies used an AT evaluation criteria for listing the advantages and limitations of AT from literature and commercial surveys.

**OB4:** "To categorize ATs based on the systematic mapping study results"

This objective has been achieved through the systematic mapping process by using AT types and their functionalities for AT categorization.

**OB5:** "To explore the state of AT based research for the PWD in different countries"

To achieve this objective, bibiliometric analysis are performed for world leading countries in AT research for the PWD with respect to their research contributions, areas of focus, national dementia strategies and research open directions.

**OB6:** "To identify important factors for AT being used by the PWD"

For this objective semi-structured interviews and questionnaire based surveys have been performed by involving the PWD. The interviews and questionnaires were based on AT usability questions, which helped to identify the important factors with respect to AT use for the PWD.

**OB7:** "To explore the support of ATs in travel and tourism for the PWD"

The questionnaire data is used through SPSS for exploration of AT support in travel and tourism. This objective explains the motivations and resulting achievements of the PWD through AT supported travel and tourism.

**OB8:** "To investigate the impacts of different factors on AT acceptance and retention"

The questionnaire data was used through Statistical Package for the Social Sciences (SPSS) and Analysis of a Moment Structures (AMOS) tools for factor ranking and analysing their impact on AT acceptance and retention by the PWD.

**OB9:** "To highlight how usable current ATs are for the PWD and to understand their requirements for the future ATs"

The data gathered through semi-structured interviews and questionnaires also helped to understand the usability of the ATs based on the experiences of the PWD and to list their requirements for the future ATs.

**OB10:** “To design and develop assistive software application for the PWD based on their real needs”

For this objective, an assistive software application is designed and developed based on the actual requirements of the people PWD, elicited through questionnaires and semi-structured interviews based surveys.

**OB11:** “To experiment with the use of assistive software application by involving the PWD”

Eight case studies are carried out with the PWD by providing them the assistive software application. These experiments contribute towards the realization of researcher idea of the E-Communities for Dementia (ECD).

**OB12:** “To analyze the impacts of assistive software application on the lives of the PWD”

The results of the experiments are analysed to check the impacts of assistive software application on the daily routines and behaviour of the PWD.

**OB13:** “To propose guidelines for improving AT productivity and user friendliness”

The results from the questionnaire, semi-structured interviews and case studies are used to propose guidelines for improving AT productivity and user friendliness.

## 1.7 Research Approach

This thesis followed User-centred Design (UCD) approach by applying multi-methods research technique (collection of qualitative and quantitative). The UCD is one of the popular concept used in Human Computer Interaction (HCI) research and it encourages the participation of the users throughout the research process (Abras et al. 2004). The

UCD approach was first introduced in 1980s and has seen number of contributions to its initial theory. These days UCD is regarded as “one of the guiding principles for designing usable technologies”(Haklay 2010). The major characteristics of the UCD followed in this thesis are: earlier user involvement, iterative design and empirical evaluation. Throughout the thesis the users are involved at four stages as indicated in figure 1.5.

At 1st stage the users (PWD) were contacted and consulted during AT exhibitions visits and research workshops, which helped in generating lists of current ATs in use by the PWD. The 2nd stage involved PWD through interviews and questionnaires to explore the usability of existing ATs and to elicit their requirements for the future ATs. The 3rd stage involved PWD during the design and development of the ECD application. Finally the 4th stage involved the PWD through user case studies for analysing the usability and impacts of the newly developed ECD application.

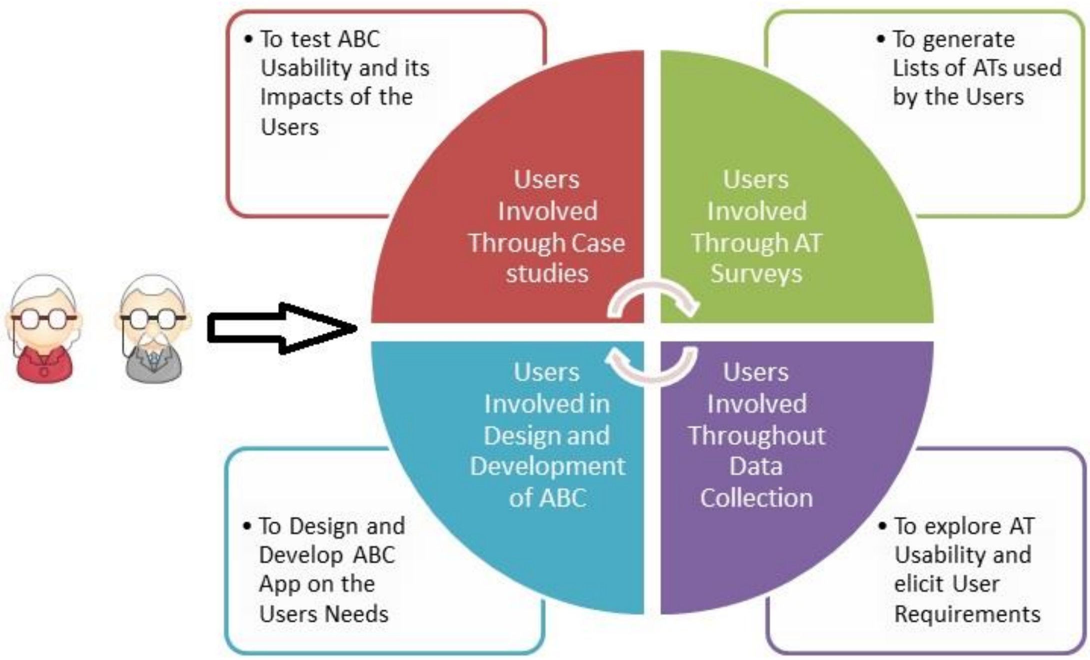


Figure 1.5: The Research Process Used for the Thesis

## 1.8 Research Contributions

The major research contributions from this thesis are described below:

**C1:** New Empirical Research Area

The biggest contribution of this thesis is the implementation of new empirical research area by involving the PWD throughout the research process. The involvement of the PWD started right from the beginning of the project when the researcher met them during AT exhibitions and care homes (details in chapter two). Later on 32 PWD participated in the development of the questionnaire through the pilot study (details in chapter three). As the next step 20 PWD participated in semi-structured interviews and 327 PWD participated in questionnaire based surveys for analyzing the usability of existing ATs and eliciting their requirements (details in chapter four and five). The PWD were kept engaged during the design and development of the ECD application as well. Finally eight PWD participated in testing the usability and impact evaluation of newly developed ECD application on their daily routines (details in chapter five).

**C2:** Largest Study to Involve the PWD

There are few studies available which involve the PWD in experiments, testing, case studies, interviews or focus groups. However, most often these studies only include small population of few the PWD ranging from five to 63. To the best of knowledge, this is the largest study to involve 347 PWD at different stages of the research including: requirements elicitation, design, development and testing of the ECD application (details in chapter four and five).

**C3:** First PWD Related Study in Pakistan and the South Asia

Pakistan is the 6$^{th}$ most populated countries in the world and has an annual 1.9% steady rate of dementia population increase. Yet, dementia related research has been ignored in

Pakistan. To the best of our knowledge this research is the pioneer research effort undertaken with the focus on AT support for the PWD.

The South Asia is regarded as one of the most important region in the world as it holds nearly 25% of the worlds' population. According to official figures this region is also home to 4.5 million PWD (the number of unregistered PWD is expected to be much higher than this). The literature and bibliometric studies indicated the lack of research in this region (details in chapters two and four).

**C4:** AT Categorization

This thesis includes two systematic mapping studies, the 1st related to general ATs and the 2nd related to software based ATs used by the PWD. These studies helped to categorized ATs on the basis of their types, functionalities, advantages and limitations following the systematic mapping study method which has never been used for AT research with focus on the PWD. The general AT based study resulted into five categories and software based AT study resulted into nine categories (details available in chapter two).

**C5:** Identification of Different Factors and AT Usability Evaluation

The major part of the thesis is based on identifying important factors for AT usability with respect to the PWD. The data gathered from 327 PWD through questionnaires acted as input for factor identification. Exploratory factor analysis conducted through SPSS resulted into 11 important factors for AT usage by the PWD, which include: operational support, physical support, psychological support, social support, cultural match, reduced external help, affordability, travel help, compatibility, effectiveness and retention.

Another important contribution of this thesis is related to the AT usability evaluation by the PWD through qualitative and quantitative surveys. The qualitative survey shows popular AT types used by the PWD along their supports to them. The quantitative survey highlights important supports of the ATs to the PWD and their relevant impact of AT effectiveness and long term retention (details available in chapter four).

**C6:** Requirements, Design and Development of E-Community for Dementia Application

As per the core aim of this study and research gaps in existing literature, this thesis elicited real requirements related to AT development from the real users (PWD in this case). The requirements are elicited from 347 PWD through qualitative and quantitative surveys. This thesis further proposed and implemented requirements mapping analysis technique and finalized six major requirements of the PWD for the later part of the.

Another highlight of this thesis is the development of the ECD application to assist the PWD in certain activities based on their own requirements. The prototyping approach is used to involve the PWD during the development as well (details available in chapters four and five).

**C7:** Case Studies for Testing Acceptability and Retention of ATs

One of the core contributions of this thesis is the realization of the ECD idea through multiple case studies. The case studies involved PWD and volunteers living at same streets. The case studies analyzed the support of the ECD application with the combination of human involvement.

This thesis highlights important factors which impact the acceptance, effectiveness and long term retention of ATs by the PWD. It further explains lessons learned and provides suggestions to the AT producers for improving AT acceptance and retention rate (details available in chapter four and five).

## 1.9 Thesis Structure

The overall report is based on six chapters. This section briefly explains the details of the upcoming chapters summarized in figure 1.6.

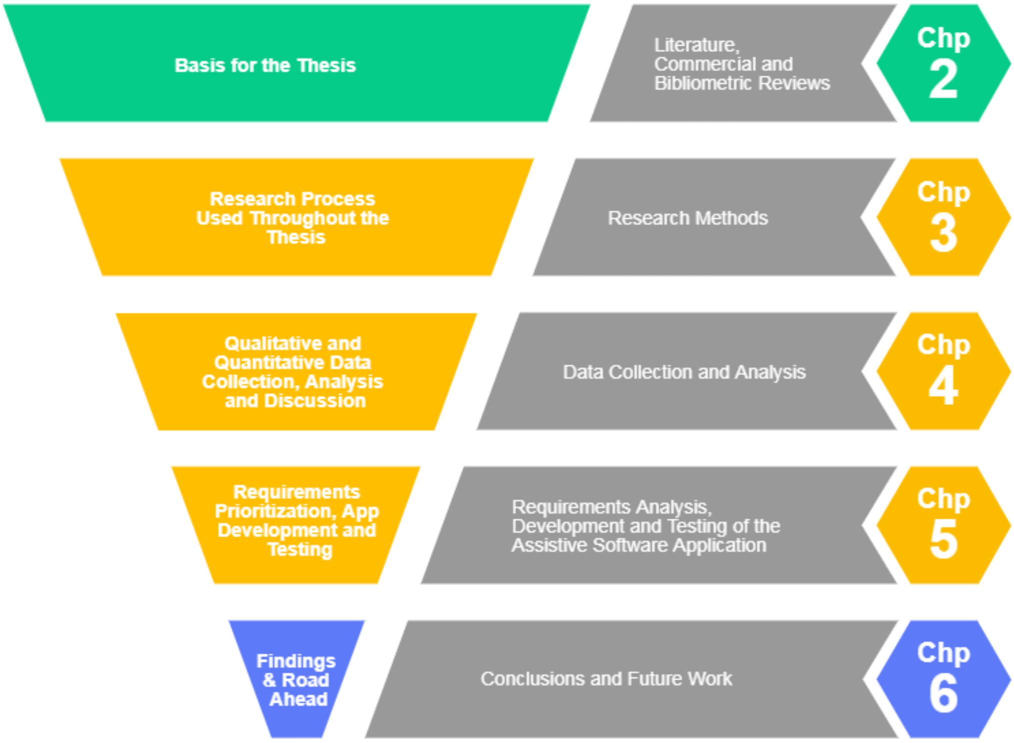


Figure 1.6: Thesis Flow Diagram

**Chapter Two:** Literature, Commercial and Bibliometric Reviews

Chapter two is based on three main parts. The "Literature Review" part discusses important literature available on AT based studies for the PWD. It further explains the methods, population, results and impact of these studies. A brief summary of open research areas is also presented. The "Commercial and Online Reviews" parts focused on the results generated through two systematic mapping studies. The 1$^{st}$ systematic mapping study is based on general ATs for the PWD (47 from literature and 15 from AT exhibitions). The 2$^{nd}$ systematic mapping study is based on SWAT for the PWD (18 from literature and 33 from online sources). The AT and SWAT categorization is done and explained in this chapter as well. The “Bibliometric Review” part is based on the research overview related to AT based research in different countries. The study highlights major contributors to AT research, their specialized research areas, national dementia strategies and research open areas.

**Chapter Three:** Research Methods

Chapter three describe the research methodology used for the project. The chapter starts with highlighting methodology issues, research types (primary and secondary, qualitative, quantitative and multi-methods research), advantages and limitations of different of popular research types. Then goes into the details of research process used for the two mapping studies including search strategy, systematic mapping of ATs and AT categorization. Later on describes the research process used for the bibliometric study including: search string, papers selection and data analysis. The chapter continues with explaining the research method used for the qualitative study including: semi-structured interview template design, interview process, data collection, data interpretation and data analysis. As next step the chapter explains the detailed process used for the quantitative study including: the questionnaire design, pilot study, data collection, data interpretation and data analysis. The final part of the chapter highlights the research process used for the case studies. The whole chapter further specifies the ethical considerations followed throughout the thesis. The chapter ends by summarizing the whole research process used for this thesis by explaining each step and their connection with each other.

**Chapter Four:** Data Collection and Analysis

Chapter four explains data collection and analysis through three studies. The “Qualitative Study for AT Themes” part presents details of the qualitative study. The qualitative study is based on 20 semi-structured interviews conducted with the PWD to understand their needs for ATs and take help in the design of the questionnaire for the quantitative study. The “Quantitative Study for AT Factors” presents details of the quantitative study conducted for comprehensive data collection. The questionnaire based quantitative study is conducted to collect data related to AT usability and future requirements of the PWD. In total 327 PWD participated in this study. This chapter highlights the uses of existing ATs, important factors for AT usability, factor ranking and explores requirements of the PWD. The “Quantitative Study for AT Support in Travel and Tourism” part investigate the support and impacts of AT in travel and tourism for the PWD.

**Chapter Five:** Requirements Analysis, Design, Development and Testing of the Assistive Software Application

Chapter five is based on three parts. The “Requirements Analysis” part presents requirements analysis and application development. The requirements analysis process and results are discussed in detail. The “Application Development” part is focused on the design and development of the application following the prototyping method is also discussed in detail. The “Software Application Testing and Evaluation” part is based on the testing and evaluation of the software application developed for the PWD. The case studies and interviews are used to test and evaluate the usability of newly developed software application. The results are compared with existing ATs and literature.

**Chapter Six:** Conclusions and Future Work

Chapter six revisits objectives set for the study and how these are achieved one by one. The chapter further lists the empirical findings of the thesis by relating them to research questions set in the first chapter. The thesis conclusions, research limitations and possible future research directions are also summarized in this chapter.

# CHAPTER TWO

## Literature, Commercial and Bibliometric Reviews

***Declaration:*** *Parts of this chapter are published in journals/conferences, which is the original work of the author for this PhD thesis. Other co-authors have important supervisory role in producing these publications. Detail of publications is as follows:*

Asghar, I., Cang, S. and Yu, H., 2017a. Assistive technology for people with dementia: an overview and bibliometric study. *Health Information & Libraries Journal,* 34**,** 5-19.
Asghar, I., Cang, S. and Yu, H., 2017b. Usability Evaluation of Assistive Technologies through Qualitative Research Focusing on People with Mild Dementia. *Computers in Human Behavior,* 79**,** 192-201.
Asghar, I., Cang, S. and Yu, H., 2018a. Impact evaluation of assistive technology support for the people with dementia. *Assistive Technology,* UATY #1411405.
Asghar, I., Cang, S. and Yu, H., 2016. Software based assistive technologies for people with dementia: Current achievements and future trends. *In: 10th International Conference on Software, Knowledge, Information Management & Applications, 2016*. Chengdu, China. IEEE, 162-168.
Asghar, I., Cang, S. and Yu, H., 2015. A systematic mapping study on assitive technologies for people with dementia. *In: 9th International Conference on Software, Knowledge, Information Management and Applications, 2015*. Khatmandu, Nepal IEEE, 1-8.

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This thesis investigates the impacts of ATs in supporting the PWD during their daily activities. An extensive literature review has been performed on ATs and their applications in the daily activities of the PWD with the aim to identify the research gapes for this specific field. This chapter presents a review of existing state of the art for the topic under investigation. This chapter further presents review and analysis of existing ATs for the PWD through commercial surveys (AT exhibitions visits and online searches). The literature and commercial surveys are then linked to analyze how existing ATs are helping the PWD in their daily lives. The final part of the chapter presents an overview through bibliometric analysis for the top AT research countries and related research gaps.

The chapter is divided into three major sections. The 1st section named "Literature Review" presents important definitions, background and classifications of ATs, summary table of existing ATs available in literature, summaries of the existing empirical studies available within the research domain and enlists open research areas. The 2nd section named "Commercial and Online Surveys" presents results from mapping study one, which is based on the analysis of general ATs for the PWD and the results of the mapping study two, which is based on software based ATs for the PWD. This section also highlights some open research areas. The 3rd section named "AT Bibliometric Analysis" presents and overview of AT research activities among top research countries and contribute to further open research areas.

This chapter is focused on achieving the following research objectives:

OB1: "To investigate different ATs available in literature for the PWD"

OB2: "To investigate different ATs available commercially for the PWD"

OB3: "To analyze different ATs for their respective advantages and limitations"

OB4: "To categorize ATs based on the systematic mapping study results"

OB5: "To explore the state of AT based research for the PWD in different countries"

## 2.1 Literature Review

### 2.1.1 Important Definitions Used in the Thesis

Assistive Technology: AT is a broad term used to describe *"any item, object, device or system that enables a person to perform tasks that they would otherwise be unable to do, or increase the ease and safety by which certain tasks can be performed"*. Put simply, the purpose of AT is to provide any aid that can assist the frailest and vulnerable members of our society to live well and safe at their own home or in a care home environment (Au et al. 2015b).

The federal Individuals with Disabilities Education Act (IDEA) define AT as *"any item, piece of equipment, or product system, whether acquired commercially off-the-shelf, modified, or customized, that is used to increase, maintain, or improve the functional capabilities of individuals with disabilities"* (Marino et al. 2006).

The Convention on the Rights of Persons with Disabilities (CRPD) defines AT as *"the technology designed or adapted to improve the performance and quality of life for individuals with disabilities"* (Assembly 2007).

Dementia: The term dementia is quite famous in different fields of research these days. This term is used to describe a category of *"brain diseases that includes any disease that causes loss of cognitive ability (the ability to think and reason clearly) that is severe enough to affect a person's daily functioning"* (Draper et al. 2010). In simple words dementia is a continuing mental processing disorder due to some injury or disease which result into personality change, mental disorder and reduced reasoning ability.

Wellbeing: Another important concept involved in this thesis is the wellbeing of the PWD. The term wellbeing describes *"the state of being comfortable, healthy, or happy"* (Kinney and Rentz 2005).

Assistive Technology Impact: Since the major aim of this study is to investigate the impact of AT in supporting the PWD, therefore understanding term is important. The term AT impact means *"the marked effect or influence"* of AT on the behaviour of the users (Chaudhry et al. 2006).

Assistive Robotics: Assistive robotics is defined as *"An assistive robot performs a physical task for the well-being of a person with a disability. The task is embedded in the context of normal human activities of daily living (ADLs) and would otherwise have* *to be performed by an attendant; the person with the disability controls the functioning of the robot"* (Feil-Seifer and Mataric 2011).

Activity Monitoring Systems: The term activity monitoring systems refers to the *"facilities in providing supervision or assistance with activities of daily living (ADLs); coordination of services by outside health care providers; and monitoring of resident activities to help to ensure their health, safety, and well-being"* (Safian 2009).

Prompts and Reminders: The prompts and reminders are also used to help the PWD. The prompts and reminders provide *"visual and audible cues, they include clock calendars, medication reminders and memo minders"* (Pollack et al. 2003).

Assistive Mobile: Assistive mobile refers to *"A device, such as a PDA or smart phone, that can store, access, create, allow to modify, organize, or otherwise manipulate data in various forms from a location without being required to be tethered to any particular spot"* (Mageswaran 2012).

Assistive Software: The term assistive software or adaptive software *"refers to computer programs designed for specialized hardware used by physically challenged people"*(Kouroupetroglou 2013).

### 2.1.2 Background of Assistive Technology

If we look into research related to the history of AT, then we find out that most comprehensive study conducted on this topic came in 2011. That study distributed AT development into three eras. They named the first era as "The Foundation Period", the second era as "The Establishment Period" and the third era as "The Empowerment Period" (Bryant and Bryant 2011).

The Foundation Period (Stone Age to 19$^{th}$ Century): The first era known as "The Foundation Period" started in the Stone Age when people from that time attempted to use a 'stick' as a cane to assist other person with an injured leg (Bryant and Bryant

2011). During the 17th and 18th centuries the pirates maintained their functional capabilities by using a ‘metal hook’ and ‘wooden legs’. In 1829 ‘Braille method’ of reading and writing was established for blind or partial sighted people. In this method people perform reading and writing through touch. After some years in 1836 ‘phonograph’ was invented by Edison to help his mother and other people with hearing problems to enable them to listen recordings (Cook and Polgar 2014).

The Establishment Period (1900 to 1972): The second era for AT development is known as “The Establishment Period” which spans from 1900 to 1972. This era is known for the establishment of different laws, policies and litigation. The famous law established during this era is ‘The Soldier Rehabilitation Act 1918’ which was extended in 1920 for the nonveterans as well. During this period many notable inventions were made like in 1937 the ‘Xframe-folding wheelchair’ was invented and later on in 1947 the ‘Hoover Cane’ was invented. Another interesting aspect of this period is the establishment of various organizations to help people with disabilities and their family members. Examples includes organizations like ‘Council for Exceptional Children-CEC’ established in 1922 and the Learning Disabilities Association-LDA’ established in 1963 (Cook and Polgar 2014).

The Empowerment Period (1973 till now): The third era for AT development is known as “The Empowerment Period” which spans from 1973 till now. This era started with the ’Education for All Handicapped Children Act – EAHCA’ in 1974. A few years later in 1988 ‘The Technology Related Assistance for Individuals with Disabilities Act (Tech Act)’ law was established to support AT development and implementation financially. In 1998 ‘The AT Act (ATA)’ was established which resultantly increased the access and availability of AT services and devices (Alkahtani 2013). During Empowerment period the demand and development of ATs has increased exceptionally. Another proof of empowering people with disabilities through AT is the statement by IBM which describes that *"For most people, technology makes things easier, but for persons with disabilities, technology makes things possible"* (Bryant and Seok 2016).

### 2.1.3 Assistive Technology Classification

The existing literature related to ATs can be classified into three categories named as: (i) Low-Tech Assistive Technologies, (ii) Mid-Tech Assistive Technologies and (iii) High-Tech Assistive Technologies (Ganschow et al. 2001).

Low-Tech Assistive Technologies: Low-tech ATs are easy to use devices as they are often non-electronic devices. They need little or no training at all for using them. These devices are commonly available everywhere at very low cost. These devices either need little or no maintenance at all. The examples of low-tech ATs include adapted furniture, highlighter tape or pens, pencil grips etc. (Ganschow et al. 2001).

Mid-Tech Assistive Technologies: Mid-tech ATs are mostly electronic based devices. These electronic can be easily operated with small amount of training. These electronic devices just require basic level of maintenance, so the cost is not too high for such devices. These electronic devices are widely available in markets on reasonable price. The examples for Mid-tech ATs include electronic dictionaries, digital recorders, adapted keyboards etc. (Ganschow et al. 2001).

High-Tech Assistive Technologies: High-tech ATs are complex electronics and mostly contain microcomputer components for storing and retrieving data and information. Mostly these ATs are of higher cost and these also require continuous maintenance which increases its cost even more. Since these are complex technologies, these require broad training for operating them properly. The examples of high-tech ATs include talking calculators, software, hearing and vision devices, robotics, monitoring systems, prompting devices etc. (Ganschow et al. 2001). In an interesting study Cook and Hussey described that *"yesterday's high tech is tomorrow's low tech"*. They further recognized that *"as the field advances, there will be new considerations that will further stretch our concepts and force new ways of categorizing and describing ATs"* (Hussey et al. 2002).

### 2.1.4 Popular Assistive Technologies from Literature

The ATs offer various types of functionalities for the PWD like socialization, cognitive help, activity monitoring, health conditions monitoring, safe walking, medication on time, leisure activities, rehabilitation etc. For eliciting popular ATs from literature we have developed an AT evaluation criteria (based on their definitions) to better understand the ATs in details.

Assistive Technology Evaluation Criteria: The AT evaluation criteria include basic functionality, operations, advantages of AT usage and limitations associated with existing AT. The criterion is followed as:

- ✓ As evident from the definition, the assistive robot should be able to help the PWD in their daily living activities like mobility, transportation, social assistance, disability rehabilitation exercises, climbing stairs, physical support etc.
- ✓ The monitoring systems assist in activities like supervision of the PWD while living at their homes or care homes. These systems should provide continuous monitoring with respect to person's health, safety, wellbeing etc. Furthermore these systems should provide help in deviations from routine daily activities, tracking location, detecting falls, wondering at night etc.
- ✓ The prompts and reminder systems should provide help especially to the persons with cognitive disabilities. It should be able to perform activities like generating prompts and reminders for taking medicine, prompts for performing daily

activities in a proper sequence, remind people to perform various tasks on predetermined time, prompts for executing a plan etc.

- ✓ Assistive mobile technology includes mobile devices tailored to specific needs of the PWD. These devices should provide support in making calls, video messages as reminders etc. Further these devices can also be used for monitoring patient's physiological data like weight, blood glucose, blood pressure etc.
- ✓ Assistive software applications are specifically designed applications for the PWD. These applications should fulfil the needs of the PWD like organizing activity calendar, leisure, storing patient information etc. Additionally these applications can be used in combination with other ATs for the wellbeing of the PWD.

Table 2.1 shows the summaries of the different ATs available in literature by highlighting their support, source, functionalities, advantages and limitations.

### 2.1.5 Empirical Studies on Assistive Technology Support for the People with Dementia

Empirical studies are conducted by using empirical evidence. These studies are used for gaining direct knowledge through observations of experiences. Empirical studies can be conducted through qualitative, quantitative or multi-methods research approaches. Research approaches used for empirical studies depend on the nature of research questions and research domain.  Empirical studies are popular in almost all research fields. The literature review shows that there are also few empirical studies on ATs with focus on the PWD.

Table 2.1: Popular ATs found in Literature

| AT Name | AT Support | AT Source | Functionality | Advantages | Limitations |
|---|---|---|---|---|---|
| **ROBADOM Robot Butler** | Reminders and Socialization | (Wu et al. 2013) | The robot is capable of carrying some traits of machine and animals.<br>The robot is also capable of reminders and simulations. | The participants rated positively the traits of the robot.<br>Reminders help in carrying daily activities. | Young and old people perceived the expressions of the robot differently. Old people are reluctant to adopt robots. |
| **Smart Walkers** | Physical Mobility | (Martins et al. 2012b) | The smart walkers help older people to move independently at their homes. Smart walkers use navigation system and sensors for detecting obstacles. The smart walkers offer:<br>Physical help,<br>• Sensorial help,<br>• Cognitive help,<br>• Health monitoring help,<br>• Advanced interface between human and machine. | Smart walkers help in rehabilitation for people with disabilities:<br>Detect obstacles,<br>Cost effective,<br>Increase the confidence of disabled people. | The extensive use of such devices can result into health challenges as the users have to be in sitting position for longer times. |
| **Lokomat** | Mobility and Rehabilitation | (Colombo et al. 2000) | Physical support functionality for enhanced gait stability for the users.<br>The therapy intensively addresses movement repetition.<br>Movement exercise devices are capable of helping the therapists for providing enough chances to all patients for better results. | The goal of the exercises is to improve functional activities and sensorial motivations by replications. | The use of Lokomot needs many cycles and often patients get fed up and feel reluctant to use it time and again. |
| **LokoHelp** | Mobility and Rehabilitation | (Swinnen et al. 2010) | Physical support functionality for enhanced gait stability for the users.<br>The LokoHelp aims at providing rigorous exercises on movement replications. | Helps to train the people with physical disabilities. | LokoHelp is only useful for people with physical disabilities. It's not that much supportive for people with cognitive impairments. |
| **LOPEZ** | Walking and Training | (Veneman et al. 2007) | LOPES chains an adaptable & 2D actuated pelvis piece having leg exoskeleton having 3 rotational joints.<br>The LOPES offers a "patient- in-charge" mode where robot follows the patient and "robot-in-charge" mode where the robot leads the patients. | LOPES provides gait training based on specific tasks.<br>Unhindered walking using this device is possible. | LOPES position calculations are not precise for conducting "inverse dynamical gait analysis".<br>There are no LPOES trials |
| **WHERE-I** | Mobility | (Seo and Lee 2009) | WHERE-I is based on portable manipulator having one link robotic arm, intention analysis system and safety system | WHERE-I facilitates patient movements to help them learn walking with correct and straight postures. | WHERE-I do not consider user intention and has no mechanism to measure what user wants at some specific moment. |

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| **WHERE-II** | Mobility | (Seo and Lee 2009) | WHERE-II is based on portable vehicle having one link robotic arm, intention analysis system, electronic compass and safety system. | It helps in activities for rehabilitation of people with disabilities. | For using WHERE-II, the patients' needs extensive training. |
| **GaitTrainer** | Safe Walking | (Schmidt et al. 2007) | GaitTrainer is a feet exercise device, which holds patient's feet for the robotic manipulator.<br>It helps and support the patients in practicing walk situations.<br>It supports different walking scenarios including: climbing upstairs, going downstairs, walking on straight levels etc. | GraiTrainer focuses on copying patient movements in natural manner.<br>The mock feet actions helps the slack muscles to be in movement again.<br>It is especially useful for people with neurological disorders. | Often patients get fed up using these devices all the time and need human presence. |
| **HapticWalker** | Safe Walking | (Schmidt et al. 2007) | HapticWalker is another feet exercise device, which holds the person's feet to a robot manipulator.<br>It offers gait stability through supporting physical activities. | HapticWalker helps in close to natural movements.<br>It is especially useful for people with neurological disorders. | HapticWalker provides just physical support to the users, for psychological and social support a combination of this technology and human support is necessary. |
| **NEUROBike** | Individualized Therapy | (Monaco et al. 2008) | The NEUROBike robot is based on:<br>• Leg-joint pointed excursion closer to natural walk<br>• Less interaction (leg & robot)<br>• Support for the patients on bed rest<br>• Cognitive motivation for gait cycle duration<br>• Patient specific controls | NEUROBike platform helps gait rehabilitation in biomechanical and neurological challenges | NEUROBike is mostly used for people with serious illness. Not suitable to people at early stage of disease. |
| **HAL-3** | Controlled Walking | (Kawamoto et al. 2003) | HAL-3 system is a combination of sensors, controllers and skeleton/actuator.<br>HAL-3 is used for analyzing walk tests by focusing on muscle force and it splitting walk into different stages. | Experimental findings show effective power support with HAL-3. | Alongside HAL-3, the patients wish to have human facilitator as well. |
| **RoboKnee** | Stair Climbing | (Krupp and Morse 2004) | RobiKnee gains higher transparency.<br>The patient intent is decided by "knee joint angle" and "ground reaction forces".<br>Torque is used for relaxing patients' muscles.<br>Elastic actuators are used for low impedance. | The RoboKnet helps the patient in climbing stairs and deeper knee bends. | Specialized training and safety measures needed for using this technology successfully. |
| **SmartCane** | Monitoring | (Spenko et al. 2006) | This system support health monitoring.<br>SmartCane uses camera and signposts on ceiling.<br>SmartCane uses sonar array to detect obstacles. | SmartCane helps to delay shifting old people from assisted living place to nursing home.<br>The system performs well and have high user acceptance. | The user needs attention to be aware to obstacle detections. |
| **Rollator** | Mobility | (Constantinescu et al. 2007) | The Rollators are easy to use four-wheel walkers.<br>Due to modern wheel equipment, the Rollators needs little strength for rolling and pivoting.<br>These walkers can be attached with shopping baskets. | The elderly people favor smart walkers like Rollators as compared to traditional walkers. | The user training for applying breaks for safety. |

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| | | | Hand breaks for stopping the walker. | | |
| **Mobil Walker** | Walking | (Ryu and Mun 2004) | Physical support functionality for improving gait stability.<br>Provides help for the user to perform standing and sitting activities. | Mobile Walker assists the forearms. | The device in only useful for people with physical disabilities. |
| **i-walker** | Reduce Falling | (Cortés et al. 2008) | The i-Walker is a robotically augmented rollator to reduce fall risk and confusion.<br>It provides an agent based intelligent decision making system.<br>It increases rollator convenience and enjoyment. | The i-walker increases confidence of the old persons.<br>The i-walker improves the QoL for both the users and their caregivers. | Sometimes the agent-based decisions differs to actual perceptions of the individuals using it. |
| **PAMM Smart Walker** | Mobility | (Dubowsky et al. 2000) | These walkers offer more stability then four point canes.<br>Helps to find destinations through embedded maps, commands, schedules and obstacle detection.<br>Support health monitoring and assist in communication. | PAMM are useful at care facilities for elderly people.<br>PAMM offers physical assistance and can monitors vital signs of the users. | Most of the decision making is based on already programmed maps, so improvising sudden changes is very tough with this device. |
| **Walker with a joystick** | Obstacles Detection | (Hashimoto et al. 2006b) | It is a friendlier system for making elderly walking safer through obstacle detection.<br>The walker uses joystick embedded system.<br>The user can recognize the surroundings based on the data generated by the system.<br>The system uses "virtual potential field" for the direction and distance of the obstacles. | The users can quickly learn system operations.<br>The users develop feeling of security through recognizing the surroundings based on the system information. | The size of the walker should be reduced. |
| **JAIST** | Rehabilitation | (Lee et al. 2010) | JAIST Provides efficient and cost effective solution for recovering from disabilities.<br>The development considered the lack of knowledge by the elderly and therefore the system is based on a "pair of infrared sensors and with laser range finders". | Sensors detect lower limb position of the user to calculate the speed and direction.<br>Promote independence through daily exercises. | JAIST is only useful for people with disabilities. |
| **ASBGo** | Smart Movement | (Martins et al. 2012a) | In ASBGo smart walker the sensor reads user movements for commanding walker.<br>The joystick is clever enough to cite users' navigations commands.<br>Fall detection sensors improves the security and safety of the older users in case of falls. | ASBG0 is a cost effective walker with higher security and consistency. | System testing for usability and interface efficacy remains a challenge. |
| **Light Paths** | Monitoring and Fall Prevention | (Tchalla et al. 2012) | This system uses "light paths" combined with "tele-assistance service" to avoid accidental falls among the old people. | Significant improvement in reduction of falls by using light. | Installation of these physical light paths at private houses is tough.<br>It would be better to come up with a logical solution. |
| **Monitoring System** | Monitoring and Fall Detection | (Schikhof et al. 2010) | This system is used for nighttime remote monitoring of people living at dementia care.<br>The system uses infrared sensor and sound sensor. | The system notifies alarms when the person encountered a fall. | Some users feel the use of camera compromises their privacy. |

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| | | | The system also uses router, camera and server as well. | | |
| **Mobile Multimedia Technology** | Reminders | (Donnelly et al. 2010) | Mobile multimedia is a novel system for frequent prompting reminders to the people with mild dementia.<br>It consists of the associations between:<br>• Caregiver's device<br>• Server & database<br>• Mobile device of the user<br>• Mobile device of the caregiver<br>This technology uses prerecorded messages. | The system provides reminders to people with dementia.<br>The system provides communication means as well. | Only limited number of pre-recorded messages can be used as more and more messages will be confusing for elderly people. |
| **Smart Prompting Technology** | Prompts for Medication | (Seelye et al. 2012) | Prompting technologies provides help for patients, caregivers and doctors to set routines for different activities like medication etc. | Prompts to set reminders for different activities. | Training to understand reminders is necessary for the rehabilitation purposes. |
| **Cyberminder** | Smart Prompts | (Dey and Abowd 2000) | Cyberminders determines prompts based on complex circumstantial data.<br>It uses multiple context situations including (time, user location, user activities) and generates prompts based on multiple conditions. | Cyberminder is helpful in issuing a prompt when multiple conditions are considered. | Sometimes patient needs help in just one condition, so Cyberminder needs to be tailored to issue special prompts for individual situations as well. |
| **Assistive Cognition Prompting System** | Situation based Prompts | (Mihailidis and Fernie 2002) | This system senses both home and out of home environment and position of the user through multiple sensors including (motion detectors, GPS and active badges).<br>The system also senses whether the users are able to achieve their goals through their emotional reactions and helps them through timely prompts. | Smart prompting system issues prompts by analyzing situations of the users. | Although the system is context-aware, but it cannot measure the feelings of the user.<br>It should be used in combination of human caregiver as well, who can understand user's feelings. |
| **Forget-Me-Not** | Reminders for Socialization | (Lamming and Flynn 1994) | It is a little digital devise similar to a PDA (Personal Digital Assistant).<br>The device collect circumstantial data from the environment of the users.<br>The device support the users for different tasks including calls, emails etc. through the help of different icons. | Forget-Me-Not is very useful for realizing the users to complete their tasks on time. | 100% understanding of users' circumstantial data is not possible for any device. |
| **Nursebot** | Robotics Intelligent Reminders | (Pineau et al. 2003) | Nursebot is an artificially intelligent robot which assists older people in their daily activities.<br>The robot mainly provides intelligent reminders.<br>The robot also engages older people to a certain level of social interaction. | The Nursebot is useful for socially engaging older adults which improves their rehabilitation chances greatly. | Sometimes older people get too much attached to these robots, that they feel isolated without them. |

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| **Autominder** | Information and Plan Management | (Pollack et al. 2003) | The Autominder is based on three modules:<br>• Cognitive orthotic is used to analyze the differences between activities planned and observed, and is able to issue prompts with the help of a robot.<br>• Plan manager is used to save daily activities data of the users.<br>• Client modeler oversee the users plan executions. | Autominder help people in their assisted daily living. | The robot is capable of only a limited number of pre-programmed reminders. |
| **COACH** | Monitoring and Prompts | (Boger et al. 2006) | The COACH system uses video camera for monitoring hand-washing activities of the users.<br>The system uses AI (Artificial Intelligence) to detect deviations from the pre-planned activities and issues audio-visual reminders for task completion. | The system greatly helps in hand-washing activity and its. | The caregiver reported that the automated prompt system is not as effective as human prompting. |
| **Google Calendar** | Reminders for Events | (Sjogreen 2006) | This application is famous among users to give audio and vibrations prompts through the help of internet.<br>It helps user attentions at the time of different daily appointments. | Event management for reminders is very useful. | Sometimes Google calendar encounter issues like not saving data, limit exceeds etc. |
| **HYCARE** | Reminders and Social Contact | (Du et al. 2008b) | This system is based on four categories of reminders including “remember, maintain social contacts, preform social contacts, and perform daily activities and enhanced safety feeling”.<br>Smart reminders follows the principles of environmental data including “user activity, time and location”. | This context aware system provides smart reminders based on the actions of the user. | This system is capable of providing only few context aware prompts. |
| **CoReDa** | Fun filled Prompts | (Si et al. 2007) | This system supports people in assisted living through prompts.<br>The prompts are released in three different ways including object photos, light blinks and text messages. | CoReDa provides multi type reminders in the form of lights, texts and pictures which is highly interesting. | Although the idea is interesting, but it require an intensive training to understand blinking lights and pictures objects reminders. |
| **EMA** | Prompts | (Witte 2008) | EMA (Electronic Memory Aid) helps the PWD.<br>EMA helps people to carry out daily assisted living activities through reminding them. | Participants with moderate disease respond to the prompting. | Participants with severe disease did not respond to the prompting. |
| **MPVS** | Communication | (Zhang et al. 2014) | This system is based on three modules:<br>• The 1st module uses mobile phone to deliver video messages as reminders. Users can also respond to the message by pressing button on the device.<br>• The 2nd module for the care giver has touch screen interface for recording different reminders.<br>• The 3rd module is the backend server that stores, | The predictive model used in this system can help the older people staying at their own homes rather than transferring to care facilities.<br>It minimizes the possibility of undesirable impact on the user mood and helps improve their QoL. | A continuous interaction between user and care-giver is needed for updating reminders according to the situation. |

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| | | | communicate and transmit data between mobile application and caregiver application. | | |
| **Videophone Mock-Up** | Communication | (Boman et al. 2014) | Videophone Mock-Up has the capability for the people with dementia to make calls without any assistance.<br>These devices can add in communication quality. | Help to remain in social networking.<br>Dementia people can use these devices without external help. | Initially people with dementia faced problems in handling some of the functions of videophone mock-up.<br>They require training to overcome these problems. |
| **Rosetta System** | Monitoring | (Meiland et al. 2014) | The Rosetta system is used to support in performing daily activities and monitoring deviations from normal routines. | | |
| **AP@LZ** | Prompts | (Imbeault et al. 2014) | The electronic organizer AP@LZ provides organization of different events and can prompts alerts as well.<br>The users can customize the settings according to their needs. | AP@LZ helps the PWD in performing some of their routine activities. | AP@LZ should be able to customize the agenda to each person's needs and preferences. |
| **Automated Hand Washing Assistance** | Monitoring | (Hoey et al. 2010) | This system is capable of oral and visual reminders and takes videos as input.<br>The caregivers can use the system as well for alerting reminders. | Automated real time system assistance for old people to carry out hand washing activities. | There is need for systems that can adapt to user requirements in short and long terms. |
| **The Independent** | Monitoring and Entertainment | (Torrington 2009) | The Independent project includes:<br>• Simple Music Player (You can manage your own music play list).<br>• Window of the World (Camera filming the outside neighborhood).<br>• Conversation Prompter (Replays last few seconds' conversation when a person forgets what he was talking about).<br>• Sequence Device (The system divide tasks into small, simple, clear and easy stages and reminds users to do them step by step). | This project helped technology assisted participation of the PWD in fun filled activities. | |
| **Geriatric Software** | Information Management | (de Oliveira Assis et al. 2010) | Geriatric software technology includes software program, calendar, activity board and routine organizer.<br>This software system provides the following components:<br>• Patient Information<br>• Standardized Tests<br>• Selection of Exercises and Games<br>• A File for Storing Information<br>• Help Page | Geriatric software technology is a cost effective aid for rehabilitation of PWD cognitive abilities. | The Geriatric Software system is more useful for care-giver rather than the person himself. |

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| **Ambient Assistive Living** | Monitoring and Safety | (Aloulou et al. 2013) | This system is based on software platform and multiple sensors.<br>Assistive services installed at nursing home include:<br>• "Wondering at night" through motion and pressure sensors.<br>• "Showering too long" through motion sensor and vibrator.<br>• "Leaving the washroom tap on" through proximity sensor and vibrator.<br>• "Toilet fall detection" through motion and proximity sensors. | This systems supports in assistive living activities like using washroom, toilets and remaining in the care home.<br>It provides continuous monitoring of dementia patients. | The system issues prompts to care-giver in emergency situations, it can be adjusted to prompt the user himself that don't do this activity to increase its immediate impact. |
| **GPS Device** | Safe walking | (McCabe and Innes 2013) | The GPS system is used to track the location of dementia patients when they are walking outside their homes. | The GPS will promote safe walking among people with dementia. | This technology is only useful in outdoor environments for patient monitoring. |
| **Socially Assistive Robots** | Social Assistance | (Feil-Seifer and Matarić 2011) | The SAR (Socially Assistive Robot) can perform the activities of the caregiver like encouraging PWD to perform exercises, take medicine etc. | SAR is beneficial for the caregivers as it can monitor PWD on their behalf. | Often patients got emotionally attached to social robots and expects from them a lot that only humans can support them like cognitive support etc. |
| **TEBRA** | Monitoring and Prompts | (Peters et al. 2014) | The TEBRA (TEethBRushing Assistance) system delivers automatic prompts for executing different tasks in a proper sequence.<br>The system help the users to perform activities without the involvement of caregivers. | Helps in carrying out assistive living daily activities. | The sequence of tasks should be considered while delivering prompts. |

In an empirical study effort the researchers investigated the opinion of the relatives of the PWD regarding AT support. They used 22 PWD relatives for the experiments. Two questionnaires were filled from the participants. The results show that the PWD relatives have positive view about the AT use for the wellbeing of the PWD (Engström et al. 2006). Another study investigated the staff members' satisfaction with AT usage for the wellbeing of the PWD. The study used questionnaire based method to collect data from 33 staff members. Data was collected before, during and six months after the implementation of the AT support at the nursing home. The ATs used include activity monitoring, alarms, internet and fall detectors. The overall results showed that the use of AT significantly improved the job satisfaction of workers with their work (Engström et al. 2005).

In another similar study the researchers investigated staff members' perception of Information and Communication Technology (ICT) use for the PWD. They conducted interviews with 14 members of staff before, during and after ICT implementation. These ICT include communication technology, fall detector, alarms and computers. The staff members have diverse perceptions. After the ICT implementation mostly the perceptions were on the positive side (Engström et al. 2009).

The use of computer technology is explored in another research effort. The computer technology focused in this study is automated prompt system. A total of eight participants participated in 60 trials. The results show that the PWD were able to complete more steps with the help of prompt system. Such ATs can help reduce the number of interaction required between the PWD and their caregivers (Labelle and Mihailidis 2006).

Another empirical study investigated the use of assistive prompter during the hand washing activity. Six PWD participated in the study. The results showed that the PWD completed

11% more steps independently with the help of prompter AT. Additionally the number of interactions with the caregivers also reduced by 60% (Mihailidis et al. 2008).

Wondering is another critical problem for the PWD which also creates lot of stress for the caregivers as well. This problem is investigated by testing GPS device with the PWD and asking their future needs through a case study. The results show that although the participants appreciated the use of GPS but their concerns were related to the shape and volume of the device. This empirical study further conclude to use user centric approach during the development of AT for the PWD (Faucounau et al. 2009).

In an interesting research study the researchers used an entertainment robot for therapy of the PWD. The robot was made of metal and can respond to commands. The researchers conducted case study at a care home. Although the patients recognized the robot, still the results show increased communication between the PWD and the robot. The robots can be effective tool in rehabilitation of the PWD (Tamura et al. 2004).

The most comprehensive work on this field in recent years came from the Australian researchers who used a systematic review to identify empirical studies on AT for the PWD (Fleming and Sum 2014). There extensive search efforts enabled them to identify 178 potentially relevant studies. The evaluation criteria excluded 142 studies. The remaining 32 studies received validity assessment using the approach from (Forbes 1997). The results show only eight studies as strongly relevant, nine studies as moderately and 19 studies as weakly relevant. However deep analysis of these shortlisted studies further indicate that only small empirical evidence of supporting the PWD through AT exist. The researchers concluded:

- ✓ There is high rate of non-acceptance of AT
- ✓ The studied AT are often unreliable

- ✓ The AT should be tailored to the individual needs
- ✓ There is critical need of better designed AT empirical studies based on large samples
- ✓ The existing AT makes little difference to practical outcomes
- ✓ The ability of AT for enabling the PWD outside their home is rather weak
- ✓ The best use of AT is face to face communication

These empirical studies not only evaluate existing AT, but also point towards many research areas still open for future research.

### 2.1.6 Literature Open Areas

There are many researchers of the view that although there are a lot of AT available for the PWD, but these AT are not thoroughly evaluated. The lack of AT evaluation for the PWD may result in their lack of trust on AT and reluctance in its use (Fischer et al. 2014). In another study the authors emphasized the need to conduct trials for analysing the AT impacts and its effectiveness in supporting the PWD (Leroi et al. 2013).

Another study describe the user satisfaction with AT as the most important factor for AT long term use and adaptation. User satisfaction for AT is driven by their needs, preferences, personal values and attitudes (Carvalho et al. 2014). Another study is also of the view that usability is a critical challenge for technology adaptation and AT usability can be increased through interaction with the PWD (Carrillo et al. 2009). Additionally human cantered design and development of AT can yield better results as compared to training them on the use of AT (Schikhof et al. 2010). Another study emphasized the need to involve the PWD at early stage of AT development. The AT users usually face anxiety, lack of socialization and aggression. They further recommended to use an integrated approach for AT development for the PWD (Okoro et al. 2010).

Although there have been few empirical studies already performed in this research field, but those studies have many limitations associated with them. One of the major limitation of existing empirical study is a small sample size used in studies (Labelle and Mihailidis 2006). Most of these studies collected data from caregivers and staff workers from care homes rather than the PWD themselves (Engström et al. 2009). Furthermore the PWD can explain their requirements for future AT better, as they know better what they need (Wherton and Monk 2008). Some researchers especially emphasize the need to involve the PWD in empirical AT studies to analyse the impact of these AT on their lives (Topo 2009).

## 2.2 Commercial Review

This section is related to the two stage commercial review of ATs available for the PWD. The 1st stage is based on the data collected for general ATs through visits to different AT exhibitions, whereas the 2nd stage involve data collected for the software based ATs (SWAT) through online sources.

### 2.2.1 Systematic Mapping Study One

For the systematic mapping analysis of existing ATs, firstly we elicited data related to general ATs available in literature. The details of the ATs available in literature are given in table 2.1. As the next step we visited different AT exhibitions to take first-hand information related to commercially available ATs. By applying the same AT evaluation criteria mentioned in literature review section, we then investigated existing commercially available ATs for their respective pros and cons. The details of the ATs found through commercial survey are summarized in table 2.2, which shows details about the AT names, their relevant category, reference, company name, functionalities, advantages and limitations. The systematic mapping process is used for identification, analysis and classification of the existing ATs in literature and the ATs available commercially. This process helped to classify the existing ATs into five major types:

1- Robotics

2- Health Monitoring

3- Prompts and Reminders

4- Communication

5- Software

Based on the definitions of all five types of ATs, the mapping process further distributed the functionality of these ATs into eight categories:

1- Activity monitoring (help to continuously monitor the movements of a person at his place)

2- Mobility (help in moving physically from one place to another)

3- Detection (help in detecting some abnormal behavior or deviation from daily routine activities)

4- Cognitive Help (helping in intellectual activities),

5- Health Information (monitoring patients' conditions like blood pressure, sugar level)

6- Rehabilitation (helping in rehabilitating people especially with disabilities)

7- Socialization (helping to make contacts with family and friends)

8- Leisure Activities (helping in activities like playing music, tourism)

A single type of AT can perform multiple functionalities as well; therefore a single AT can belong to more than one category.

Robotics: Almost 51% (24 out of 47) of the studies from literature belongs to the robotics area. The identified robotic AT are named as: ROBODOM, Smart Walker, Lokomat, Lokohelp, Lopez, WHERE I, WHERE II, GaitTrainer, HapticWalker, NEUROBike, HAL-3, RoboKnee, SmartCane, Rollator, Boomer, U-Step, Mobile Walker, i-Walker, PAMM Smart Walker, Walker with a joystick, JAIST, ASBGo, Nursebotand Socially Assistive Robot. These robotic ATs can help in all eight activities some way or another. Most of the robotic based AT help in physical mobility of PWD and in their rehabilitation activities.

Table 2.2: Commercially Available ATs

| AT Name | AT Category | Company | Functionality | Advantages | Limitations |
|---|---|---|---|---|---|
| **Appello** | Health Monitoring | Appello | Appello handles with health solutions by providing the services like:<br>Tele-Care,<br>Activity Monitoring,<br>Nutrition and exercise advice, and social connections.<br>Appellos is the UK's largest emergency alarm monitoring service provider. | Appello technologies are very useful as it not only offer health monitoring, it also offer social connections as well. | The user themselves have to press the button to generate an alarm in emergency situations. |
| **GPS Watch** | Health Monitoring | HealthAlert | HealthAlert presents a GPS tracking wrist watch which act as 2G mobile phone with multiple speed dials.<br>It provides various health-care options like:<br>SOS calls,<br>Bluetooth docking station,<br>And tracking system. | GPS Watch can be used to monitor the patient's location and circumstances which add to his security. | GPS does not work well indoors. |
| **Activity Monitoring System** | Monitoring System | Just Checking | Just Checking provides an activity monitoring system specific for dementia patients which is web-oriented solution.<br>It uses wireless sensors to analyze about a person's activities.<br>Usually these sensors are placed in home at different locations.<br>The doctors and family members can view the activities pattern through website.<br>GSM network is used for the communication. | Activity Monitoring System provides patient monitoring system.<br><br>It provides communication facility as well. | This system only monitor activities pattern, it cannot recommend proper sequence of activities through prompts etc. |
| **Carephone 62** | Monitoring System | BOSCH | BOSCH presents Carephone 62 an IP, analog or GSM or PSTN-based Tele-Care and ambient assisted living solution.<br>It uses various sensors including fall detectors, ManDown sensor, wireless motion detectors, wireless contact detector, wireless pull cord, wireless smoke detector, wireless gas detector and wireless flood detector etc. | It is useful for monitoring elderly people and dementia patients. | Sometimes communication can be a problem this system involves lot of sensors. |
| **HomePod** | Mobile Technology | Medvivo | Medvivo provides a HomePod with a touch screen tablet to monitor patient physiological data for: Weight, Blood glucose, Blood pressure at home. | HomePod is a useful household device which provides basic medical checks at user's own home. | This device can only be used by the user; the data can't be transferred to other location. |

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| **Monitors** | Health Monitoring | True-Kare | True-Kare uses various monitors i.e. blood pressure and blood glucose etc. to get physiological data and transmit it through using Bluetooth to a mobile phone. | Helpful device for physiological data transmission. | Data transmission is only possible with a small geographical area. |
| **UMO** | Health Monitoring | Verklizan | Verklizan provides UMO platform by including ICT which is very popular worldwide for Tele-Medicine.<br>UMO provides various services related to health including collection of physiological data and communicate it to the hospital and nurse for observation and quick action in case of emergency. | Data gathering and communication of data at remote locations. | |
| **MyClinic** | Health Monitoring | Tunstall | Tunstall provides a health-care solution named as “myclinic” which is combination of software, hardware and few recommended devices.<br>The solution provides multi-user support on a common location like hospital etc. by sharing the equipment which ultimately reduces the cost of product.<br>It integrates different sensor and monitoring devices which collect data and connect to a central device which uploads data information to a central server.<br>It uses GPRS for communication and proper encryption mechanisms are used for security. | The system is very useful for hospital use for monitoring situations of different patients. | |
| **WSC** | Software | True-Kare | True-Kare provides a Web based platform called Web Self Care (WSC) which is capable of providing 24 hour emergency service with GPS to identify:<br>Location<br>Medication<br>It also provides scheduling support through:<br>Reminders<br>Texts<br>Emails | The WSC web based assistive technology provides monitoring, scheduling and reminding activities efficiently. | Although this platform is quite useful, it require an extensive training on the part of dementia people to learn its use. |
| **Tele-Care Service** | Monitoring System | MedvivoCareline | Medvivocareline provides Tele-Care services for elders and patients by using fall detectors and bed/chair sensors.<br>These services keep check when patient has left the bed or chair and not came within normal | The Tele-Care Service helps in reducing the number of falls among older adults. | Mostly this system is used in care-home settings. |

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| | | | time.<br>Bluetooth and GSM and PSTN can be used for communication. | | |
| **Nourish Carer Dashboard** | Health Monitoring | Nourish Care | Nourish provides a platform known Nourish Carer Dashboard.<br>This dashboard is beneficial for nurses, doctors and families to view notes regarding health information and conclude few results with default custom options.<br>GSM or wifi can be used to upload the data using cloud services. | The Nourish Carer Dashboard is helpful for the family, caregivers and doctors to monitor health situation of different patients. | |
| **Doro** | Mobile Technology and Reminders | Dorocare | Doro provides products which assist older people to live independently at their homes. Doro products added dedicated buttons on health care devices like mobile phones and fixed phones. These buttons help the users to control functionalities of the device. | The buttons help patients to do their desired activities from the device. | The older people require proper training to use these specialized devices. |
| **LiteGait** | Robotics | LiteGait | Physical support functionality for better gait stability to the user.<br>It provides support for maintaining balance and posture.<br>Helpful in older patient's rehabilitation. | Provides support for better gait stability and balance for safe walking. | LiteGait requires some physical effort as well on from the user. |
| **KineAssist** | Robotics | KineAssist Walking & Balance retraining | KineAssist provides assistance for older adults in their movement.<br>It provides partial body weight support and postural control for training rehabilitation of older adults. | Mobility assistance for the older adults. | As KineAssist only provides partial body weight support, the user has to invest some physical effort himself as well. |
| **ReWalk** | Robotics | Argomedtec | Physical support for patient's rehabilitation by helping them to walk repeatedly in rehabilitation environments.<br>The system is adjustable for different users, and can accommodate a range of heights and weights. | Rehabilitation assistance | The user needs training with ReWalk Rehabilitation for walking, standing, sitting and using stairs. |

From the AT exhibitions survey 20% (3 out of 15) of the identified AT belongs to the robotic area. These AT are known as: LiteGait, KineAssist and ReWalk. Interestingly all these robotic ATs are used for rehabilitation of the PWD.

Figure 2.1: Social Commitment Robot (Mordoch et al. 2013)

Health Monitoring: Health monitoring AT from literature contribute 17% (8 out of 47) to this study. The literature based health monitoring AT include: Light Paths, Monitoring System, Rosetta System, Automated Hand Washing Assistance, The Independent, Ambient Assistive Living, GPS Device and TEBRA. Most of these ATs are used for activity monitoring of PWD, detection of abnormal activities from daily routines and cognitive help, whereas these ATs are useful for all other functionalities as well in some cases.


Figure 2.2: Health Monitoring AT (Service 2015)

From the AT exhibitions survey 60% (9 out 0f 15) of AT have capability of monitoring. These ATs are known as: Appello, GPS Watch, Activity Monitoring System, Carephone 62, Monitors, UMO, MyClinic, Tele-Care Service and Nourish Carer Dashboard. Usually these AT are used for the PWD activity monitoring at their homes or care-homes. These ATs are also useful for health monitoring activities like (blood pressure, heartbeat, sugar level etc.) of the PWD.

Prompts and Reminders: From ATs identified in literature the contribution from the prompts and reminders is almost 30% (14 out of 47). The names of these AT are: Mobile Multimedia Technology, Smart Prompting Technology Cyberminder, Assistive Cognition Prompting System, Forget-Me- Not, Autominder, COACH, Google Calendar, HYCARE, CoReDa, EMA, AP@LZ, The Independent and TEBRA. Even though most of the times the prompt and reminders are used as memory aid, yet sometimes these ATs also help in activity monitoring and health monitoring by issuing smart prompts after detecting deviation from normal routines. Furthermore such ATs could also be helpful in the rehabilitation of the PWD.

Interestingly from the AT exhibitions survey, we found just one AT providing prompts and reminders service with the name Doro. This AT is helpful for providing cognitive help on pre-defined times and deliver pre-recorded messages to the PWD.

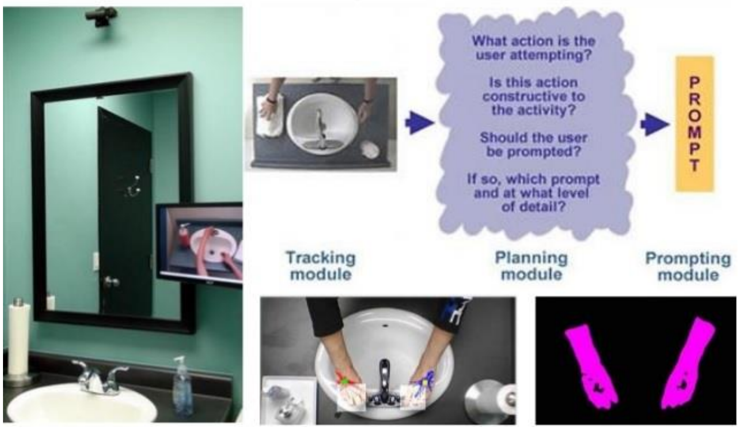



Figure 2.3: The COACH Reminder System (Mihailidis et al. 2008)

Communication: From literature identified ATs only 4% (3 out 0f 47) studies focus on communication. The names for communication based AT are: MPVS, Videophone Mock-Up and The Independent. Usually these AT are used for socialization (making contact with family and friends) and leisure activities (music play lists) by people with dementia. Most interestingly there were no communication based AT on display at the AT exhibitions that we attended.


Figure 2.4: Videophone Mock-Up (Boman et al. 2014)

Software: There are just two software based ATs identified from literature survey named as: Geriatric Software and Ambient Assistive Living system. The software based ATs are mostly used to monitor patient health information details like (blood pressure, heartbeat, sugar level etc.) by doctors and nurses.

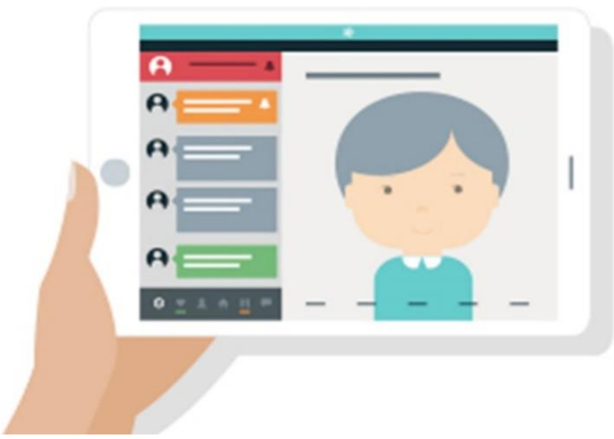


Figure 2.5: Nourish Carer Dashboard (Nourish Care 2015)

From the AT exhibitions survey we found six ATs belongs to the software domain. The software ATs are named as: Activity Monitoring System, HomePod, UMO, WSC, Nourish Carer Dashboard and Doro. Similarly to the literature, these AT are usually used for patient health conditions monitoring (blood pressure, heartbeat, sugar level etc.). Some of these AT are also used in combination with monitoring AT to monitor activities of the PWD to analyze their health recovery level.

### 2.2.2 Future Research Directions from the Systematic Mapping Study One

Based on the results of the AT exhibitions survey and literature review, the following research directions are identified for future research work.

AT Usability Evaluation by the Actual Users: This study evaluates existing ATs available commercially and in the literature. There is need for AT usability evaluation from the actual users of such ATs. The AT usability can be analysed through AT usability questionnaire, interviews and case studies. This evaluation will help to understand the real impacts of ATs on the lives of the PWD.

Need for the Development of Mobile Applications and Software Based ATs: As evident from literature review section, most of the existing ATs belong to the robotics and reminders categories. In this modern era the mobile applications and software based technologies are the backbone for everyday activities and even most of the common people understand how to use these technologies. There is strong need of developing more mobile phone software based technologies for the PWD. Furthermore mobile applications and software based ATs can easily be integrated with other ATs like, robotics, monitoring systems, reminder technologies etc. This integration could help the PWD to carry out their daily activities independently and safely.

Need for Close Cooperation between Academia and Industry Regarding AT Development: The results of the first part of mapping study show that most of the research done in this field by the academia is based on robotics, whereas the second part shows that commercial companies are mostly producing monitoring systems. In reality most of the PWD use ATs for socialization and communication. So, there is need to fill this gap between academia and industry. The academic research can be used by the industry for producing better and reliable ATs for the PWD. This close cooperation could definitely result into better quality products for the PWD.

### 2.2.3 Systematic Mapping Study Two

The 2nd systematic mapping study conducted for this thesis is related to software based assistive technologies (SWAT) for the PWD. Firstly we elicited data related to SWAT available in literature. The details of the SWAT available in literature are given in table 2.3. As the next step we performed online surveys to search SWAT for the PWD, which are summarized in table 2.4.

This study applies the systematic mapping technique to identify, investigate and categorize existing SWAT for the PWD from literature and compare those with commercially available SWAT. The systematic mapping process categorizes existing SWAT into nine categories based on their functionalities offered to the PWD. Some SWAT belongs to more than one category as they offer more than one functions. These categorizes are named as:

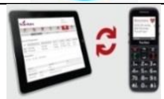
1- Cognitive Help
2- Reminders
3- Health/Activity Monitoring
4- Socialization
5- Leisure
6- Travel Help
7- Dementia Detection
8- Dementia Prevention
9- Rehabilitation

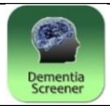
Table 2.3: Categorization and Systematic Tracking of Assistive Software Applications from Literature

| S. No | ASA Name | Publisher | Reference | Cognitive | Reminders | Monitoring | Communication | Leisure | Travel | Detection | Prevention | Rehabilitation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Geriatric Software | Wiley | (de Oliveira Assis et al. 2010) | ✓ | ✓ | | | | | | | ✓ |
| 2 | Ambient Assistive Living | Springer | (Aloulou et al. 2013) | | | ✓ | | | | | | |
| 3 | CIRCA | IEEE | (Alm et al. 2007) | ✓ | | | ✓ | | | | | |
| 4 | Software Agent | IEEE | (Hanada et al. 2014) | ✓ | | | | | | | ✓ | |
| 5 | Reminder Software Tool | IEEE | (Du et al. 2008a) | ✓ | ✓ | | | | | | | |
| 6 | Jungle App | IEEE | (Yamagata et al. 2013) | | | | | ✓ | | | | |
| 7 | MCS (Mobile Cognitive Screening) | Elsevier | (Zorluoglu et al. 2015) | ✓ | | | | | | ✓ | | |
| 8 | COGKNOW | Elsevier | (Davies et al. 2009) | ✓ | | | | ✓ | | | | |
| 9 | Opportunity Knocks (OK) | Elsevier | (Patterson et al. 2004) | | | ✓ | | | ✓ | | | |
| 10 | Telematic Applications Supporting Cognition (TASC) | Elsevier | (Ager and Aalykke 2001) | ✓ | | | ✓ | | | | | |
| 11 | Alzheimer's Carer Internet Support System (ACISS) | PMC | (Vehvilainen et al. 2002) | | | ✓ | ✓ | | | | | |
| 12 | net-book | Elsevier | (Perilli et al. 2013) | | | | ✓ | ✓ | | | | |
| 13 | TeleCARE | JITH | (Camarinha-Matos and Afsarmanesh 2004) | | | | ✓ | | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 14 | Nintendo Wii Fit | Gerontechnology | (Aarhus et al. 2011) | | | | ✓ | ✓ | | | | ✓ |
| 15 | Silver Promenade | ACM | (Gerling et al. 2011) | | | | | ✓ | | | | |
| 16 | Golden Journal | IEEE | (Pang and Kwong 2015) | ✓ | | | | ✓ | | | | |
| 17 | Alive Inside | IEEE | (Nezerwa et al. 2014) | ✓ | | | | ✓ | | | | |
| 18 | IMIS | JNNP | (Tárraga et al. 2006) | ✓ | | | | | | | | ✓ |

Table 2.4: Categorization and Systematic Tracking of Commercially Available Assistive Software Applications

| Sr. | ASA Name | ASA Logo | Producer | Reference | Cognitive | Reminders | Monitoring | Communication | Leisure | Travel | Detection | Prevention | Rehabilitation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | HomePod |  | Medvivo | (medvivo 2015) | | | ✓ | | | | | | |
| 2 | Web Self Care |  | True-Kare | (True-Kare 2016) | | | ✓ | | | | ✓ | | |
| 3 | MyClinic |  | Tunstall | (Tunstall 2016) | | | ✓ | ✓ | | | | | |
| 4 | Nourish Carer Dashboard |  | Nourish Care | (Nourish Care 2015) | | | ✓ | ✓ | | | | | |
| 5 | Just Checking | Just Checking | Just Checking | (Juct Checking 2016) | | ✓ | ✓ | | | | | | |
| 6 | Triagemanager |  | Tunstall | (Tunstall 2015) | | | ✓ | ✓ | | | ✓ | | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | Myworld |  | Tunstall | (Tunstall 2016) | | ✓ | | ✓ | | | | | |
| 8 | Housing Services Portal |  | Tunstall | (Tunstall 2016) | | | ✓ | ✓ | | | | | |
| 9 | ACEmobile |  | ACEmobile | (Ace Mobile 2016) | | | ✓ | | | | ✓ | | |
| 10 | Digital Reminiscence Therapy Software | NHS | My Life | (My Life 2016) | | | | ✓ | ✓ | | | | |
| 11 | Dementia Screener |   | Bioinformatics Research Group BIRG | (Bioinformatics Research Group BIRG 2016) | | | | | | | ✓ | ✓ | |
| 12 | Dementia Clock |  | Wearing the Green | (Wearing the Green 2016) | ✓ | ✓ | | | | | | | |
| 13 | Day-Clock |   | Designability | (Designability 2016) | ✓ | ✓ | | | | | | | |
| 14 | Dementia Digital Diary |  | Fashmel | (Fashmel 2016) | ✓ | ✓ | | | | | | | |
| 15 | MindMate |  | MindMate Ltd. | (MindMate Ltd 2016) | ✓ | ✓ | | | | | | | |
| 16 | Young Onset Dementia (YOD) |   | Leicestershire Health Informatics Service | (Leicestershire Health Informatics Service 2016) | | | | | | | ✓ | | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 17 | Sea Hero Quest | | GLITCHERS | (Glitchers 2016) | ✓ | | | | | | | | |
| 18 | Care and Connect | | Newcastle University | ( Newcastle University Research 2016) | | | | | ✓ | | | | |
| 19 | Dementia Test - Dr.Jey | | Jeycorp | (Jeycorp 2016) | | | | | | | ✓ | | |
| 20 | HAMARU: Brain Games & Training | | STUDIO ms32 | (Studion MS32 2016) | | | | | ✓ | | | ✓ | |
| 21 | Aphasia Talk Around It | | Neuro Hero Ltd. | (Neuro Hero Ltd 2016) | ✓ | | | | ✓ | | | | |
| 22 | Dementia Caregiver Application | | Melvyn Zhang Weibin | (Weibin 2016) | ✓ | | | | | | ✓ | | |
| 23 | Smart Caregiver | | Treata Smart Solutions | ( Treata Smart Solutions 2015) | | ✓ | | ✓ | | | | | |
| 24 | Nudgu Reminders | | Nudgu Reminders | (Nudgu Reminders 2016) | | ✓ | | ✓ | | | | | |
| 25 | Dementia Care Matters | | Dementia Care Matters | (Dementia Care Matters 2016) | | | | | ✓ | | | | |
| 26 | Alert Family Emergency Button | | Help Around | (Helparound 2016) | | | | ✓ | | ✓ | | | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 27 | Alarm Memo Clock | | Androcalc | (Androcalc 2016) | ✓ | ✓ | | | | | | | |
| 28 | SPARK Memories Radio | | SPARK Memories Radio | (Spark Memories Radio 2016) | | | | | ✓ | | | | ✓ |
| 29 | MyAreas | | Applicate IT | (Applicate IT 2016) | | | | ✓ | | ✓ | | | |
| 30 | Ideo Prompt Lite | | Oralys | (Oralys 2016) | | ✓ | | | | | | | |
| 31 | Ob Elder Remote | | Birikis | (Birikis 2016) | | ✓ | | ✓ | ✓ | | | | |
| 32 | Remember First | | WenBit | (WenBit 2016) | | ✓ | | ✓ | | | | | |
| 33 | Mind Palace | | Waqas Ahmed Ansari | (Ansari 2016) | ✓ | | | | | | | | |

The following sections highlight the data collected related to the important SWAT from literature and online survey in more details. The figure 2.6 shows the systematic mapping analysis by presenting the SWAT, their functionalities, percentage contributions for each category and their nature of research.

Cognitive Help: The PWD usually face cognitive challenge of reasoning, perception and judgments. Most of the SWAT these days assists in providing the cognitive help to the PWD. The SWAT identified from literature is usually focused on cognitive help to the PWD with a healthy number of eight (44%). These include: Geriatric Software (de Oliveira Assis et al. 2010), CIRCA (Alm et al. 2007), Software Agent (Hanada et al. 2014), Mobile Cognitive Screening (MCS) (Zorluoglu et al. 2015), COGKNOW (Davies et al. 2009), Golden Journal (Pang and Kwong 2015), Alive Inside (Nezerwa et al. 2014) and IMIS (Tárraga et al. 2006). The eight (24%) commercially available SWAT are also used for providing cognitive help. These include: Dementia Clock (Wearing the Green 2016), Day-Clock (Designability 2016), Dementia Digital Diary (Fashmel 2016), MindMate (MindMate Ltd 2016), Sea Hero Quest (Glitchers 2016), Aphasia Talk Around It (Neuro Hero Ltd 2016), Dementia Caregiver Application (Weibin 2016) and Mind Palace (Ansari 2016).

Reminders: The reminders based SWAT assist the PWD in reminding them to perform daily activities on time and in the correct sequence. These reminders include medication, meal times, events schedules etc. There is just one (6%) reminder based SWAT found from literature called as the Reminder Software Tool (Du et al. 2008a). The Five (15%) commercially available SWAT also belong to the reminders category which include: Smart Caregiver ( Treata Smart Solutions 2015), Nudgu Reminders (Nudgu Reminders 2016), Alarm Memo Clock (Androcalc 2016), Ideo Prompt Lite (Oralys 2016) and Ob Elder Remote (Birikis 2016).

Health/Activity Monitoring: The SWAT are also used to monitor the health conditions like (blood pressure, heart rate, sugar level etc.) and daily activities like (kitchen, toileting, falls etc.) and in helping the PWD in self-management of their health. There are two (11%) health/activity monitoring SWAT from literature which include: Ambient Assistive Living (Aloulou et al. 2013) and Alzheimer's Carer Internet Support System (ACISS) (Vehvilainen et al. 2002). From commercial survey seven (21%) of the SWAT belongs to health/activity monitoring category. These include: HomePod (medvivo, 2015), Web Self Care (True Kare 2016), MyClinic (Tunstall 2016), Nourish Carer Dashboard (Nourish Care 2015), Just Checking (Juct Checking 2016), Triagemanager (Tunstall 2015) and Housing Services Portal (Tunstall 2016).

Socialization: The SWAT helps to the PWD for staying in touch to their family and friends by offering picture based calling and messaging, easy to use phones, audio and video interactions etc. There are six (33%) SWAT found in literature which facilitates socialization for the PWD. These include: CIRCA (Alm et al. 2007), Telematic Applications Supporting Cognition (TASC) (Ager and Aalykke 2001), Alzheimer's Carer Internet Support System (ACISS) (Vehvilainen et al. 2002), net-book (Perilli et al. 2013), TeleCARE (Camarinha-Matos and Afsarmanesh 2004) and Nintendo Wii Fit (Aarhus et al. 2011). The Four (12%) commercially available SWAT also helps the people with dementia in socialization. These include: Myworld (Tunstall 2016), Digital Reminiscence Therapy (Life 2016), Ob Elder Remote (Birikis 2016) and Remember First (WenBit 2016).

Leisure: The leisure activities are considered very important for the PWD in their rehabilitation. The SWAT helps the PWD in leisure activities through music playing, music composition and painting memories etc.

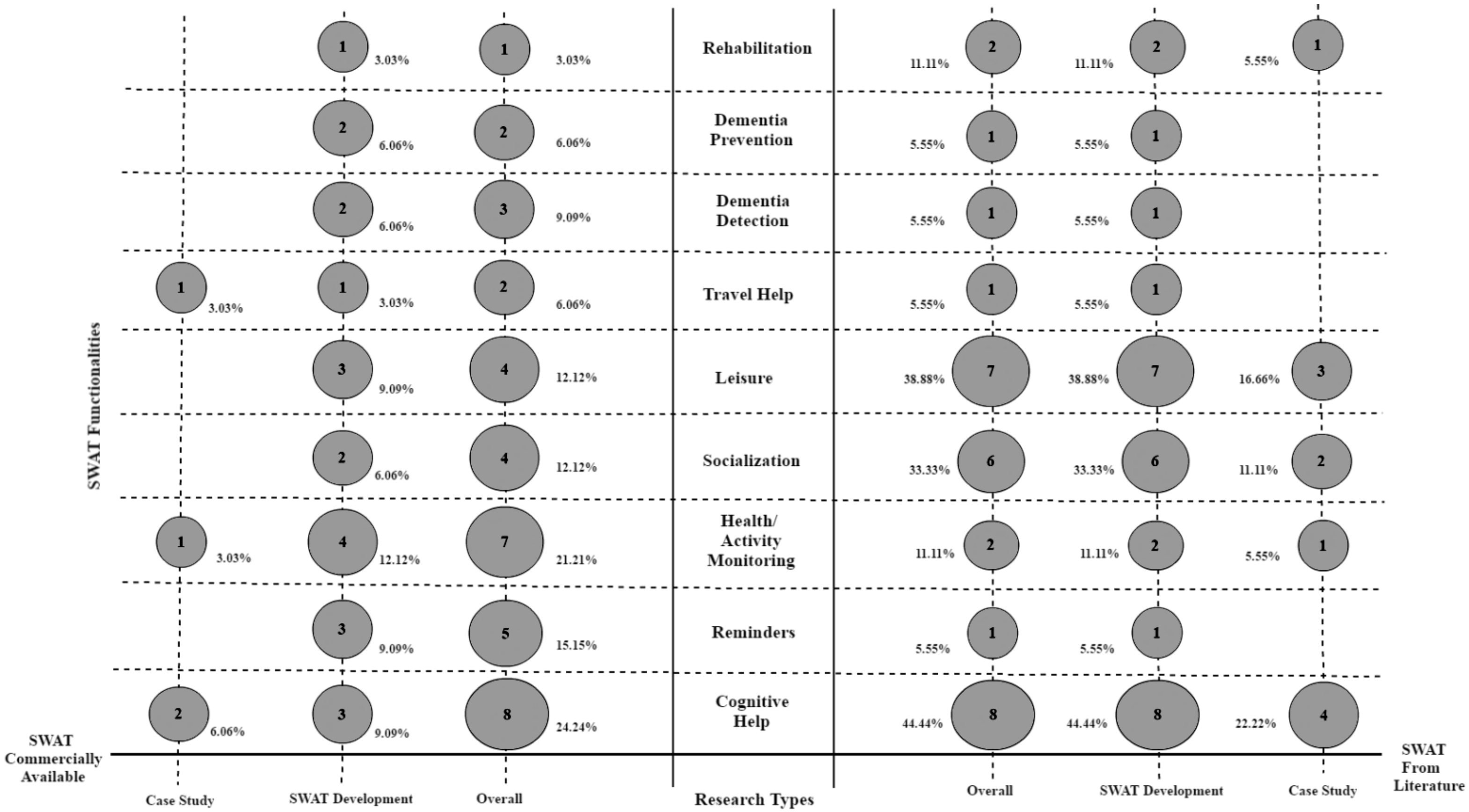



Figure 2.6: Mapping Results for SWAT for the PWD

There are seven (39%) of the SWAT available in literature which helps to promote the leisure activities for the PWD. These include: Jungle App (Yamagata et al. 2013), COGKNOW (Davies et al. 2009), net-book (Perilli et al. 2013), Nintendo Wii Fit (Aarhus et al. 2011), Golden Journal (Pang and Kwong 2015), Alive Inside (Nezerwa et al. 2014) and IMIS (Tárraga et al. 2006).

The four (12%) commercially available SWAT also facilitates the leisure activities among the people with dementia. These include: Digital Reminiscence Therapy (Life 2016), Care and Connect (Newcastle University Research 2016), Dementia Care Matters (Dementia Care Matters 2016) and SPARK Memories Radio (Spark Memories Radio 2016).

Travel Help: Independent travelling is always a major challenge for the PWD. The SWAT can assist them in travelling from one place to another independently and safely. If the user is lost on the way, the SWAT can also be helpful in finding his location. The literature indicate that there is lack of work in this area as we just found one (6%) SWAT which offer assistance in travelling to the PWD called the Opportunity Knocks (OK) (Patterson et al. 2004). The two (6%) commercially available SWAT also used for travel help. These include: Alert Family Emergency Button (Helparound 2016) and MyAreas (Applicate IT 2016).

Dementia Detection: Dementia detection is very critical and usually manual methods are used for detection and diagnosis of dementia. Recently these manual methods are being automated in the form of SWAT to help diagnose dementia symptoms amongst the users. There is just one (6%) SWAT found in literature which is used for dementia detection called the Mobile Cognitive Screening (MCS) (Zorluoglu et al. 2015). The three (9%) commercially available SWAT provide help in dementia detection. These include: ACEmobile (Ace Mobile 2016), Young Onset Dementia (YOD) (Leicestershire Health Informatics Service 2016) and Dementia Test - Dr.Jey (Jeycorp 2016).

Dementia Prevention: Dementia prevention can be achieved by diagnosing early signs of dementia and through the mental exercises for the elderly people. The SWAT can be useful for providing the elderly people mental exercises. We found just one (6%) SWAT from literature which support dementia prevention with the name of Software Agent (Hanada et al. 2014). The two (6%) commercially available SWAT are also being used for dementia prevention. These include: Dementia Screener (Bioinformatics Research Group BIRG 2016) and HAMARU: Brain Games & Training (Studion MS32 2016).

Rehabilitation: The SWAT can be useful in rehabilitating the PWD through maintaining, restoring and improving their cognitive abilities. There are two (11%) SWAT available in literature which assist the PWD in rehabilitation These include: Nintendo Wii Fit (Aarhus et al. 2011) and IMIS (Tárraga et al. 2006). Just one (3%) commercially available SWAT is used for rehabilitation with the name SPARK Memories Radio (Spark Memories Radio 2016).

### 2.3.4 Open Research Areas from Systematic Mapping Study Two

The results of the systematic mapping analysis highlight that currently most of the SWAT for the PWD are focused only on some specific areas of: cognitive, reminders, leisure, monitoring help etc. The software technologies in general have much larger scope to help the general people in their daily lives and that scope is visible in many fields of life. The need of the hour is to analyze the ways of implementing the broader scope of general software technologies in SWAT with focus on the PWD. In the near future the SWAT will be integral part of the lives of the PWD similarly as software technologies are the integral part of the lives of the general people.

Socialization Help through SWAT: Socialization refers to enabling the people to interact with each other easily through the help of the SWAT. Socialization is an important need of every human being in this age. Socialization becomes even more important for the PWD as often they are socially isolated from rest of the society because they either live alone at their homes or live at care homes (Robison et al. 2009). Currently many socialization applications including Skype, Facebook, Instagram, WhatsApp etc. are available for the general users. These socialization applications can be used for the PWD as well. However the literature often indicates that the requirements of the PWD for socialization applications are different as compared to socialization applications currently available (Carrillo et al. 2009). The PWD also find it difficult to use the socialization applications independently which are developed for the general users. There is need for further research on SWAT for socialization especially designed and developed based on the requirements of the PWD. For that the software engineers should follow the user centric approach and involve the PWD throughout the development process (de Oliveira Assis et al. 2010; Topo 2009). The future researchers should focus on providing easy interaction, social networking and getting formal and informal support through the use of software based socialization applications.

Travel Help through SWAT: Travelling independently and safely is another area of concern for the PWD. Usually the PWD are dependent on others for travelling purposes as they often face cognitive challenges. Independent travelling can provide psychological support and increase the self-confidence of the PWD and contribute towards their rehabilitation (Page et al. 2014). Another recent and interesting area of research is helping the PWD in tourism through travel and destination guidance support (Innes et al. 2015). The travelling and tourism activities can help the PWD to adopt a healthy lifestyle and remain active for the longer period of time. SWAT can be used in combination with

GPS (Global Positioning System) to help the PWD for safe and independent travelling. The researchers should focus on the development of the SWAT which can manage travel plans and tourism activities automatically for the PWD. Such SWAT can act as their travelling and tourism companions.

Dementia Prevention through SWAT: Like any other disease dementia prevention can be more useful as compared to helping the people with this disease. Usually dementia is an age related disease and its severity continues with the increase in the age of the person affected with it. SWAT can be used to help the elderly people with their cognitive abilities and can improve the chances of dementia prevention (Hanada et al. 2014). The SWAT can use intelligent algorithms and machine learning approaches to help the elderly people with their memory issues as well.

Gaming for Cognitive Fitness: Another emerging area of research for helping the cognitive abilities of the PWD is using the cognitive fitness games. Currently there are some brain fitness games available for the elderly people. These games include Lumosity, Clevermind, Fit Brain Trainers, Brain Trainer, and Eidetic etc. (Nouchi et al. 2012; Huntsman 2014). As we already discussed earlier that the requirements of the people with dementia are different as compared to general elderly people. Therefore the game developers should make more efforts for specialized cognitive games for the PWD with the help of the academic researchers, psychologist and care givers.

Case Studies by Using the SWAT: The figure 2.6 show the research types used for both the SWAT found in literature and available commercially. Although many papers and commercially available SWAT reports discuss the SWAT design and development process but there is clear lack of validating the impacts of these SWAT through case studies. Therefore the future studies should focus on involving the PWD in case studies of the SWAT usage and analyze the impacts of these SWAT on their daily lives.

## 2.3 Bibliometric Review

This section summarises the results of the bibliometric study conducted for this thesis. The bibliometric studies are used to explore breadth and depth of different research areas, yet this method has not been fully utilised in AT research for PWD. Therefore this bibliometric study presents an overview of recent research activities in AT research for the PWD. Based on inclusion/exclusion criteria, the AT studies with a focus on the PWD are considered. The study is based on factors such as number of publications, citations per paper, collaborative research output, P-Index, major research and application areas and national dementia strategies. Data were collected from 2000 to 2014 in AT research. The top 10 countries are selected based on their research outputs. The national dementia strategies, research investments, research trends and some open research areas are also discussed in this study.

### 2.3.1 Overall Research Scenario

The overall scenario for AT related research publications for 2000 to 2014 is depicted in Figure 2.7. The number of publications in Scopus rose:

- By a factor of over 5 from 8 in 2000 to 42 in 2004.
- By a factor of 3 from 42 in 2004 to 135 in 2008.
- By a factor of 2 from 135 in 2008 to 323 in 2013 and then dropped to 248 in 2014.

The drop in 2014 may be due to some publications that are not added to/indexed in Scopus, as we conducted the search in February 2015.

As is clearly evident from the earliest results shown in Figure 2.7, AT research for people with dementia was at the exploratory stage at the start of the new millennium with barely a few publications till 2003. From 2004 to date there is a sharp and continuous increase in the number of publications for AT.

Overall there is 29% growth in the first 15 years of the 21st century. This increase is the result of the realization of dementia's importance due to its economic impacts on bigger economies of the world (Prince et al. 2013). Currently, due to the economic implications, various governments have started investing and companies are developing AT for the wellbeing of people with dementia.

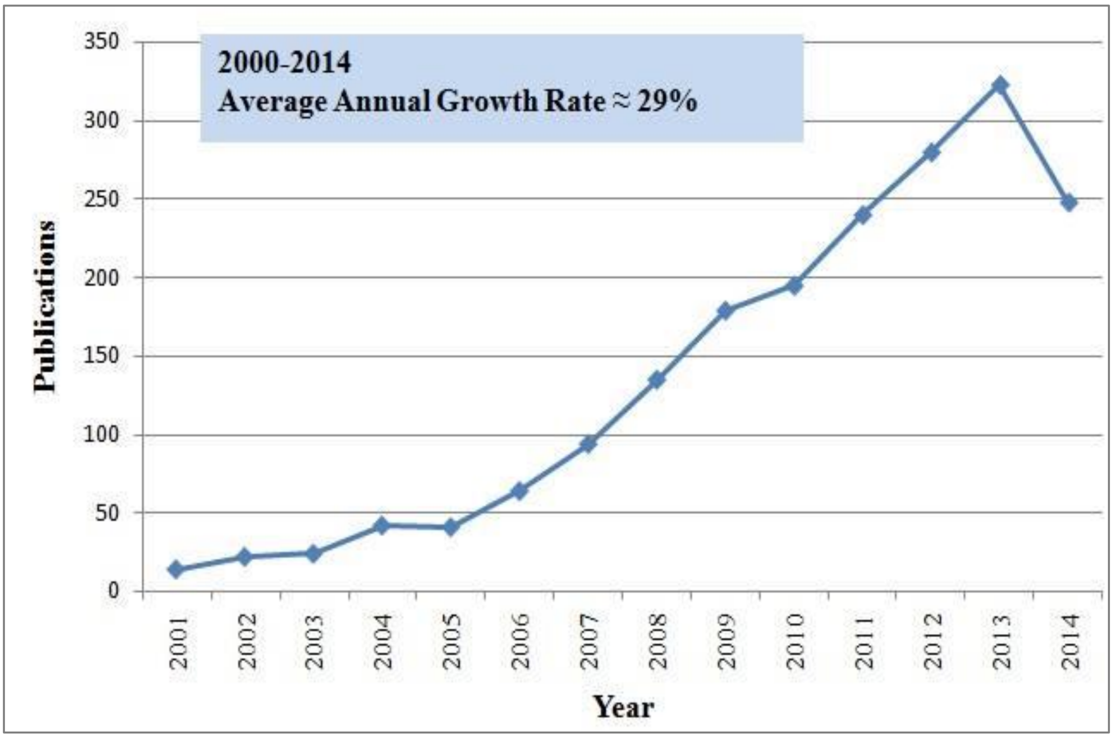



Figure 2.7: World-wide Growth for Publications in AT Research for Dementia

### 2.3.2 Research Scenario for Top 10 Leading Assistive Technology Research Countries

According to Thomson Reuters, the greater the number of papers are, the greater the chance of more citations and hence the impact (Reuters 2008). Some studies highlight the number of papers as the measure of productivity as well (Sahel 2011). Therefore the number of papers published in a country can be a good indicator of its research output against the investments made by the government.

Figure 2.8 represents yearly increase in the number of AT publications along with average growth rate of each country. The country representation is assigned based on the location of the first author. Table 2.5 presents 'total number of publications' for the top 10 countries.

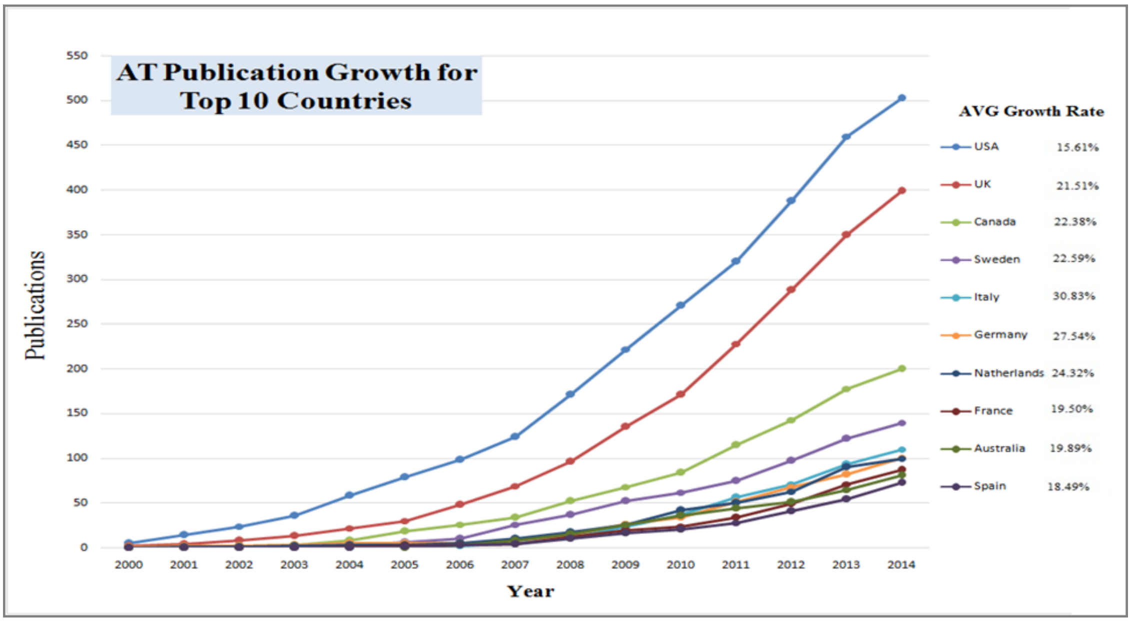



Figure 2.8: Growth in Publications in AT Research for PWD

United States of America (USA) clearly takes the lead with a total of 503 publications and almost 26% of the combined publications by all other countries in these first 15 years of 21st century. USA has a steady average growth rate of 16% right throughout the specified period. Although UK, Canada and Sweden have almost similar average growth trend of 22% each, still UK stands at number two with overall 399 publications which is almost double in number to its nearest competitor Canada with 200 publications and Sweden with 140 publications.

Italy, Germany and Netherlands stand at number five, six and seven respectively with overall publication numbers 110, 101 and 100 but all these countries show good growth rates with 31% (Italy), 28% (Germany) and 24% (Netherlands).

Table 2.5: No. of Publications in AT Research for Top 10 Countries

| Country | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | Total No. of Papers | AVG Growth Rate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **USA** | 5 | 9 | 10 | 12 | 22 | 21 | 19 | 26 | 47 | 51 | 49 | 49 | 68 | 72 | 43 | **503** | **15.61** |
| **UK** | 2 | 2 | 4 | 5 | 9 | 8 | 18 | 21 | 27 | 39 | 36 | 57 | 60 | 62 | 49 | **399** | **21.51** |
| **Canada** | 0 | 1 | 1 | 1 | 5 | 10 | 8 | 8 | 18 | 16 | 16 | 31 | 28 | 35 | 22 | **200** | **22.38** |
| **Sweden** | 0 | 0 | 0 | 1 | 2 | 3 | 4 | 16 | 11 | 15 | 10 | 13 | 22 | 25 | 18 | **140** | **22.59** |
| **Italy** | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 3 | 6 | 13 | 13 | 19 | 15 | 22 | 17 | **110** | **30.83** |
| **Germany** | 1 | 1 | 0 | 1 | 2 | 0 | 0 | 3 | 6 | 13 | 7 | 17 | 17 | 14 | 19 | **101** | **27.54** |
| **Netherlands** | 0 | 1 | 0 | 1 | 1 | 0 | 2 | 5 | 7 | 9 | 16 | 8 | 13 | 27 | 10 | **100** | **24.32** |
| **France** | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 8 | 7 | 5 | 10 | 15 | 22 | 16 | **87** | **19.50** |
| **Australia** | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 5 | 7 | 11 | 10 | 8 | 7 | 14 | 16 | **81** | **19.89** |
| **Spain** | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 1 | 6 | 6 | 4 | 8 | 13 | 13 | 19 | **73** | **18.49** |

A close look at their average growth rates shows that these countries (Italy, Germany and Netherlands) have focused in this research area since 2007. The remaining countries (France, Australia and Spain) have 87, 81 and 73 overall publications respectively with rather similar average annual growth rates of 20%, 20% and 18%.

### 2.3.3 Quality of Publications

As is evident from the literature the number of citations gained by a research publication is one of the effective and easy to use measures of the importance of that publication (Bajwa et al. 2012). Therefore, the average number of citations per paper (C) represents a fair picture of the quality (impact) of publications for each country.

Table 2.7 presents data for the publications shown in Table 2.5; in terms of the number of times those papers have been cited by other studies. Average citations per paper are shown in the second last column in Table 2.7 for the period 2000 to 2014.

In the research literature, quality of publications is determined by using different parameters in the previous research studies. The quality parameters include H-Index (Hirsch 2005), G-Index (Egghe 2006), HG-Index (Alonso et al. 2010) and P-Index (Prathap 2010). Each of these indexes has some advantages and limitations. These indexes are compared in Table 2.6.

Recent studies related to comparative analysis prefer to use the P-Index which provides a fair balance between the quantity (as determined by citations C) and quality (as determined by the ratio C/P), where P is the total number of publications (Braun et al. 1997; Bajwa et al. 2012).

The performance index is defined as:

$$\boldsymbol{p} = [\boldsymbol{C}.\left(\frac{\boldsymbol{c}}{\boldsymbol{P}}\right)]^{\mathbf{1/3}} \qquad \textbf{(1)}$$

Table 2.6: Different Parameters for Quality of Publications

| Parameter | Definition | Advantages | Limitations |
|---|---|---|---|
| **H-Index** | Reflects both the number of publications and the number of citations per publication. | • Measure the quality and quantity of scientific output simultaneously. | • Works only for same fields comparisons.<br>• Can be manipulated through self-citations.<br>• Just provide total number of citations for a given scholar |
| **G-Index** | For a (set of articles) ranked in decreasing order of the number of citations that they received. | • Show authors performance<br>• Helps to showcase authors' impact.<br>• Give value to low cited papers as well.<br>• The high cited papers can bolster the low cited papers. | • Works on longer table of numbers to reach your conclusions. |
| **HG-Index** | The HG-Index is computed as the geometric mean of his h- and g- indices. | • Provide more granularity then H and G Indices.<br>• Easy to compare and understand. | • Granularity does not necessarily mean precision.<br>• Both H and G are defined on ordinal scales. |
| **P-Index** | Provides a fair balance between the quantity (as determined by citations C) and quality (as determined by the ratio C/P), where P is the total number of publications. | • Best balance for research quantity and quality.<br>• The P-Index is more versatile as compared with other indices. | • It requires both citations and ratio of citation data. |

The last column in Table 2.6 shows P-Index for each country calculated using the above formula. From Table 3 these 10 countries can be divided into two groups. The 1st group with a better P-Index (P>22.00) and C value (C>9.00), whereas the 2nd group with an acceptable P-Index (P>10.00 and <21.99) and C value (C>2.00 and <8.99).

According to the above mentioned criteria the 1st group includes USA, UK, Canada, Germany and Australia. Table 2.7 shows USA has the highest number of publications and the highest P-Index of 44.73 and a good C value of 13.34. However, performance of Germany is notable. Although it has produced 4 times less research papers as compared to USA, it has the best C value of 16.43 and a high P-Index 30.09. These statistics indicate that the most papers from Germany are better quality and published in the high impact factor journals (impact factor >1.0).

Among other countries UK (P-Index: 33.57 and C: 9.74), Canada (P-Index: 30.74 and C: 12.05) and Australia (P-Index: 24.27 and C: 13.28) have performed well in producing better quality research and being published in the high impact factor journals.

The 2nd group includes Sweden (P-Index: 21.11 and C: 8.20), Italy (P-Index: 14.11 and C: 5.05), Netherlands (P-Index: 18.50 and C: 7.96), France (P-Index: 16.57 and C: 7.23) and Spain (P-Index: 10.98 and C: 4.26). These countries have the acceptable value for C and P-Index, which indicate that the most papers by these countries have been published in the medium impact factor journals (impact factor >.50 and <1.0).

Table 2.7: Citation Comparison for AT Research for Top 10 Countries

| **Country** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | **Total Cites (TC)** | **Cite Per Paper (C/P)** | **P-Index** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **USA** | 32 | 68 | 94 | 153 | 215 | 294 | 437 | 493 | 689 | 827 | 1002 | 1209 | 1172 | **6710** | **13.34** | **44.73** |
| **UK** | 3 | 11 | 24 | 55 | 81 | 123 | 154 | 241 | 418 | 573 | 639 | 829 | 735 | **3886** | **9.74** | **33.57** |
| **Canada** | 1 | 1 | 16 | 47 | 70 | 89 | 158 | 171 | 254 | 366 | 358 | 467 | 412 | **2410** | **12.05** | **30.74** |
| **Sweden** | 0 | 0 | 1 | 6 | 17 | 40 | 65 | 114 | 106 | 140 | 179 | 253 | 227 | **1148** | **8.20** | **21.11** |
| **Italy** | 0 | 0 | 0 | 0 | 3 | 7 | 11 | 24 | 32 | 55 | 80 | 147 | 197 | **556** | **5.05** | **14.11** |
| **Germany** | 4 | 1 | 2 | 26 | 38 | 36 | 62 | 99 | 205 | 248 | 313 | 343 | 280 | **1659** | **16.43** | **30.09** |
| **Netherlands** | 2 | 0 | 0 | 1 | 10 | 18 | 21 | 44 | 65 | 103 | 135 | 192 | 205 | **796** | **7.96** | **18.50** |
| **France** | 0 | 0 | 0 | 0 | 2 | 1 | 8 | 35 | 73 | 79 | 121 | 147 | 163 | **629** | **7.23** | **16.57** |
| **Australia** | 0 | 0 | 0 | 0 | 0 | 1 | 27 | 79 | 153 | 203 | 211 | 237 | 165 | **1076** | **13.28** | **24.27** |
| **Spain** | 0 | 0 | 0 | 0 | 2 | 4 | 8 | 14 | 25 | 33 | 58 | 68 | 99 | **311** | **4.26** | **10.98** |
| **Total** | 42 | 81 | 137 | 288 | 438 | 613 | 951 | 1314 | 2020 | 2627 | 3096 | 3892 | 3655 | **19181** | | |

### 2.3.4 Collaborative Research Output

The collaborative research output includes those publications which have international co-authors. For the purpose of this review collaborative research includes the following types of research publications:

- Doctoral or Post-Doctoral research carried out in a foreign country.
- Foreign faculty members hired by universities and used address of their parent university.
- Foreign researchers hired by research organizations and used address of their parent organizations.
- Research studies with foreign universities under collaborative research projects.
- Research teams residing in different countries.

Figure 2.9 shows trends of the collaborative research output for the top 10 countries. Almost all countries have considerable collaborative research output. Italy, Spain and Netherlands emerged as top collaborative research countries with very high percentages 84%, 84% and 79% respectively.

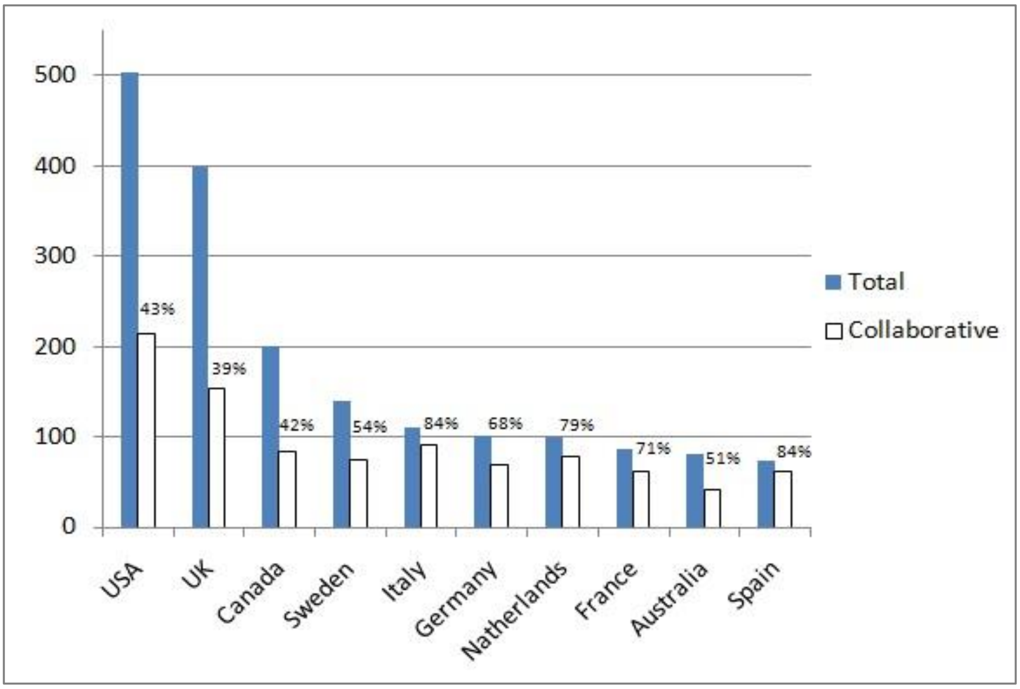



Figure 2.9: Collaborative Publications in AT Research for Dementia for the Period

### 2.3.5 Assistive Technology Research Focus in Different Countries

A closer analysis indicates that different countries have their own focus areas of AT research and its applications.

The focus of AT research in the USA is related to remote monitoring of people with dementia through activity recognition, which help them to remain at their homes for a longer period of time. The idea of digital cities for elderly people is another popular research area (Doukas et al. 2011; Rowe et al. 2009; Carrillo et al. 2009).

Most of the research done in the UK is related to Tele-care. While using social care in combination with AT for the wellbeing of PWD is equally popular in the UK and Germany (Saborowski and Kollak 2015; Torrington 2009; Leroi et al. 2013; McCabe and Innes 2013). Additionally German researchers are also focused on providing assistance to PWD through activity monitoring (Peters et al. 2014).

Simple and specialized mobile phone based AT for setting reminders and prompts for cognitive help to PWD are also gaining importance from researchers in the UK and the USA (Donnelly et al. 2010; Zhang et al. 2014; Torrington 2009; Lauriks et al. 2007; Wherton and Monk 2008; Seelye et al. 2012).

AT research activities in Canada and France are mainly focused on use of robotics based technologies for providing help and social interaction to PWD (Wu et al. 2013; Aloulou et al. 2013; Mordoch et al. 2013). Other interesting AT research areas in Canada includes the use of electronic organizer for cognitive help and sensors for health care (Imbeault et al. 2014; Hoey et al. 2012).

Use of monitoring AT for decreasing fall risk is another focused area for researchers in France and the Netherlands (Tchalla et al. 2012; Aloulou et al. 2013; Schikhof et al. 2010; Tchalla et al. 2013).

Human like assistive communication robots for the emotional wellbeing of PWD are used in Australia (Khosla et al. 2012; Khosla and Chu 2013). AT supported leisure activities are also hot research area for research in Australia for wellbeing of PWD (Nansen et al. 2014).

Mobility devices for safe walking and wellbeing management of PWD are top research interests in Spain for AT research (Martins et al. 2012b; Kamel Boulos et al. 2009).

AT research in Sweden usually revolves around improving interaction among PWD and their care givers through specialized devices like tailored mobile phones and video mock-ups (Boman et al. 2014; Rosenberg and Nygård 2011). For improving rehabilitation of PWD, timing devices are also commonly used for safety of older adults living at their homes (Nygård 2009).

Most of the AT research activities in Italy are focused on ambient intelligence for cognitively impaired PWD (Bravo et al. 2014).

### 2.3.6 National Dementia Plans of the Top 10 Countries

There are a few studies already published on national dementia strategies for some individual countries. Many researchers suggest that the national dementia strategies for different countries can better managed by following the procedures adapted for preparing diabetes and HIV/AIDS strategies for those countries. This study further emphasizes the need of comparing dementia strategies of different countries (Wortmann 2013). Another study highlights features of Japanese national dementia policy with international standards. The results show that Japan has multiple access points for dementia care for the elderly people. However fragmentation remains to be solved in dementia health care pathways (Nakanishi and Nakashima 2014). In another study a person centric approach is followed for studying dementia strategies for some countries. The current dementia strategies mostly help in early transition of the dementia journey, while the future strategies should focus on later transitions as well (Fortinsky and Downs 2014).

The literature investigation further highlights, that there are no comparative studies available on national dementia strategies of different countries(Wortmann 2013; Nakanishi and Nakashima 2014). This overview examined the existence of national dementia strategies in the top AT countries (see table 2.8). Seven of these 10 countries have their own national dementia strategies in place. Usually these plans are made with the collaboration of Alzheimer's Disease International (ADI) which helps to deal with the impacts of dementia on each country.

The individual plans developed through ADI are able to resolve issues through a system customized to distinct culture and demographics of that specific country (Alzheimer's Disease International 2015). Typically a government national plan for dementia includes objectives such as:

- To promote awareness among common people about dementia and combating stigma.
- To identify AT support for dementia at every stage of this disease.
- To measure the population effected with dementia.
- To improve health-care quality through AT, social care and long term support.
- To ease access to diagnosis and AT services.

Table 2.8 summarise different statistics related to dementia population, investments and national strategies for all 10 countries.

Table 2.8: Summary of Dementia Statistics, Investments and National Strategies

| Country | Dementia Strategy Implementation Year | Dementia Population (Current) | Total Population (Dementia %) | Future Dementia Population Estimates (Year) | Investments (Current) | Future Investments Estimates (Year) |
|---|---|---|---|---|---|---|
| **USA** | 2012 | 530,0000 | 318,900000 (1.65%) | 138,0000 (2050) | 216$ billion | 1.1$ trillion (2050) |
| **UK** | 2009 | 850,000 | 62,798,099 (1.62%) | 100,0000 (2025) | 37$ billion | 47$ billion (2050) |
| **Canada** | NA | 747,000 | 351,60000 (2.13%) | 149,4000 (2031) | 33$ billion | 293$ billion (2040) |
| **Sweden** | 2010 | 173,135 | 9,495,392 (1.82%) | 250,000 (2050) | 7.2$ billion | NA |
| **Italy** | 2014 | 100,0000 | 60,964,145 (2.09%) | NA | 12.3$ billion | NA |
| **Germany** | NA | 1,572,104 | 81,990,837 (1.92%) | 2500000 (2030) | 2.6$ billion | NA |
| **Netherlands** | 2012 | 245,560 | 16,714,228 (1.47%) | NA | 3.35$ billion | NA |
| **France** | 2000 | 1,174,956 | 63,457,777 (1.85%) | NA | 7.85$ billion | NA |
| **Australia** | 2006 | 342,800 | 231,30000 (1.48%) | 100,0000 (2050) | 4.9$ billion | 83$ billion (2060) |
| **Spain** | NA | 818,347 | 46,771,596 (1.75%) | NA | 16.7$ billion | NA |

USA: Currently there are 5.3 million PWD in the USA which is estimated to rise to 13.8 million by 2050. It costs USA economy $226 billion each year that can rise to $1.1 trillion by 2050. The USA released a national plan for fighting Alzheimer’s and dementia in May 2012. This plan is based on the National Alzheimer's Project Act in 2011. This plan demands broad collaboration between states, private firms and non-profit organizations. The plan was updated in October 2015 (Health et al. 2012). The major goals of the USA national plan include:

- Effectively prevent and treat Alzheimer’s disease by 2025.
- Enhance care quality and efficiency
- Expand supports for people with Alzheimer’s disease and their families.
- Enhance public awareness and engagement
- Improve data to track progress.

UK: According to recent figures 850,000 people across the UK have dementia; this number is expected to rise to one million by 2025. The economic costs for dementia in the UK are estimated at $37 billion per annum. To tackle this issue the department of health issued “Living well with dementia: A National Dementia Strategy” in 2009. The major aim of this strategy revolved around making major improvements in three core areas: to improve awareness, to diagnose early and intervention and to provide a higher quality care. Furthermore this strategy identified 17 core objectives which can be implemented at the local level. The UK is one step ahead from other countries in realizing dementia’s importance and its prime minister launched a program called “Prime Minister's challenge on dementia” in March 2012 (Health 2012).The major milestones of the program are:

- By 2015, two-thirds of people should have a diagnosis, with appropriate post diagnosis support.
- Creating dementia-friendly communities that understand how to help.
- Over 100,000 members of the public through dementia awareness sessions.
- $70.4 million funding in dementia projects mostly related to social science and technology.
- By 2025, a new generation of research leaders able to continue to expand the UK's capability for applied dementia care underpinned by excellent research.

Canada: Canada is yet to have a national strategy for dementia, although "Rising Tide" a non-governmental group is persuading the Canadian government to have a national strategy for dementia as dementia figures in Canada are rising in recent years (Dudgeon 2010). According to a recent study the number of PWD living in Canada is over 747,000 and the number will be double by 2031. Dementia is impacting Canadian economy $33 billion each year and by 2040 it will rise to $293 billion per annum (Dudgeon 2010).

The Alzheimer Society is trying to convince the government to come up with a national strategy for dementia focused on the following points:

- Increasing amount of funding for dementia research in all aspects.
- Promoting earlier intervention through early diagnosis.
- Dementia workforce skills enhancement through training.
- Recognizing and improving support for caregivers.

Sweden: Currently 173,135 people have dementia in Sweden. In 2010, the first Swedish national policy for dementia was proposed with the purpose of supporting decision makers for social services and healthcare. As this policy encourages people to go for annual check-ups, an increase of 7,000 people per year is expected which will cost $5 to 7 million. This increase in regular examination will result into less cost for dementia related disease every year. The Swedish national strategy for dementia revolves around diagnosis, treatment and research. Although most research in Sweden is carried out in universities, but there is also an institute for brain research (Swedish Brain Power) working actively in this area (Westerlund 2014).

Italy: According to 2014 estimates there are 1,272,317 PWD in Italy. Italy's dementia strategy was developed by close cooperation of health ministry, three national patient/career associations and National Institute of Health (NIH). The newly proposed dementia strategy is being implemented at regional and national levels (Fiandra 2014). The dementia strategy is based on four major objectives:

- Promoting policies and actions for social approach and public health.
- Developing the network of integrated services
- Implementing policies for high quality care
- Improving quality of life for the PWD along their families through eliminating stigma.

Germany: In Germany 1,572,104 PWD and this number is expected to rise up to 2.5 million by 2030. Although dementia costs German economy $2.6 billion every year, there is no national strategy for dementia in place currently. Dementia related issues are generally addressed by various ministries including (health, research, family and social affairs). Recently the German Alzheimer Association is pressurizing the government to have a national strategy for dementia. Now, German government in association with "Allianz für Menschen mitDemenz" has launched an agenda for dementia with the title

“Together for People with Dementia”. By 2017 the government plans to have more care-homes for PWD by increasing local support networks (Alzheimer Europe 2014a).

Netherlands: There are 245,560 PWD in Netherlands. Netherlands developed its strategy for dementia care from January 2011 to May 2012. This strategy is based on care, welfare, housing and treatment of PWD according to their wishes. Since 2012, the strategy is being used for purchasing integrated care in 85 care networks for dementia. This dementia program will last for eight years. The Netherlands national strategy is quite similar to the Swedish national strategy as it also revolves around factors of diagnosis, treatment and research (Alzheimer Europe 2014b).

France: In France there are 1,174,956 PWD. France had two dementia plans in 2000 and 2004 but there were no specific budgets allocated for research in those plans (Alzheimer Europe 2013b). In February 2008, France launched its 3rd plan for dementia when their president chose to fight against dementia as a critical challenge (Le Duff et al. 2012). This plan was based on three major dimensions:

- Improving patient and their care-giver quality of life.
- Having proper knowledge for action
- Organizing for a social concern

The government also allocated about $1.8 billion funding for carrying out these plans over the next five years. A national steering committee was formed to look into the progress and implementation of the national plan.

Australia: Currently there are 342,800 PWD in Australia. In next 10 years this number is expected to increase to 400,000. In 2009-2010 the total cost spent for diseases related to dementia was $4.9 billion which is expected to increase to $83 billion by 2060. Taking these figures into account, Australia has their national strategy for dementia with the title “Fight Alzheimer, Save Australia” in place since 2006. This national strategy is based on four key areas of focus:

- Improving support and empower consumers
- Ensuring better quality of dementia care
- Increasing understanding and awareness of dementia.
- Identifying useful strategies to prevent and delay inception of dementia.

For implementing these key areas, Australians are developing dementia friendly communities similar to the UK and also celebrating dementia awareness weeks every year (Australia 2015).

Spain: In Spain there are 818,347 PWD. Spain does not have a national strategy for dementia at government level so far. However, the Spanish Alzheimer Federation (CEAFA) and the “Alzheimer’s Alliance” aim to convince the government for a national dementia plan. Currently most dementia patients have to pay 40% of the costs of the pharmaceutical products used for their treatments, while on some items the discount is up to 90%. Some categories of people like pensioners don’t have to pay anything for their treatments (Alzheimer Europe 2013a).

### 2.3.7 The Bibliometric Findings

To the best of our knowledge, this is the first study to investigate the AT research contribution of different countries for PWD. In recent years AT research is transforming from the exploratory stage to the implementation stage. This boom is largely because of the recent focus of academic researchers and industrial experts on design and development of AT for the wellbeing of PWD. The results show that from 2004, the AT research witnessed steady increase in publications with USA and UK contributing almost 50% of the total research. Other indicators like average research growth, citations per paper and the P-Index also acknowledges USA and UK's leading the numbers.

The high P-Index values indicate that along USA and UK, the research studies from Canada and Germany are of good quality and published in the high impact journals.

Italy and Netherlands lead the way for collaborative research as most of their studies are done in collaborative projects with one or more countries.

Further analysis show, that all these countries have their own specialities in research related to AT. The major AT research interest and application include tele-care, activity monitoring, fall detection, socialization, specialized mobile phones for communication, robotic based assistance, sensors, mobility devices, prompts and reminders etc. The health information scientists can conduct further studies to explore the research interests of each country as they have basic knowledge and required skills for such research. The country based research interests can help in finding similar research interests and collaborative projects.

Strong national dementia strategies also play an important role in research for the wellbeing of PWD. The countries like UK, USA and France have well established dementia strategies at national level. These strategies guide them for better AT research because of the already established research goals, objectives and priorities. The countries not having national dementia strategies including Canada, Germany and Spain are all working towards their national dementia strategies.

The findings from the overview have insights for researchers and industry on the level of AT research in different developed countries, the major research areas, research applications and national dementia strategies for the top AT research countries. The health information scientists utilizing their knowledge and expertise should investigate national dementia strategies for individual countries and compare these strategies with already well-established national dementia strategies of USA and UK. Dementia is going to affect developing countries as well in near future. Such empirical studies will help the developing countries with fewer resources to take advantage from developed countries experiences to develop their own national strategies for dementia. The similar studies using the same methodology can be performed in other research areas like; AT research for people with disabilities, AT usage for special children in education, AT impact studies with regard to society etc.

### 2.3.8 Research Open Areas

After close analysis, the following research directions are proposed for future research.

Eastern View for AT Research for Dementia: From 2000 to 2014 there are a total of 1909 publications for AT research for dementia. 1793 (94%) of the total number of publications are from the top 10 countries. Other than Australia all countries are from the West. So, it can be assumed that current research is a western view of AT research for dementia. More efforts are needed from eastern countries of the Asia Pacific for research on the topic under investigation (AT for PWD). Currently the Asia Pacific holds almost 4 billion people and the dementia population of this region will rise to 71 million till 2050 (Alzheimer's Disease International 2014). Countries especially China, Japan, South Korea, India, Indonesia, Malaysia, Pakistan, and Thailand need to invest more in their aging and dementia research programs as 70% of the dementia investments come from Western countries and there is only a small portion from eastern countries (Alzheimer's Disease International 2014). Furthermore Asian countries should also come up with national strategies to tackle challenges of dementia as already done by Japan, South Korea and Indonesia (Alzheimer's Disease International 2014).

Involving Social Care in Combination with AT: Although there is research going on AT development for PWD and helping them to have quality life, still literature suggests that too much use of AT brings aggression in PWD as they believe that by adopting AT, their family and care-givers will reduce their visits to them (Boman et al. 2014; Seelye et al. 2012). Therefore, there is a strong need for cooperation between academia and industry to manage this challenge by adopting a balance between AT and human care factor for better results.

Software Based AT for People with Dementia: Close analysis of literature indicates that most available AT for PWD lies in the category of robotics based AT, health and patient monitoring based AT, reminders based AT and communication based AT (Asghar et al. 2015). The literature suggests that currently there are only a few software related AT for PWD which demand more efforts from software engineers to design and develop more AT for helping people with dementia (Mordoch et al. 2013; Hoey et al. 2012). Therefore, software applications development for assisting PWD is another area of great potential.

Research Output of UK and USA Universities: The results indicate that USA and UK play an important role in dementia research and have well established national dementia strategies in place. As most of the research comes from the universities, another interesting future research direction can be analysing the research outputs for USA and UK at university level. This will provide insights into institutional contribution, their research interests, areas of expertise and impact for dementia research. The results of such studies can open new ways for collaborative research between different institutions with different expertise.

## 2.4 Chapter Summary

There were three sections in this chapter. The 1st section of the chapter was focused on state-of-the-art literature investigation of the use of ATs for the PWD. This section presented AT history and classifications. Furthermore popular ATs from literature are summarized along their functionalities, advantages and limitations. Empirical studies available on the topic along their population, methods and findings have been covered in this chapter as well. In the final part of the 1st section, some literature open areas for research have been discussed.

The 2nd section of the chapter was focused on the explanation of the systematic mapping studies. In mapping study one, the general ATs for the PWD were examined. Data was collected from literature and different AT exhibitions. The systematic mapping process catagarized existing ATs into five major cagagories and eight working groups. The mapping study two examined the SWAT for the PWD. The systematic mapping process catagorized SWAT support into nine working groups. Both studies identified many open research areas as well.

The 3rd section of the chapter presented summary of the AT Bibliometric Analysis. This section presented and overview of AT research activities among top research countries, highlighted national dementia strategies, research domains and also contributed to some open research areas.

In the next chapter, the overall research methodology used for this thesis is described by focusing on each of the studies carried out for this thesis.

# CHAPTER THREE

## Research Methods

***Declaration:*** *Parts of this chapter are published in journals/conferences, which is the original work of the author for this PhD thesis. Other co-authors have important supervisory role in producing these publications. Detail of publications is as follows:*

Asghar, I., Cang, S. and Yu, H., 2017a. Assistive technology for people with dementia: an overview and bibliometric study. *Health Information & Libraries Journal,* 34**,** 5-19.

Asghar, I., Cang, S. and Yu, H., 2017b. Usability Evaluation of Assistive Technologies through Qualitative Research Focusing on People with Mild Dementia. *Computers in Human Behavior,* 79**,** 192-201.

Asghar, I., Cang, S. and Yu, H., 2018a. Impact evaluation of assistive technology support for the people with dementia. *Assistive Technology,* UATY #1411405.

Asghar, I., Cang, S. and Yu, H., 2016. Software based assistive technologies for people with dementia: Current achievements and future trends. *In: 10th International Conference on Software, Knowledge, Information Management & Applications, 2016*. Chengdu, China. IEEE, 162-168.

Asghar, I., Cang, S. and Yu, H., 2015. A systematic mapping study on assitive technologies for people with dementia. *In: 9th International Conference on Software, Knowledge, Information Management and Applications, 2015*. Khatmandu, Nepal IEEE, 1-8.

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The focus of this chapter is to explain and justify the research methodology used for the research design, data collection and data analysis and reporting. The research methodology is used to solve a problem through a systematic process. More precisely the research methodology is defined as *"the procedures by which researchers go about their work of describing, explaining and predicting phenomena are called the research methodology"* (Rajasekar et al. 2006). The major aim of the research methodology is to give a work plan for the research project.

This chapter is divided into six sections. The chapter starts by explaining the methodology issues, followed by discussion on primary and secondary research types. After that the qualitative, quantitative and multi-methods research approaches are explained along their characteristics and advantages. The 2nd section highlights the research process used for conducting two systematic mapping studies. The section starts with research strategy used for selecting studies from literature followed by AT identification from literature and UK markets and development of systematic map based on the data gathered. The 3rd section briefly explains the methodology used for the bibliometric study. The 4th section focuses on the application of qualitative method for data collection related to AT use by the PWD through semi-structured interviews. The 5th section highlights the research process used for quantitative method for data collection related to AT usability, limitation and future requirements from the PWD through questionnaire. The 6th section describes the qualitative method used for case studies and semi-structured interviews for conducted for validation of the assistive software application developed for the PWD. The ethical considerations followed throughout the research process are also explained with each section.

## 3.1 Methodology Issues

Based on the scope of this thesis, it involves both secondary and primary research methods. The following section describes secondary and primary research and their implication for the current research.

### 3.1.1 Secondary Research

The Secondary research is based on *"the findings from other people's research; it involves the gathering of results of other's research from books, journals or the Internet"* (Hafner 2007). The secondary data could be already published in the form of journal papers, conference papers, personal documents, newspapers, government or non-governmental organization (NGO) statistics reports, magazines etc. (Veal 2006). The use of secondary research is situation dependent. In some studies this method is used as the sole research method for the whole project. In other studies, this method is used to gain basic understanding of what is already known and what to do next. This thesis uses literature review and systematic mapping studies as the secondary research methods.

A literature review tries to cover the important work done in academia related to a specific area of research interest. For this thesis a through literature review is conducted for collecting data and for aggregating evidence from literature according to the recommendations of (Kitchenham et al. 2009). For secondary data collection the search engines used for this research project so far includes IEEE Explorer, Science Direct, Elsevier, ACM Portal, Springer, Psychinfo, CINHAL, Pubmed, Cochrane etc. The research publications from journals and conferences are included in the literature review section. The search strategy for literature review is adapted and modified from (Jalali and Wohlin 2010). The details of search strategy are available coming section of this chapter.

### 3.1.2 Primary Research

The primary research is *" is the research you generate by asking questions, conducting trials and collating results"* (Hafner 2007). In this form of research the researchers themselves collect first-hand data. There are many types of primary research methods used commonly among the research community. These methods include: ethnography, observations, interviews, questionnaires, case studies etc. Furthermore the primary research can take the form of qualitative, quantitative or multi-methods research approaches. For better understanding of these three research approaches, the following section describes them in detail along their characteristics and advantages.

## 3.2 The Qualitative Research

The qualitative research refers to the *"meanings, concepts, definitions, characteristics, metaphors, symbols, and descriptions of things"*. Literature often describes the qualitative research as exploratory research for which the research questions are developed (Guba and Lincoln 1994). The major focus of the qualitative research is on understanding the individual's interpretation of their environments and of their own and other's behaviour (Bryman 2003). The qualitative research offers a number of advantages including: It provides details and in-depth understanding of some situation as it focuses on behaviours, feelings and attitude of the people rather than counts and ranks. It creates open environment and encourages the participants for extended responses, which can open interesting topics not considered initially. Can encourage people to share their experiences and can help to know why people act in specific ways in certain conditions. It can help to understand the feelings of the people related to the topic under investigation. If it is used in combination of quantitative data collection, it can help to avoid pre judgements and can clarify about the answers of certain questions.

### 3.2.1 Types of Qualitative Research Methods

Usually the qualitative analysis is used to answer the "why?" questions, as often these are based on the grounded theory practices. This method pays greater attention to research cases on individual bases. Various methods can be used for qualitative data collection, such as: focus groups, observations, interviews etc. (Bryman 2003). Based on the requirements of this thesis, interviews are used as qualitative method.

#### 3.2.1.1 Interviews

An interview in usually one to one conversation where questions are asked and answers are given. The first person asking the questions acts as interviewer and the replier acts as the interviewee (Gubrium and Holstein 2002). There are three major types of interviews which include: unstructured interviews, semi-structures interviews and structured interviews (Santiago 2009). Again according to the needs of the thesis, semi-structured interviews are used for qualitative data collection.

**Semi-Structured Interviews:** Semi-structured interviews are also known as focused interviews. The semi-structured interviews are based on open ended questions series on a topic of interest. Usually this method involves broad questions and some hints for the interviewee to prompt response. The open ended nature of the questions gives the opportunity to the interviewer and the interviewee to discuss topic in detail. This method gives the freedom to the interviewer to probe the interviewee experiences as well (Fylan 2005). The advantages of using semi-structured interviews are: The interviewee can answer in details. Valid information about opinion, attitude and values of the interviewees can be gained. The informal environment can encourage the interviewee to be more honest and open. The interviewer can change direction and adjust questions during the discussion.

## 3.3 Quantitative Research

The quantitative research is one of the famous types of empirical investigation. The focus of this research type is on the verifiable observation rather than logic or theory. The results for such research are expressed in the form numbers as it refers to the measuring and counting of things. In quantitative research the questions normally start with how much or how many. It is also known as explanatory research type (Guba and Lincoln 1994).

This form of research is widely popular in economics, marketing, psychology, community health, sociology, health & human development fields. The results of a comprehensive study based on 1274 research studies from two top ranked American journals for the period of 1935 to 2005 show that nearly 66% studies used the quantitative methods (Hunter and Leahey, 2008). For quantitative research the data is usually gathered through experiments or surveys (Bryman 2003). This approach is good to study a large number of people. The findings are more reliable and generalized as the results are more independent from the researchers' bias. The advantages of using quantitative research are: It involves more number of people for broader study, enhancing the chance of results generalization. It can provide more accuracy of results and greater objectivity. These methods are used to present data summaries related to the topic under investigation. As quantitative methods use standards, it allows the researchers summarize huge information sources and helps comparing similarities or differences among different categories. The personal bias could be reduced, because usually the researchers have distance from the participants.

### 3.3.1 Types of Quantitative Research Methods

The quantitative research use structured format for asking the people about their opinions and produces statistics and facts about the topic under investigation. It usually involves large number of people. The quantitative approach include many form of surveys like; online questionnaire, paper questionnaire, mobile questionnaire etc. (Veale 1998). According to the nature of our research, we used paper based questionnaires for quantitative data collection.

#### 3.3.3.1 Paper Questionnaire

The questionnaire is used as research instrument for collecting information from the respondents based on a series of questions or prompts. Usually it is made up of many questions, but it should also include clear instructions and enough space for answers. The questionnaires are used to collect data in statistical format (Oppenheim 2000). The advantages of using the questionnaires are: It can reach to a large number of people as this method is easy to reach geographically dispersed population at low cost. The respondents can fill the questionnaire in free time. It is especially useful for the people with disabilities as it gives them time to think and fill. Researcher or any other nominated person can carry out data collection. The results can be easily quantified by using statistical software. The data is easy to measure and compare and more data collection in less time.

#### 3.3.3.2 Case Study

The case study research can take the form of either qualitative or quantitative. The case study is usually described as *"published report about a person, group, or situation that has been studied over time"* (Gerring 2006). The case study method has long history in disciplines such as, sociology, psychology, political science, social work, education and administration (Yin 2003). In recent years the case study based research has also gained importance for technological studies (Olapiriyakul and Scher 2006). The advantages of using case study are: The case study method exposes the participants to real life environment. It helps to simplify the complex situations. It provides better arguments to the researchers to defend their claims. The results of case study can be ready solution, if another person faces the same issues

## 3.4 Multi-methods Research

The Multi-methods research uses more than one data collection methods. It includes the *"mixing of qualitative and quantitative data, methods, methodologies, and/or paradigms in a research study"*(Johnson and Onwuegbuzie 2004). This method takes advantage by using multiple ways to explore a research problem. The Multi-methods research helps to overcome the limitation of a single method by using combination of different methods. Furthermore this method helps to test a question at different levels (Creswell et al. 2003). The advantages of using multi-methods research are: This method is easy to report and describe. This method is useful when unexpected results arise from previous study. This method can help to generalize qualitative data to some extent. It can help in instrument design and validation.

According to the needs of this thesis and as per literature recommendation, we selected to use multi-methods. We used semi-structured interviews (qualitative method, details available in section 3.7) for eliciting data from the PWD related to AT performance, advantages, limitations and their future requirements. Then we used questionnaire (quantitative method, details available in section 3.8) for gathering data from the PWD related to AT usability, important factors and their impact on AT success and retention. Later on we used case studies for the validation of our findings and analysing the impact of AT support on the lives of the PWD (details available in section 3.9).

The following sections elaborate the process used for conducting the systematic mapping study, the qualitative and the quantitative study.

## 3.5 Research Method Used for the Systematic Mapping Studies

As per study requirements, we performed two systematic mapping studies. The 1$^{st}$ systematic mapping study is based on general ATs which support the PWD in their daily activities. The 2$^{nd}$ systematic mapping study is focused on software based ATs for the PWD. The research process used for the systematic mapping study is based on three tiers.

### 3.5.1 Systematic Mapping Study One

The research process used for systematic study one is divided into three parts. In part one, a search strategy is developed for eliciting AT studies from literature. Part two involves listing of ATs available in literature and UK market. In part three the actual systematic mapping of ATs available in literature and UK market is performed.

Search Strategy: The search strategy used in this study is adapted and modified from (Jalali and Wohlin 2012). The process starts by defining the scope of the study from all aspects related to AT for the PWD. The study scope helps in the formulation of research questions formulation and selection of appropriate keywords. To begin, we only used ACM and IEEE explorer to find the related papers and more keywords. Afterwards we searched Web of Science, Sciencedirect and Scopus as well for collecting more research papers on the topic under investigation. A self-developed Microsoft Word "Data Extraction Form" shown in literature review chapter is used for information extraction from the shortlisted papers. The process used for the search strategy is depicted in figure 3.1.

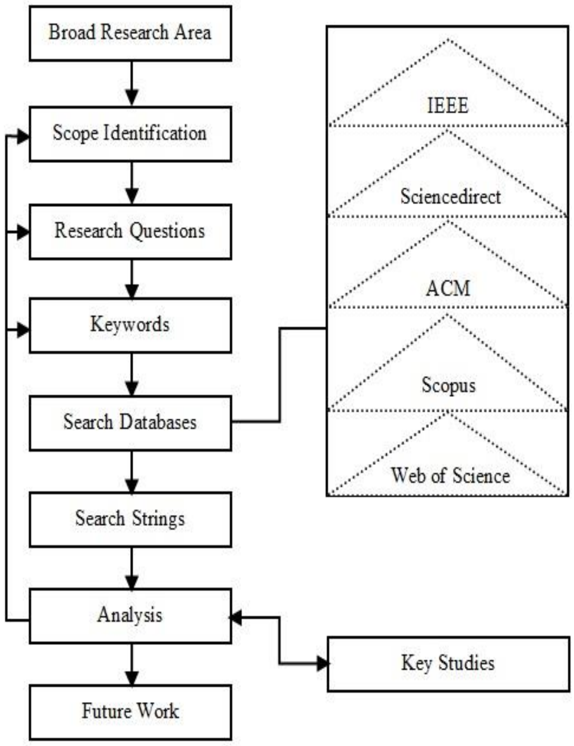


Figure 3.1: Search Strategy Adapted and Modified from (ammended from Jalali and Wohlin 2012, p.5)

AT Identification from Literature and UK Markets: The part two of research process for mapping study one is focused on eliciting AT available in literature and UK markets. By following the search strategy mentioned in figure 3.1, we finalized 47 studies from literature. These 47 studies are based on the design, development and implementation of

47 ATs for the PWD. These ATs involve software systems, reminders and prompters, robots, assistive walkers, patient monitoring, health monitoring technologies etc.

For the market survey, we visited different AT exhibitions held at different parts of Dorset, UK for the PWD. We visited different stalls of the participating companies and enquired firsthand information about the functionalities and working of ATs that are being used by the PWD. This study shortlisted 15 such ATs that are commercially available in the markets and are used by the PWD.

Systematic Mapping of ATs: As per definition the *"Systematic mapping is a process to map out and categorize the existing literature on a particular topic"*(Petersen et al. 2008). We developed systematic map based on AT functionalities, its advantages and limitations. The ATs are categorized into five major types based on the types of supports these AT provide to the PWD. Furthermore by following the mapping process these AT are divided into further eight sub-categories based on their core functionalities.

Research Limitations: Although the researchers tried to cover as many AT from literature as possible, but the data used for mapping study is gathered from studies for the period 2000 to 2015. The commercially available ATs are identified based only few visits to AT exhibitions held at Dorset, UK.

### 3.5.2 Systematic Mapping Study Two

The 2nd systematic mapping study also uses the systematic mapping approach for analyzing the software based assistive technologies (SWAT) for the PWD proposed in literature and available commercially. The systematic mapping approach is popularly used in different research domain within SE discipline. This methodology is rarely used for AT research with focus on the PWD (Asghar et al. 2015). According to the best of author's knowledge, this methodology has not been applied for analyzing the SWAT for the PWD. The research process used for this study is shown in figure 3.2.

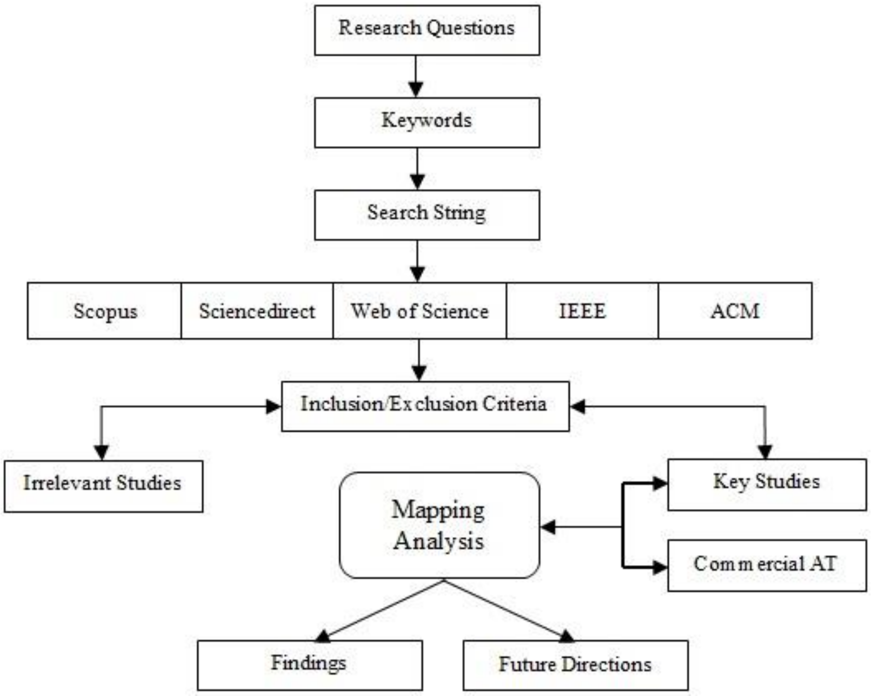

Figure 3.2: Research Process Used for the Study

Search String: As 1st part of the research process, relevant research papers were searched from popular research databases including Scopus, Sciencedirect, Web of Science, ACM and IEEE from the year 2000 onwards. The search string used for identifying relevant papers is: ((Alzheimer* OR Dementia* OR memory* OR cognitive impairments*) AND (Software* OR Web Application* OR Mobile Application* OR Web App* OR Mobile App* OR Game* OR Computer Program* Android* OR Tablet* OR Smart Phone* OR Mobile Device* OR iPad*)).

Papers Inclusion and Exclusion Criteria: The inclusion (IC) and exclusion (EC) criteria is used to identify relevant paper according to the scope of our study. The papers which fulfill the below mentioned criteria are considered for further analysis:

IC1: The study is focused on the SWAT.

IC2: The study uses empirical research methods.

IC3: The study highlights the SWAT from design till implementation.

IC4: The study is either journal or conference full or short paper (not abstract).

On the other hand the studies that conform to any of the following conditions are excluded:

EC1: The study is published before 2000.

EC2: The study is not written in English language.

EC3: The study based on the SWAT, but not for the people with dementia.

EC4: The study that just discuss the SWAT idea, not its design, development and implementation.

The search string resulted into 47 relevant studies. Based on the inclusion/exclusion criteria, only those papers discussing the SWAT design, development and implementation with focus on the people with dementia are considered for this study. Only 19 papers met the inclusion criteria but one of these was in Portuguese language which was also excluded and the remaining18 papers are retained for further analysis. The data from finalized papers is extracted using a Microsoft Word “data extraction form”.

Data for Commercially Available SWAT: As 2$^{nd}$ part of research process, data related to the commercially available SWAT for the PWD is gathered from different online sources. The same Microsoft Word “data extraction form” is used for eliciting important information from commercially available SWAT. The SWAT case studies and review reports are also studied for deeper understanding of the SWAT market trends and their impacts. A total of 33 commercially available SWAT are shortlisted for this study. As next step the systematic mapping approach is applied on both types of data gathered. The systematic mapping results for this study are based on the SWAT types, functions and their pros and cons.

## 3.6 Research Method Used for the Bibliometric Study

The research methodology used for this overview is adopted from Braun whose approach focuses on monitoring the trend of a new field of technology in the simplest way by analysing bibliometric quantification of that specific term in journals databases for a determined period (Braun et al. 1997).

There are number of studies published on bibliometric data analysis. Most work done on bibliometric data analysis can be found in nano-science and nano-technology (Karpagam et al. 2011; Tang and Shapira 2011; Gupta 2009; Roco 2011). To the best of our knowledge, a bibliometric study focusing on AT for people with dementia is not available in the current literature.

In this overview several aspects of the dementia AT research growth in leading countries are explored. These aspects include:

(1) Growth of publications and citations in the new millennium (2000-2014).
(2) Quality of publications defined by two important parameters, average citation per paper and the P-Index.
(3) Internationally collaborated publications.
(4) Analysis of research outcome by top 10 leading AT research countries.

This overview is based on data obtained from Scopus, which is the largest abstract and citation database of peer-reviewed literature in the world (Rew 2010). Scopus has 50% more publishers and twice the number of titles than any other database. Scopus is also updated daily so includes the most current research.

Figure 3.3 shows the search strategy used in this study which is adapted and modified from (Jalali and Wohlin 2010). The scope of the overview is defined from aspects related to AT for people with dementia. Defining the scope helps in research question formulation and selecting appropriate keywords. The initial search keywords used include: assistive technology/technologies, assisted living, rehabilitation devices, Dementia and Alzheimer, for the period 2000 to 2014. Based on initial keywords, more keywords were found and the search string was developed.

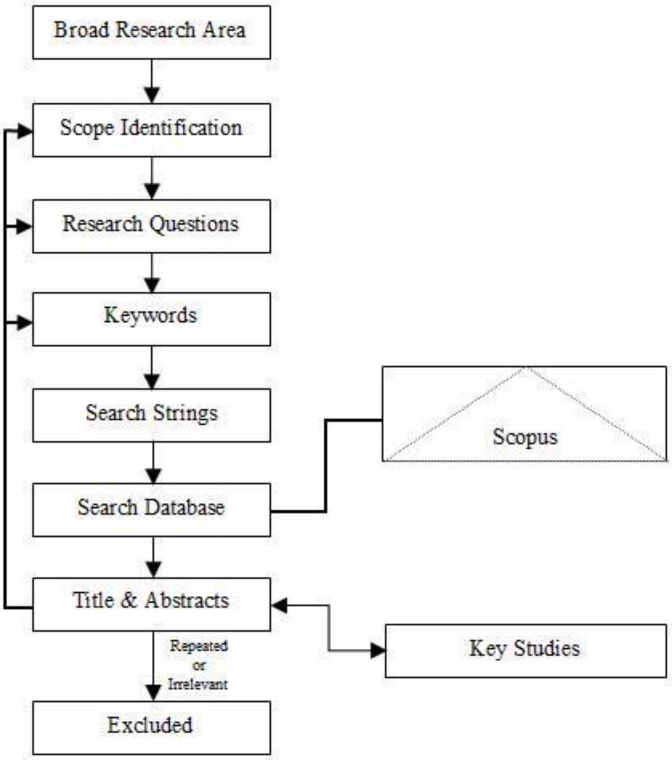


Figure 3.3: Search Strategy Used for the Bibliometric Study

The search string used was: ((Dementia* OR Alzheimer* OR cognitive impairments* OR memory*) AND (Software* OR Web Application* OR Web App* OR Mobile Application* OR Medication tool* OR Diagnostic tool* OR Mobile App* OR Prompts* OR Reminder* OR Computer Program* OR Game* Android* OR Smart Phone* OR Tablet* OR iPad* OR Mobile Device* OR Media Player* Interface*)). After standardizing the data by removing irrelevant and duplicate papers, 1909 publications were considered relevant for bibliometric analysis.

## 3.7 Research Method Used for the Qualitative Study

In the previous sections we have already seen the methods available for qualitative studies, their characteristics, advantages and limitations. As per needs of this study, we selected semi-structured interview for the qualitative part of the thesis. The next section shows the research process used throughout the qualitative study.

### 3.7.1 Semi-Structures Interviews Used for the Qualitative Study

For our project we used semi-structured interviews for collecting qualitative data from the PWD. Semi-structured interviews offer the advantages of eliciting information from respondents and explore the issues that both interviewer and the interviewee feel important (Longhurst 2003). For qualitative data 20 semi-structured interviews are carried out with the participants having mild dementia. Figure 3.4 summarizes the research process followed throughout the study. It includes (i) interviews template design and validation, (ii) survey participants, data collection and analysis and (iii) study context and ethical considerations.

### 3.7.2 Interview Template Design and Validation

Previous studies show that focus groups and interviews are both popular methods for empirical studies which involve the PWD (Fukuda et al. 2015; Lykkeslet et al. 2014). As the target population for this study was dispersed in different cities of Pakistan, therefore we adopted the semi-structure interviews method in which *“the interviewer sets up a general structure by deciding in advance the ground to be covered and the main questions to be asked”*(Drever 1995). This method gives the interviewers and interviewees a chance to explore issues they feel important in a structured way. This technique is famous for small scale research due to its flexibility.

The interview template design was a critical task as the outcome was dependent on the quality of the template. Guidelines for designing the semi-structured interview template were followed from (Jones 2004). The questions required special attention as the targeted population was PWD, therefore the questions were designed based on recommendations of the “Media guidelines for interviewing/meeting PWD” from (Alzeimer Ireland 2015).

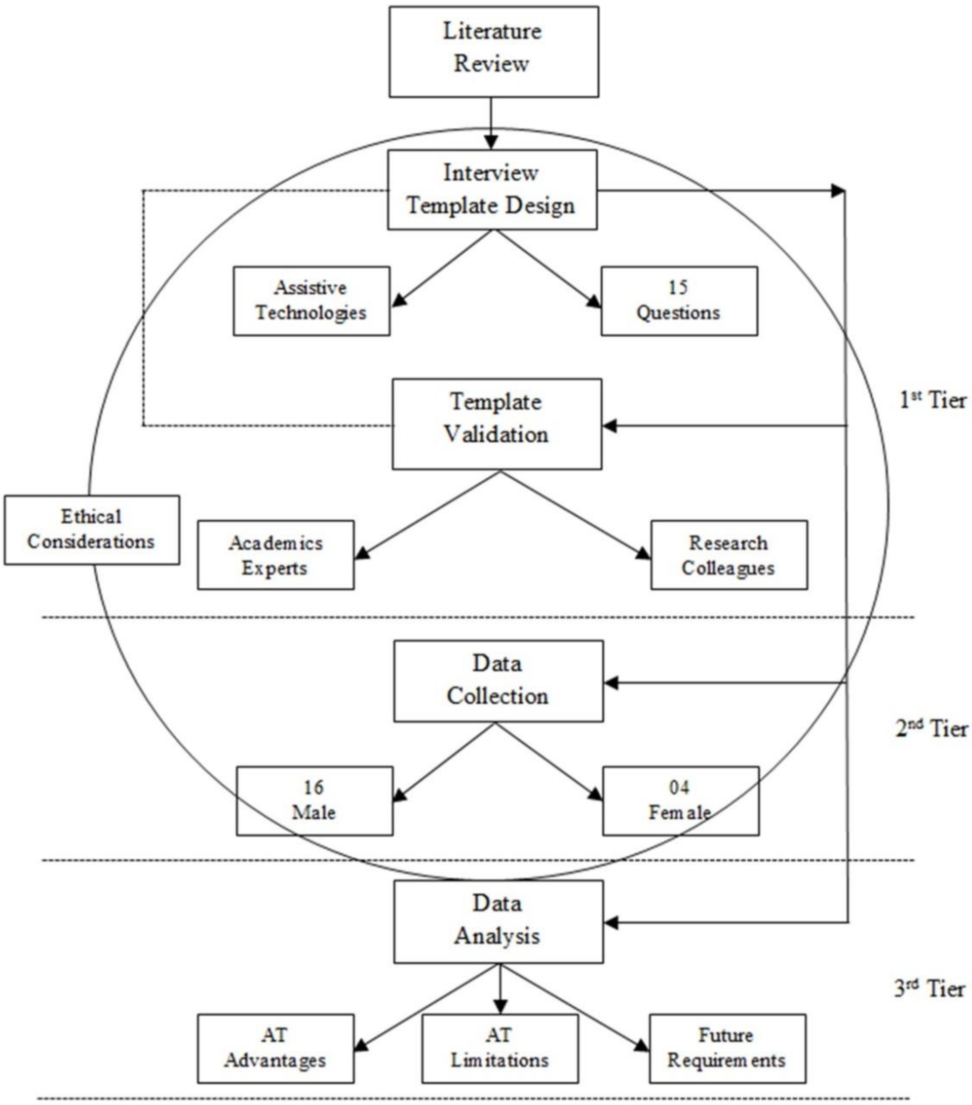


Figure 3.4: Research Process used for the Qualitative Study

The structure of questions was made simple based on the recommendations by (Beuscher and Grando 2009b). The number of questions was kept limited as often the PWD cannot concentrate for longer periods and may refuse to answer the longer questions. The PWD may also require ample time for answering the questions; therefore a shorter template can serve the purpose better.

The semi-structured interview template had 15 questions and was adapted and modified form (Microbicide Trials Network, 2014). The 1st version of the template was evaluated by two academic experts, two Master's, two PhD and one Post DOC researchers. Based on their recommendations, minor changes were made and the 2nd version was then tested with two PWD for accessing its easiness and validity. The PWD showed their satisfaction with the 2nd version.

### 3.7.3 Survey Participants, Data Collection and Analysis

After design, development and validation of the template, data was collected by interviewing the PWD. The people with mild dementia scoring 20-25 with the Mini–Mental State Examination (MMSE) were contacted (Ahmad et al. 2013). Although the researchers have different arguments on the number of interviews in qualitative research, yet there are no specific criteria regarding the number of interviews when PWD are involved in research as subjects. The existing studies involving PWD are usually based on 12 to 15 interviews (Mazaheri et al. 2014; Beuscher and Grando 2009a).

Taking this into consideration, a number of requests were made for the PWD who can use ATs to volunteer for interviews. Initially 22 PWD showed their willingness to take part in this activity, but later on two refused due to some illness. In total 20 interviews were done with the participants (16 males, 4 females) from four major cities of Pakistan. Their distribution was: six from Islamabad, three from Faisalabad, five from Lahore and six from Mianwali.

For interviews based qualitative studies the thematic analysis is popularly used as it provides *"a method for identifying, analyzing and reporting patterns within data".* For this study the six steps thematic mapping analysis is applied by following Braun and Clarke guidelines (Braun and Clarke 2006). Table 3.1 summarizes the profiling information of the survey participants.

The main contribution came from 16 males and there were one four females, as accessing female participants in Pakistan is difficult due to culture and traditions. As the targeted population was people having mild dementia, resultantly all the participants were aged between 63 to 72 years (Mean = 68). The majority of the participants (17) lived at their own homes with their families as Pakistan signifies a collectivist society, while only (3) lived at care homes (Asghar and Usman 2013). The AT usage experiences of the participants ranged from one to five years (Mean = 2.7). Some of the participants were used more than one ATs at the same time.

Table 3.1: Profiling information of the survey participants: (ATU) - AT User; (M) - Male; (F) - Female

| Participant Number | Gender | Age (Years) | Living Place | AT Use Duration (Years) | AT Type Used |
|---|---|---|---|---|---|
| ATU 1 | M | 69 | Own Home | 3 | Communication |
| ATU 2 | M | 67 | Own Home | 2 | Reminders and Prompts, Communication |
| ATU 3 | F | 72 | Own Home | 4 | Communication |
| ATU 4 | M | 71 | Own Home | 2 | Health and Activity Monitoring |
| ATU 5 | M | 67 | Own Home | 3 | Communication |
| ATU 6 | M | 69 | Own Home | 1 | Health and Activity Monitoring |
| ATU 7 | F | 64 | Own Home | 2 | Health and Activity Monitoring |
| ATU 8 | M | 72 | Care Home | 4 | Communication |
| ATU 9 | M | 64 | Own Home | 4 | Communication |
| ATU 10 | M | 63 | Own Home | 1 | Health and Activity Monitoring |
| ATU 11 | F | 68 | Own Home | 2 | Communication |
| ATU 12 | M | 72 | Own Home | 4 | Health and Activity Monitoring, Communication |
| ATU 13 | M | 67 | Own Home | 3 | Communication |
| ATU 14 | M | 69 | Care Home | 5 | Health and Activity Monitoring, Communication |
| ATU 15 | M | 70 | Own Home | 3 | Communication |
| ATU 16 | M | 66 | Own Home | 2 | Health and Activity Monitoring, Communication |
| ATU 17 | M | 67 | Own Home | 3 | Health and Activity Monitoring |
| ATU 18 | F | 65 | Own Home | 2 | Health and Activity Monitoring |
| ATU 19 | M | 71 | Own Home | 3 | Communication |
| ATU 20 | M | 66 | Care Home | 2 | Reminders and Prompts |

For data analysis, as 1st step, the verbal data was transcribed. Each interview was interpreted by listening to the recordings to develop overall understanding. After documentation of the interviews, a cross validation was done by listening to recordings. The whole data was read twice and key notes for initial ideas were taken at this stage. At the 2nd step the NVivo was used for initial data codes. The researchers tried to come up with as many candidate codes and themes as possible at this stage. After coding all the data, the data with the same codes was collated together. At the start of the 3rd step, the researchers had a long list of different codes. After that the mind maps were used to sort different codes into potential themes. Most of the codes were kept which resulted into themes and sub-themes, the other codes were discarded. The 4th step involved the refinement of themes. Two of the themes were collapsed into other themes, while one theme was fragmented in smaller components. The coherence of data extracts into each theme was tested. Additionally the relationships of the themes with each other were also checked through thematic mapping. At the 5th step, the working titles of the themes and sub-themes were replaced by the official names. After many revisions of themes in relation to the collected data, the final thematic map was produced. As 6th and final step, the analysis was transcribed as report with sufficient evidence related to each theme and sub-theme with the interviews data and existing literature.

### 3.7.4 Study Context and Ethical Considerations

The ethical approval for the study was taken from the research ethics committee of the Bournemouth University. Some care homes and medical professionals from Pakistan were also taken on board for this study. In order to establish connection with the researcher, the participants were presented traditional Pakistani sweets before the interviews. At the start of each interview, the interviewer sought willingness of the individuals and their family members as recommended by (Hellström et al. 2007). The interviewer also encouraged the PWD to tell any interesting stories while using ATs in their lives, as often these stories gives useful insights for topic under investigation (Alzeimer Ireland 2015). The interviews were audio recorded with the prior permission of each participant. The interviews lasted for 25 to 30 minutes each. To avoid ‘hit and run' impression the interviewer spent more time with each participant after finishing the interview and took tea or coffee with them so that the interest between them continue after the formal interview process (Clarke and Keady 2002).

## 3.8 The Research Process Used for the Quantitative Study

For the quantitative part of the study, the questionnaire based quantitative method is applied. The next section describes how the questionnaire based survey is carried out.

### 3.8.1 Questionnaire Based Survey

The questionnaire based survey is performed to get quantitative data related to AT evaluation by the users based on their experiences. Questionnaire based survey is recommended for situations where self-reported data from large and dispersed population is to be elicited (Lethbridge et al. 2005). The data is gathered from PWD through paper based questionnaires.

This quantitative study is conducted by following a three tier research process. As the 1st part the questionnaire was designed based on questions related to AT used by the PWD. In the 2nd part a comprehensive data collection campaign was run at different cities of Pakistan. In the 3rd part statistical analysis were performed using Statistical Package for the Social Sciences (SPSS) for factor analysis and factor ranking. The research process used for this study is shown in figure 3.5.

### 3.8.2 Questionnaire Design, Pilot Study and Lessons Learned

The major motivation of this study came from (Seok and DaCosta 2014) and current work is an extension to their work with focus on the PWD. A thorough investigation of literature is performed for eliciting for formulating the questions to gather important information on AT usage from the PWD. The questionnaire is based on five point likert-scales. There are three parts of the questionnaire. The first part is related to demographic and characteristics of the survey participants. The second part focuses on aspects related to AT usage and its importance from the participants' point of view. The third part is related to requirements elicitation from the participants for the design and development of future ATs.

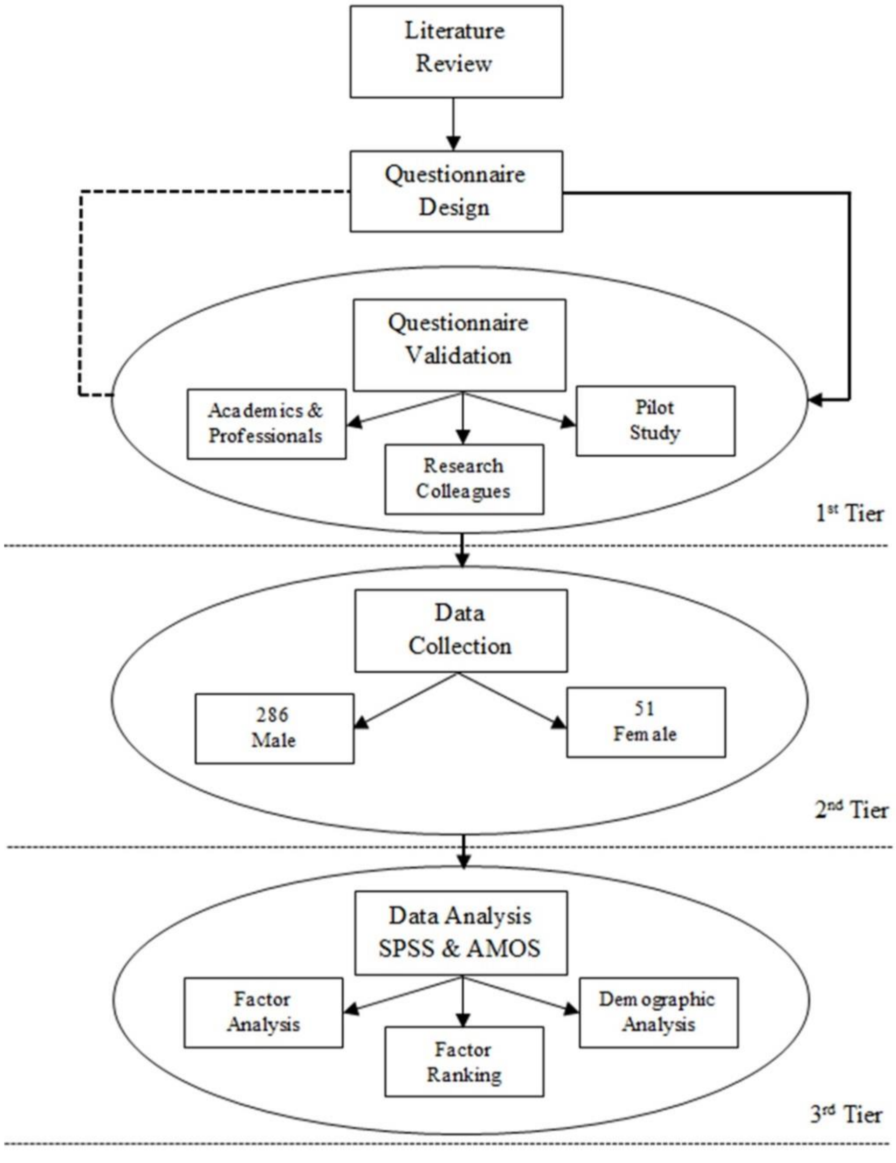


Figure 3.5: Research Process Used for the Quantitative Study

The questionnaire is validated in three stages. The 1st stage includes evaluation through academic and industry experts. The 2nd stage includes evaluation through research colleagues. While in the 3rd stage a pilot study is conducted to validate the questionnaire.

- After comprehensive literature survey the first draft of the questionnaire was prepared. The first draft was based on 57 questions. The questionnaire uses five point likert-scales for eliciting feedback from the respondents. The values assigned to likert-scales are: 5 for strongly agree, 4 for agree, 3 for neutral, 2 for disagree and 1 for strongly disagree. The questionnaire was developed in two languages, English and Urdu. The English draft was submitted to two academic experts at Bournemouth University (UK), one expert from Dorset Community Council (UK) and one expert from Alzheimer's Society (Pakistan). The idea to translate the questionnaire into Urdu also came from the same expert. The Urdu draft was submitted to the expert from Alzheimer's Society (Pakistan) and an academic expert from International Islamic University Islamabad (Pakistan). After reading the 1st version of the English questionnaire the experts from Bournemouth University emphasized the need to use positive language for highlighting importance of the wellbeing of the PWD rather than representing them as economic burden on communities and governments. The expert from Dorset Community Council (UK) suggested improvements in the questions related to demographic profile. She further advised to remove questions like participant ethnicity and national identification number (optional) questions, as these may create hesitance in getting healthy number of responses from the PWD due to privacy information. The Alzheimer's Society (Pakistan) expert helped in formation of few questions. He further appreciated inclusion of questions focusing on cultural aspects of AT users, as he believes that culture has strong effect on AT adaptation and abandonment. An academic expert in Urdu language from International Islamic University Islamabad (Pakistan) helped in proof reading the Urdu version of the questionnaire. The Urdu version was then evaluated by the expert from Alzheimer's Society (Pakistan).

- After that the questionnaire is evaluated by 13 research colleagues from cLink and Fusion (Erasmus Mundus) projects at Bournemouth University (UK). These colleagues include three Post Doctorate fellows, six PhD researchers and four Master level research students. Most of the comments from research colleagues were related to changing wording of few questions. One of the Master by research colleague helped in formatting the questionnaire in a user friendly format, as she had recently performed a questionnaire based study for her own research project. Another PhD colleague suggested reducing number of questions as the target population is the PWD. The implementation of this suggestion was delayed until the analysis of the pilot study data.
- As the next step an online version of the questionnaire was forwarded to the 50 PWD. During 10 days given time period, out of the 50, a total of 40 respondents attempted to fill the questionnaire. From those 32 respondents filled the questionnaire completely whereas 8 respondents left questionnaire incomplete. For the pilot study, we considered results of the 32 completely filled questionnaires and used SPSS for data analysis. There were 25 male and 7 female respondents. Their ages lie between 56 to 85 years. The respondents living at their own home and care homes have the proportion as 27 to 5. Some of them indicated to have cognitive and memory issues. Most of them were using reminders, assistive mobile phones and tablets. Overall the respondents showed positive trend towards AT usage. Some respondents suggested reducing the number of questions in suggestions section. Based on their suggestions and supervisors recommendation, we reduced few questions so that questionnaire

size can be kept reasonable as targeted population is the PWD and they may be reluctant to fill a lengthy questionnaire.

The validation process helped considerably in making the questionnaire simple enough, easy to understand and according to the needs of the PWD. The final version of the questionnaire is available in Appendix B.

### 3.8.3 Data Collection and Survey Participants

The data is collected in August and September 2015. As per the nature of the study, data is gathered from a wide population i.e. the PWD from different cities of Pakistan. According to recent studies, currently there are more than 150,000 PWD living in different parts of Pakistan (Ahmad et al. 2013). As per literature recommendations, if the targeted population is more than 50,000 then the following formula should be applied for calculating the sample size:

$$\boldsymbol{SS = Z \times 2 \times P(1-P)/C^2} \qquad \textbf{(2)}$$

*SS* = Sample Size

*Z* = *Z* – Value (e.g., 1.96 for a 95% confidence level)

*P* = % of population picking a choice, expressed as a decimal

*C* = Confidence interval, expressed as decimal (e.g., 0.07 = +/-7 percentage points)

$$SS = 3.8416 \times 0.5(1-0.5)/0.0049$$

$$SS = 196$$

Based on literature recommendations by using confidence level 95% and confidence interval of 7%, a minimum sample size of 196 is considered enough for the current study (Franca and da Silva 2009). For achieving better reliability and validity, the data is gathered from the participants belonging to different gender, age groups, cities and using different types of ATs (Asghar and Usman 2013).

According to the population distribution, around 60% of Pakistan’s’ population live in central and northern parts of the country (see figure 3.6). Most of the developed cities with better medical facilities also lie in these regions; therefore we targeted these regions of Pakistan due to larger population and ease of access.

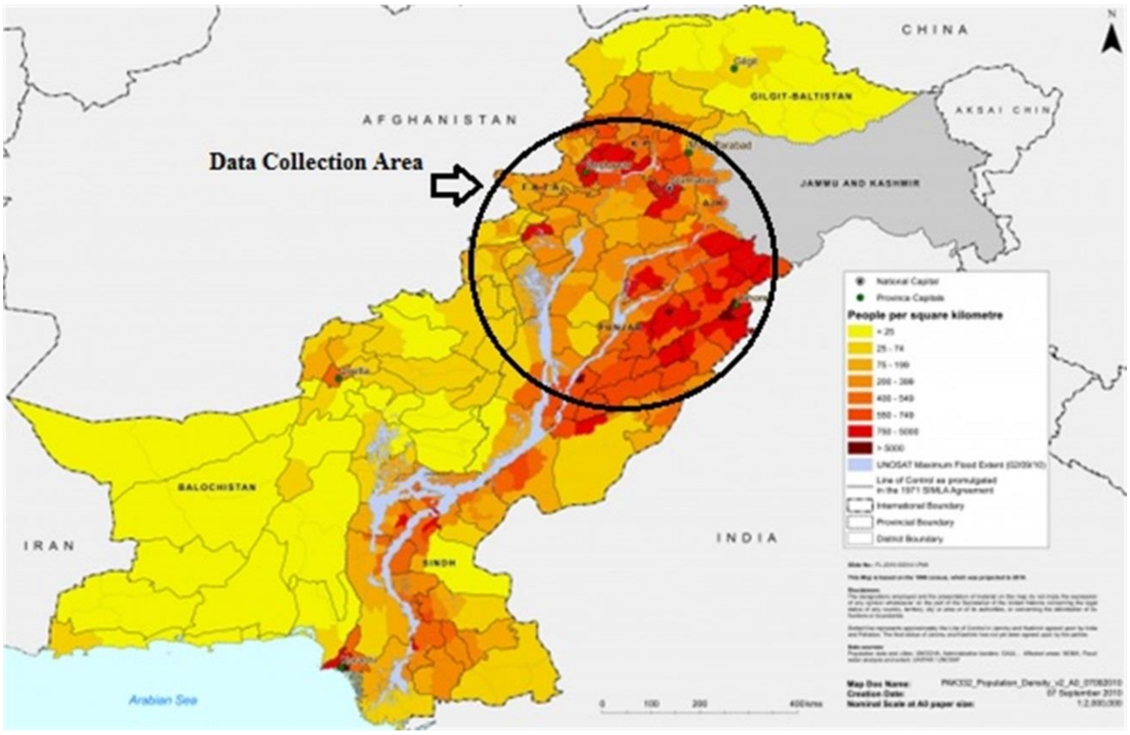


Figure 3.6: Population Density and Data Collection Area in Pakistan

During data collection campaign, we distributed around 500 questionnaires in major cities of Pakistan (Islamabad, Rawalpindi, Lahore, Faisalabad, Abbottabad, Peshawar, Attock, Mianwali, Kohat etc.). We used help from colleagues at different Universities in Pakistan and some friends working in medical profession at Shifa International Hospital (Islamabad), Pakistan Institute of Medical Sciences (Islamabad), Shaikh Zayed Hospital (Lahore), Allied hospital (Faisalabad) and Ayub Medical Complex (Abbottabad). During the 45 days period, in total we received 364 responses. After scrutiny we come to know that 29 questionnaires were not completely filled. Additionally 7 questionnaires are missing a page or two. Most interestingly on one questionnaire the respondent wrote a note that *“I do not have dementia”*. So these 37 questionnaires are excluded from the analysis. The analysis used for this study is based on 327 questionnaires completely filled by the respondents.

Table 3.2 shows the summarized demographic and characteristics properties of the survey respondents.

Table 3.2: Demographic and Characteristic Properties of the Respondents

| Demographic Properties | | Frequency (n=327) | Percentage (%) |
|---|---|---|---|
| Gender | Male | 276 | 84% |
| | Female | 51 | 16% |
| Age | 56-70 Years | 182 | 56% |
| | 70-85 Years | 145 | 44% |
| Characteristic Information | | Frequency (n=327) | Percentage (%) |
| Respondent | AT User Himself | 286 | 88% |
| | Family/Carer of AT User | 41 | 12% |
| Living Situation | Living Alone | 60 | 18% |
| | With Family Members | 211 | 65% |
| | Care Home | 56 | 17% |
| Functional Difficulty | Remembering/Thinking | 141 | 42% |
| | Learning | 40 | 13% |
| | Physical Difficulty | 36 | 11% |
| | Hearing and Seeing | 37 | 12% |
| | Interacting with Others | 73 | 22% |
| AT Type Used | Mobility Support | 28 | 9% |
| | Cognitive Games | 56 | 17% |
| | Reminder or Prompter | 55 | 17% |
| | Social Applications | 147 | 45% |
| | Leisure Support | 41 | 12% |
| Funding Mechanism Used | Insurance | 36 | 11% |
| | Personal | 249 | 76% |
| | Donation | 42 | 13% |

Gender distribution is an important feature for any survey and the current survey was filled by the both segments of gender. A total of 276 (84%) respondents are males while female representation is (51) 16%. In overall Pakistan’s population of 190 million, there are 51% male and 49% females (Data 2015). The lack of female representation in our survey is due to cultural aspects, as it is hard to approach female participants in Pakistan.

As the targeted population for this study are the old people with mild dementia, resultantly all the participants' are aged above 55 years. We categorized them into two groups: Group 1 (56-70 years) and Group 2 (71-85) years. There are 182 (56%) of the respondents in the 1st age group, while 145 (44%) of the respondents belongs to the 2nd age group. The less representation in the 2nd age group may be due to the fact that only 3.30% of the Pakistani population is 65+ years (Data 2015). Majority of the questionnaires were filled by the AT users themselves with an overwhelming number of 286 (88%), while 41 (12%) questionnaires were filled by their caregivers or family members on their behalf. This could be due to the lack of specialized caregivers in the country.

The living situation of the participants can also be used for analysing their preferences regarding technology use. For this study the living situation distribution of the survey respondents indicates that majority of the respondents 211 (65%) lived with their families as Pakistan represents a collectivist society (Hofstede et al. 1991). The remaining 60 (18%) respondents lived alone and 56 (17%) respondents lived at care homes.

Some of the respondents indicated that they experienced more than one functional difficulty during their daily activities. As dementia usually affects memory and cognitive abilities, therefore majority of the survey respondents 141 (42%) specified remembering and thinking as their major functional difficulty. Other functional difficulties include learning 40 (13%), physical difficulty 36 (11%), hearing and seeing 37 (12%), while 73 (22%) had issues in interacting with others.

In another question respondents were asked about the type of the ATs they were using for getting help in performing their daily activities. A large number of respondents 147 (45%) indicated that they used social applications for staying in touch with their families and friends. Another 28 (9%) respondents used ATs for physical support from one place to another. Other famous ATs in use included cognitive games 56 (17%), reminders and prompts 55 (17%) for setting alarms and reminders. While the remaining 41 (12%) of the respondents used leisure supportive ATs for fun and leisure activities.

The respondents were also asked about the funding mechanism that they used to purchase ATs. Majority of the respondents 249 (76%) used their own money as in Pakistan still there was no specific authority at Government level for the financial help to the PWD. Another 36 (11%) respondents used insurance money and 42 (13%) respondents used donations for purchasing/hiring AT.

### 3.8.4 Data Analysis

This part of the thesis explores different factors for AT used by the PWD, the ranking of different associated factors and their impact analysis based on the demographic and characteristic information of the survey participants. The survey items selection, validation and categorization process is adopted from (Jung 2011).

Factor Analysis: Through factor analysis, the construct validity of a questionnaire can be tested (Rattray and Jones 2007). If a questionnaire is a construct valid, all items together represent the underlying construct well. Exploratory factor analysis (EFA) detects the constructs - i.e. factors - that underlie a dataset based on the correlations between variables (in this case, questionnaire items). The EFA method is used as it *"uncover the underlying structure of a relatively large set of variables"* (Norris and Lecavalier 2010) . The EFA is usually used to identify and explore factors for an instrument and find associations between them (Byrne 2013; Hinton et al. 2014). For extracting factors and components, the normality is important only to the extent that skewness or outliers affect the observed correlations and significance. The Kaiser-Meyer-Olkin measure of sampling adequacy (KMO) can signal in advance whether the sample size is large enough to reliably extract factors. The KMO *"represents the ratio of the squared correlation between variables to the squared partial correlation between variables"*. The formula of KMO test is:

$$\boldsymbol{MO_j} = \frac{\sum_{i\neq j} r_{ij}^2}{\sum_{i\neq j} r_{ij}^2 + \sum_{i\neq j} u} \qquad \textbf{(3)}$$

Where: $R = [r_{ij}]$ is the correlation matrix and
$U = [u_{ij}]$ is the partial covariance matrix.
This test is not usually calculated by hand, because of the complexity.

For the current survey the KMO value is .858 which is sufficient for factor analysis as KMO values greater than .60 are considered good (Namlu and Odabasi 2007).

For factor analysis the Kaiser-Guttman criterion of eigen values greater than 1 was used as recommended by literature (Cliff 1988). The comparable method proposed by Cronbach is used to calculate the questionnaire's reliability:

$$\boldsymbol{\alpha} = \left((\boldsymbol{N^2 M}(\boldsymbol{Cov})\right)/(\sum \boldsymbol{s^2} + \sum \boldsymbol{Cov}) \qquad \textbf{(4)}$$

Assumption behind this equation is that the unique variance within variables ($s^2$) should be rather small in comparison with the covariance between scale items (Cov) in order to have an internal consistent measure (Cortina 1993). For the current survey the Cronbach's Alpha values ranges from 0.890 to 0.907 which shows the internal consistency of all the items (George 2003). Additionally as per literature recommendations the factor loading scores more than or equal to .40 are accepted for the current survey (Hair et al. 2006a).

Linear Regression: The linear regression is used to analyse the relative impact of each factor on AT effectiveness and retention as linear regression models *“the relationship between a dependent variable and one or more independent variables”* (Singh 2008).

Data Normality: Usually t-test is used in situations when data follows a normal distribution. Otherwise if data does not follow normal distribution, some nonparametric method should be adopted for the analysis. To check whether the data is normally distributed or not, we use Shapiro Wilk test rather than the Kolmogorov Smirnov test because this one is better for larger data set (>2000).

Significant Difference Tests: For demographic and characteristics based impact analysis the Mann Whitney U test was used for testing the difference between variables with two values like ‘Gender’ and Kruskal Wallis H test was used for finding the difference between variables with more than two values like ‘AT Type Used’.

### 3.8.5 Limitations and Ethical Considerations

The researcher travelled more than 3000 kilometers for data collection, still unable to cover all Pakistan. For the current study most of the questionnaires are filled from six major cities of Pakistan. There is little representation of smaller cities from Pakistan. For language limitation for the participants who are unable to answer the English questionnaire are given the Urdu questionnaire.

The ethical approval for the study was obtained from Bournemouth University on 19th May 2015. As per literature recommendation the survey participants are guaranteed regarding their confidentiality, free will and privacy (Oliver 2010). We asked for personal willingness to fill the questionnaire from each participant. We tried to keep the burden low on participants by allowing them two to five days for returning the questionnaire as the PWD may need time to think and respond. The families of the participants are also well informed about the survey and the role of the participants.

The questions are designed using simple language so that the PWD with varied educational background can understand the questionnaire easily.

## 3.9 The Method Used for the Case Studies

As the last part of the study, case studies are performed for experiments involving the PWD, the assistive software application and the researcher. For the case studies, a qualitative, user participatory, research design is followed throughout the research process. The user participatory research design includes multiple-subjects case studies and semi-structured interviews at different sites. The case studies followed three phases which include: (i)- training the PWD to use ECD application, (ii)- the PWD used ECD application for two days to perform different tasks and (iii)- the PWD were interviewed for analyzing the usability of the ECD application.

### 3.9.1 Participants and Volunteers Selection

Prior contacts are made with the medical professionals from Pakistan and based on their recommendations, 12 PWD are contacted for participation in the case studies. Nine PWD expressed their willingness for participation but one of them is left out due to illness. The remaining eight PWD belonging to five different cities in Pakistan participated in the case studies. The participants included in the study are shortlisted based on the following criteria:

- The participant give written and verbal consent to participate in the case study
- The participant is diagnosed with mild dementia
- The participant has moderate cognitive impairment based on Mini Mental Scale Examination (MMSE) with scores from 20 to 25.
- The participant has prior knowledge and experience of using software technologies

- The participant understand instructions

The volunteers' selection also followed a systematic process including:

- The volunteer gave written and verbal consent to participate in the case study
- The volunteer personally know the PWD
- The volunteer lives within the same street as per the PWD
- The volunteer is good at using software technologies
- The volunteer has access to car or bike and willing to purchase goods of behalf of the PWD

For the safety of both the PWD and the volunteers their aggression and criminal history is discussed with the medical professionals and local union councils and all of them are found positive fit for the case studies.

### 3.9.2 Test Environment

The study is executed in central and northern parts of Pakistan which holds almost 60% of country's population. The prior experience of software technology use by all the participants is required. Information about their needs and desires for software technology is collected via questionnaires and interviews in 2015 through the involvement of 347 PWD. Each test environment includes the living place of the PWD and five neighbors within the same street. The specially designed ECD application is used was communication medium between the PWD and the volunteers. The ECD application was installed on the Tablet for the PWD and on the smart phones of each volunteer. The Tablet was hanged on the wall, so that the PWD can access it easily and it was kept on all the time during the case study. The case studies activities continued for both days from 9 am to 8pm. The activities of the PWD and volunteers were recorded through automatic log files. The researcher also lived in the same home to observe and take notes of different activities performed by the PWD.

### 3.9.3 Interviews from the Case Studies Participants

At the end of each case study the PWD were interviewed using a semi structured interview template already discussed in the previous sub section. The interview process was carried out during April and May 2017. After finishing the interview stage, each interview is interpreted by listening to the recordings and documented using the MS Word semi-structured interview template. After documentation of all interviews, a cross validation is done by listening to recordings and verifying the documented data.

The summarized demographic information of the PWD who participated in the case studies is presented in table 3.3.

Table 3.3: The Demographics of the Case Studies Participants

| Participant | Gender | Age | Living Place | MMSE Score | Cognition Level | No. of Volunteers | Observations |
|---|---|---|---|---|---|---|---|
| P01 | Male | 71 | Own Home | 21/30 | Mild | 5 | The person was keen to use ECD |
| P02 | Male | 69 | Own Home | 20/30 | Mild | 5 | The person has some visual issues |
| P03 | Female | 74 | Own Home | 23/30 | Mild | 5 | Responded well to instruction, but had slight mobility problem |
| P04 | Male | 66 | Own Home | 21/30 | Mild | 5 | Keen to adopt ECD permanently |
| P05 | Male | 74 | Own Home | 22/30 | Mild | 5 | Needed lot of motivation to use ECD |
| P06 | Male | 69 | Own Home | 21/30 | Mild | 5 | The person was really talkative |
| P07 | Male | 71 | Care Home | 23/30 | Mild | 5 | Required training 3 times before case study |
| P08 | Male | 68 | Care Home | 22/30 | Mild | 5 | Asked caregiver to remain with him |

There were seven male and one female PWD participants in the case studies with mean age of 70.3 years. The living situation of the participants indicated that six of them lived with their families at their own homes while two lived at care homes. Their MMSE scores for the participants ranged from 20 to 23, which indicate that all PWD have mild dementia. Some of the participants have functional difficulties like mobility, remembering, thinking, interaction with others, audio and visual issues etc. As per discussions with the families and caregivers the functional status of all the participants was considered partial dependent on caregivers or family members for completing daily tasks.

### 3.9.4 Evaluation Process

At the beginning of each case study the PWD and volunteers were explained about their roles. The researcher gave them one hour training through power point slides and explained the functionalities of the ECD application. A written scenario was developed which described the use of ECD application functions in real life and how it can support the PWD to perform different activities. After that the researcher helped to install the ECD application on tablet for the PWD and on the smart phones for the volunteers. Then, they were asked to use the ECD application in their normal daily activities. At the end of each case study the PWD were interviewed to explore their opinions about the usability of the ECD application.

### 3.9.5 Ethical Considerations

The ethical approval for the study was taken from the Bournemouth University and Pakistan Medical Association. At the start of each interview, the interviewer sought willingness of the individuals and their family members as recommended by (Alzeimer Ireland 2015). The interviewer also encouraged the PWD to tell any interesting stories while using the ECD application in their daily activities, as often these stories gives useful insights for topic under investigation (Alzeimer Ireland 2015). Every interview was recorded with the prior permission of each participant. Each interview lasted for 30 to 40 minutes. The interviews were done in Urdu (national language), which is widely spoken language throughout Pakistan. The details of the case studies are available in chapter 5.

## 3.10 The Overall Research Process

The figure 3.7 shows of overall research process used for this thesis. The thesis is divided into four major parts, the problem space, the data collection space, the data analysis space and the solution space. For the 1st part the research problem is identified through extensive literature review. The 2nd part involves data collection which is done through the systematic mapping studies, semi-structured interviews and the questionnaires. The 3rd part is based on analysis of collected data. The analyses are performed for AT functionalities, advantages, limitations, AT factors, factor ranking, factors impact and future requirements of the people with dementia. The 4th part is solution space for the identified problem. The design and development of an assistive software application and case studies are carried out in this part.

## 3.11 Summary

In this chapter the overall research methodology used for this thesis was presented. The chapter started with methodology issues and discussed the qualitative, quantitative and multi-methods in details. Later on the research methods used for each study of this thesis was explained. Starting with systematic mapping studies (search strings, data collection, data analysis). Then the qualitative study (interview template design, population, data collection, data analysis and ethical considerations) were described. After that the quantitative study (questionnaire design, population, data collection, data analysis and ethical consideration) were discussed. The research process used for validation case studies along their details has been discussed as well. The final section of the chapter summarizes the overall research process used for this thesis.

The next chapter focuses on the data collection through qualitative and quantitative and discusses results in details.

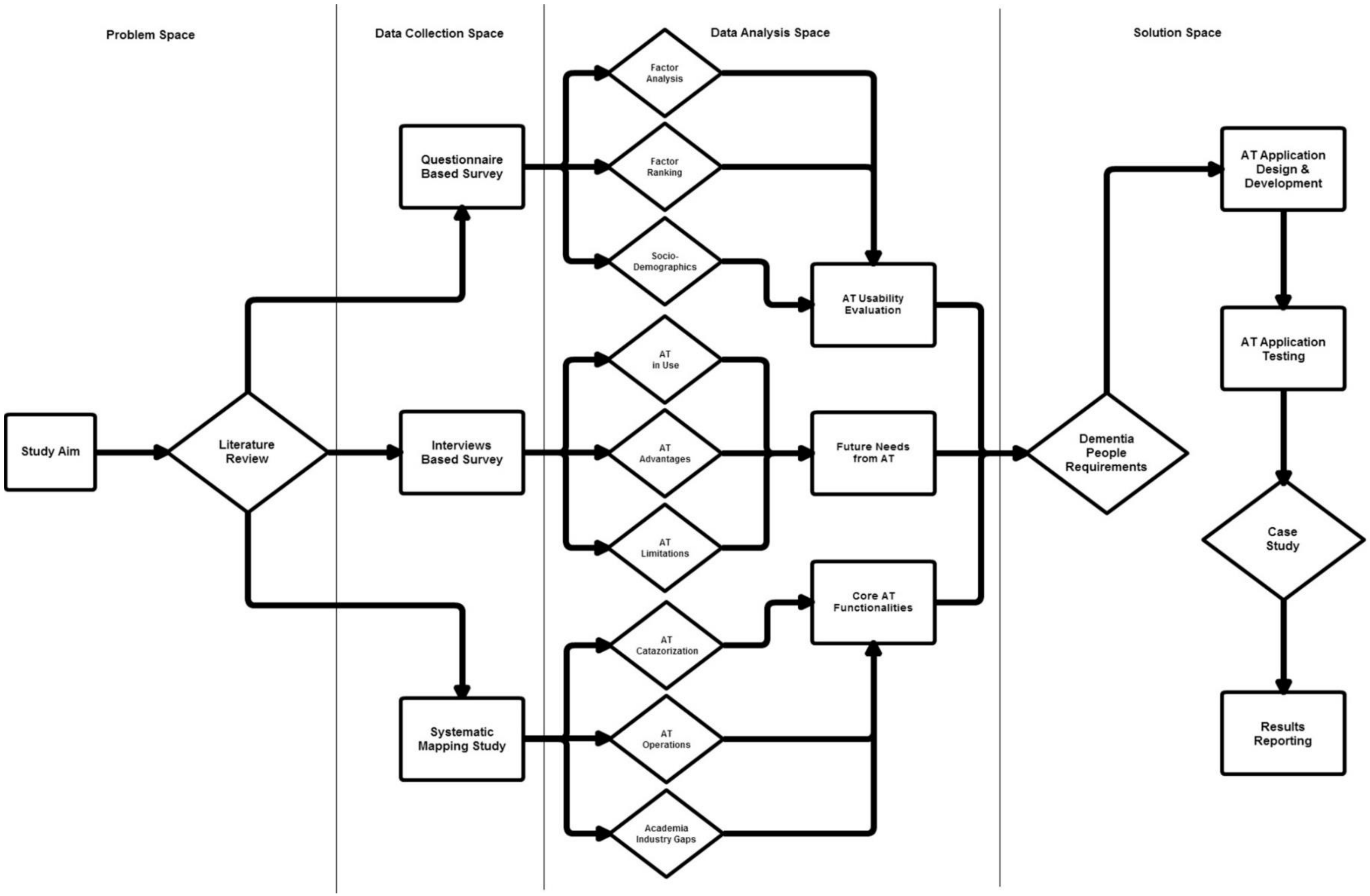


Figure 3.7: The Overall Research Process Used for the Thesis

# CHAPTER FOUR

## Data Collection and Analysis

***Declaration:*** *Parts of this chapter are published in journals/conferences, which is the original work of the author for this PhD thesis. Other co-authors have important supervisory role in producing these publications. Detail of publications is as follows:*

Asghar, I., Cang, S. and Yu, H., 2017b. Usability Evaluation of Assistive Technologies through Qualitative Research Focusing on People with Mild Dementia. *Computers in Human Behavior,* 79**,** 192-201.
Asghar, I., Cang, S. and Yu, H., 2017c. September. Empirical analysis of assistive technology support to the people with dementia. *In: 23rd International Conference* on *Automation and Computing (ICAC), 2017,* Huddersfield, United Kingdom. IEEE, 1-6.
Asghar, I., Cang, S. and Yu, H., 2018a. Impact evaluation of assistive technology support for the people with dementia. *Assistive Technology,* UATY #1411405.

***Submitted/Under review:***

Asghar, I., Cang, S. and Yu, H., 2018b. An Empirical Study on Assistive Technology Supported Travel and Tourism for the People with Dementia. *International Journal of Tourism Research*.

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This chapter focuses on the qualitative and quantitative studies conducted for this thesis. There are two sections in this chapter. The 1st section explains the qualitative study conducted by involving the PWD into healthy talks through semi-structured interviews. The data collected through semi-structured interviews is interpreted through thematic analysis. The thematic analysis resulted into three themes and six sub-themes, which are discussed with relevant examples. This section further highlights the findings of the qualitative study, suggestions for the AT producers and future requirements of the PWD. The 2nd section focuses on the quantitative study conducted by the help of a questionnaire based survey. Initially the profiling information of the participants is explained. Exploratory factor analyses are performed for understanding important factors related to AT use. The factor analysis resulted into 11 factors which are discussed one by one. The relative importance of each factor with respect to AT retention and effectiveness is also explained. The section ends by listing the future needs of the PWD. The qualitative and quantitative studies are performed to achieve the following research objectives:

OB6:“To identify important factors for AT being used by the PWD”

OB7:“To explore the support of ATs in travel and tourism for the PWD”

OB8:“To investigate the impacts of different factors on AT acceptance and retention”

OB9:“To highlight how usable current ATs are for the PWD and to understand their requirements for the future ATs”

## 4.1 The Qualitative Study

The fundamental goal for the AT industry (like all other businesses) is to gain customer satisfaction by providing them with quality products (Asghar and Usman 2013). AT usability evaluation studies can serve greatly in achieving this goal by highlighting the likes and dislikes of the PWD for existing AT. Furthermore such studies can also serve as basis for requirements elicitation from the PWD for future ATs.

Currently there is great trend in academia for research regarding AT design and development for the PWD. The industry is also transforming ideas into reality for betterment and wellbeing of the PWD (Doukas et al. 2011). Many studies are available in literature which present some new ideas and AT devices for the wellbeing of the PWD (Hoey et al. 2010). It is strongly believed that technology success depend heavily on its end user perspectives. Therefore knowing the point of view of the PWD regarding the usability of existing AT becomes more important. Yet there are only few studies carried out in this domain (Span et al. 2013). Such as (Rowe et al. 2009) in USA

(Demers et al. 2001) in Canada, (Jedeloo et al. 2002) in Netherlands conducted some studies for testing AT satisfaction from the AT users.

To the best of knowledge, there are no AT usability evaluation studies conducted in the South Asian region with focus on the PWD. The importance of this study becomes even more significant as South Asia holds 25% of Worlds' population (Rasul 2014). Delphi consensus study reports that there is an annual 1.9% increase in the dementia population of South Asia. According to a recent study statistics, South Asia has over 4.5 million PWD (Prince et al. 2013). According to recent studies, currently there are more than 150,000 PWD living in different parts of Pakistan and dementia population is increasing at a rate of 1.9% every year (Ahmad et al. 2013). This steady rate of dementia population increase will create challenge for already weak economy of Pakistan. We therefore conducted this study in Pakistan by involving the target population into productive talks and to know their point of view regarding current ATs and their future needs.

### 4.1.1 Results and Discussion

This study highlights the experiences of the PWD who use different ATs for performing their daily activities. As first step the demographic properties of the participants are summarized as profiling information in table 3.1 to understand survey participants and their characteristics. As the second step thematic analysis are performed on data collected to achieve study objectives.

### 4.1.2 Themes and Sub-Themes

The thematic mapping analysis helped to distribute data into three major themes and six sub-themes (see table 4.1), which reveal the experiences of the PWD with ATs. The experiences reflect three spheres: the person in the society (public sphere), the person in the family (private sphere) and the person herself/himself (personal sphere). The themes comprise of: the happy users because of improved communication with others (public sphere); the non-happy users due to lack of privacy and social isolation (private sphere) and the user desired to have balance between technology and human care (personal sphere).

Table 4.1: Themes and Subthemes through Qualitative Content Analysis

| **Themes** | **Subthemes** |
|---|---|
| The happy users | Facilitated communication<br>Facilitated travel<br>Timely medication and activities |
| The non-happy users | Promote social isolation and aggression<br>Not tailored to the user needs |
| Technology and human care | Special training needed |

### 4.1.2.1 Theme 1: The Happy Users

In general most (13 out of 20) participants felt 'comfortable' using ATs for their daily functioning. While discussing the advantages and limitations of the ATs, the participants were mainly happy with the AT assistance. For them the critical challenge was related to functional difficulties that they have to face during daily activities and ATs were helping them to minimize these barriers. The ATU1 expressed his delight by saying:

*"The ATs help me to do many activities easily and independently without depending on others. I can make one touch call by clicking on the pictures and go outside independently without any fear."*

The happy users termed facilitated communication, travel and timely medication and activities support as major contributions of AT support in their lives.

Subtheme 1: Facilitated Communication: The communication support for the PWD is usually believed as critical for helping them. The literature also support this argument that the ATs have the potential to increase the number of communication opportunities for the PWD and decrease their loneliness (Meiland et al. 2014). The survey participants had almost similar views regarding the communication help they were able to get through the support of ATs.

Figure 4.1: Interviewing ATU16 at his Fields

The ATU5 described that AT usage had decreased his loneliness and resulted into more frequent contacts by his friends to enquire about him. He pointed out that:

*"I can talk easily to my family members and friends. In fact they themselves contact me every day"*.

In two similar talks the AUT8 and ATU19 praised socialization and one-touch facilities for communication through ATs by describing:

*"I use Facebook and picture based calling on assistive mobile application which help me to be in contact with loved ones"*,

*"I can use assistive applications on my smart phone for connecting others at single click"*.

Another important point came from ATU9 as he not only praised the communication assistance of ATs, but also highlighted that this assistance could also be used for medical purposes. He described this situation as:

*"I use software application for contacting friends and doctors. I share my health details with the doctor who advices me regarding diet and medication".*

Based on the same concept the developers at Tunstall developed Triagemanager a software platform which shares real time information of the PWD to the doctors and nurses. It is useful for timely interventions at the time of need and improves the safety of the PWD (Tunstall 2015).

Subtheme 2: Facilitated Travel: Independent travel is often highlighted as another critical challenge for the PWD as they face constraints like physical mobility, cognition, weak memory and forgetfulness. Although most of the survey participants were concerned about their abilities to travel without the help of other people, yet some of them shared their positive experiences for the support of AT in travel. The ATU16 pointed out that:

*"I was unable to go out at my own. Recently my family bought me a smart watch which guides me when I am outside home. It is great help".*

He further recommended other PWD to start using smart watches as well for independent travel.

Some participants like ATU12 termed the AT support during travel from one place to another as a life changing experience and expressed his feeling as:

*"With the use of GPS watch, now I can wonder outside my home independently which was not possible before as I often forgot my way back".*

The literature also indicates the importance and contribution of independent travel for the rehabilitation. The systems like the Opportunity Knocks support the PWD in using public transport. It uses context aware information and whenever user deviates from their selected plans it notify them and guide them the correct way to return home (Patterson et al. 2004).

The use of ATS for travel is also evident in real life places these days. There are many advanced travel facilitated technologies available commercially and the disabled people are seen using smart walkers at markets and public places. From the survey participants the ATU17 also used such smart walker which helped him to travel independently and perform his daily activities. He described this situation as:

*"My smart walker has GPS and navigation system which help me move independently from one place to another. I go for shopping and meeting friends. I really enjoy my smart ride which gives me lot of confidence".*

A systematic literature review aggregated knowledge about the smart walkers available for the PWD and highlighted the importance of smart walkers. The smart walkers are cost effective solutions and can easily increase the self-confidence of the PWD (Martins et al. 2012b).

Subtheme 3: Timely Medication and Activities: Dementia is often associated with forgetfulness which causes lot of challenges for the people experiencing it. The weakening cognition creates issues like forgetting to take medicine, performing activities on time, and remembering about their health conditions. The ATs can be useful to avoid such situations. The assistance of ATs in this regard is highly appreciated by the ATU2 who expressed himself as:

*"The reminders help to do activities on time which otherwise I forgot most often. The main advantage of using reminders for me is to take medicine on prescribed time".*

The literature supports this situation by going one step ahead through the use of context aware reminders. These reminders not only help the PWD in daily tasks but also manages conflicts between pre-defined plans and real time destructive activities (Du et al. 2008a).

The ATs like the HomePod designed by Medvivo help the PWD to monitor their physiological data for weight, blood glucose, blood pressure etc. at home. The medical information provided by such ATs can be transferred to a doctor for analysis as well (Medvivo 2015). The ATU4 termed smart watch for health analysis as the best gift he received due to its effectiveness:

*"Previously we have to visit a doctor for health conditions check-ups but now the smart watch helps us to monitor blood pressure, body temperature, heart rate etc. at our own home"*.

The use of AT for medical purposes is also appreciated by the ATU7:

*"I have blood pressure and diabetes issues which need continuous monitoring. My doctor son and grandchildren monitor my health conditions with the help of health monitoring device. It is light weight and I always carry it with me"*.

In two similar talks the ATU14 and ATU18 showed their satisfaction with the health monitoring devices that they used by describing:

*"I am using a health monitoring device for few years and happy using it",*

*"The health monitoring device keeps me updated throughout the day"*.

The most interesting views came from ATU20 who had memory issues. His daughter brought him the Smart Caregiver in which she can record the reminders in her own voice ( Treata Smart Solutions 2015). Her voice was perceived by the participant as she was always around him. He described this situation as:

*"I had issues in remembering things, so my daughter bought me a device to manage my activities. The device prompts audio messages with the voice of my daughter. It gives me the feeling that she is always with me".*

#### 4.1.2.2 Theme 2: The Non-Happy Users

During the interviews (four out of 20) participants also showed their unhappiness with the ATs. The unhappiness was mainly associated with the consequences of AT adaptation. The most-unhappy participant was ATU6, who described his angriness as:

*"I do not like being monitored all the time and AT sometimes gives false notifications that I have fallen. Now my family believes that I am safe through this system and they spend less time with me. My friends and relatives have reduced their visits to me as well".*

The existing literature also suggest that some PWD don't like to adopt ATs as they believe these do not fulfill their requirements, compromise their privacy and result into reduced social circle.

Subtheme 1: Social Isolation and Aggression: Social isolation is amongst the critical issues associated with the PWD. The literature also indicates that in some cases the PWD who use ATs feel more isolated than others. The similar concern was raised by the ATU10 as he described the situation as:

*"Although the monitoring device helps my family to monitor my health conditions, but in fact now they are less worried about me and every day they go to their jobs. The amount of time spent with me has decreased since they bought this device"*.

The issue of social isolation was also raised by ATU6. Additionally the family members of ATU6 told the researcher that due to continuous dependence on AT, their father often becomes aggressive, which was not a problem before bringing ATs into his life.

Subtheme 2: Not Tailored to the User Needs: Another criticism about the current ATs is that often they are not tailored to the needs of the PWD. The similar concern was raised by the ATU 13 that current ATs are not tailored according to his needs rather they are more appropriate for the young people, He pointed out that:

*"Although I can use ATs for contacting people, but frankly speaking these ATs are not made for me. They are made for the young people and have difficult functions. If they are tailored as per older people needs, they can be more fun and useful for me".*

The ATU15 has similar concerns about the social websites that these are for the young people not for the older people like him:

*"I have learnt to use social websites for spending my spare time. I am fond of communication, but often these websites are difficult to use".*

The user further recommends the development of ATs that are tailored to the needs of the elderly in general and the PWD in particular.

#### 4.1.2.3 Theme 3: Technology and Human Care

During our discussions with (three out of 20) participants we noticed that although some of them were happy by using ATs, but at the same time they had some concerns as well. They emphasized the need to create balance between the use of technology and human care. The ATU3 emphasized this point as:

*"I only enjoy using the AT in the company of my grandchildren as they are very dear to me. It gives me much pleasure when my grandchildren give me more time as they are also fond of using my AT".*

The literature also supports this argument that the use of technology in combination with balanced human care can yield better results for the wellbeing of the PWD.

Figure 4.2: ATU3 Using AT Application with her Grand Children

Subtheme 1: Special Training Needed: Training regarding the use of AT is essential especially for the PWD as they are often not familiar with the use of modern technologies. The ATU11 emphasized this point as:

*"I only use the communication application on my tablet to stay in touch to my children living abroad. The functions other than calling are difficult to learn. I would prefer to learn these functions from others, as it will give me chance to see them more often"*.

The interesting thing about this point of view is that the participant thought that the training from other people will also bring him the chance to spend some time with them. This will help them to remove their social isolation as well.

### 4.1.3 Assistive Technology Scope and Categorization

Based on these characteristics of the mild dementia, this study offers insights into the usability of the current ATs based on the real life experiences of the PWD. The study further reveals that the PWD can discuss the uses of ATs and its impacts on their lives. Based on the findings of the interviews and the characteristics of the mild dementia, the ATs are categorized for further analysis. AT categorization helped to analyze the benefits and limitations of existing ATs and the requirements of the PWD for future ATs.

The existing literature shows that there are many types of ATs which provide different types of supports for the PWD. These ATs include: mobile multimedia technologies help the PWD to communicate with others (Donnelly et al. 2010), prompt technologies generate reminders to let the PWD know about doing some activity (Seelye et al. 2012), leisure technologies help in enjoyment activities (Torrington 2009) and automatic task assistance technologies help in the completion of tasks in right order (Peters et al. 2014). However, the scope of AT support for this study is limited to the ATs used by the survey participants. Based on the survey results, the ATs used by the participants are classified into three major categories: 1- communication, 2- monitoring and 3- reminders.

#### 4.1.3.1 Communication

The ATs for communication were used by 13 participants mainly for socialization and interaction with family and friends. The communication ATs used by the survey participants included different software applications installed on their smart phones, laptops, iPads and tablets etc.

The Benefits for Communication: One of the objectives of this study was to understand the advantages of ATs from the PWD point of view. Therefore, during interviews the participants were asked about the benefits they gain through the use of ATs. These benefits refer to the nature of assistance provided by the ATs in performing their daily activities.

The survey results indicated that most participants used ATs for communication and social contacts. The ATs like software applications and communication websites helped them to stay connected to their loved ones. At the same time these ATs also support leisure activities like cognitive games and paintings, pictures as memories etc.

In literature the sense of being socially isolated from rest of the society is often highlighted as a critical challenge for the PWD (Boman et al. 2014). The feeling of social isolation for the PWD is also evident from this study as well. The use of ATs for communication and socialization will help them to decrease their sense of social isolation (Meiland et al. 2014). ATs supported leisure activities are also considered important for the rehabilitation of the PWD (Torrington 2009). Therefore ATs support in these directions can be useful for the overall betterment of the PWD and they should be encouraged to use ATs for social contacts and leisure activities.

Challenges for Communication: Another objective of the study was to highlight the challenges and limitations of current from the PWD point of view. For that the participants were encouraged to talk about different challenges faced the use of ATs in their daily activities.

As far as communication ATs are concerned, the participants pointed out the small size of texts and fonts used by these ATs as a challenge for them. The small text and font size made it hard to read instruction and act upon them. Easy to use interface is also recommended by several researchers as well (Aloulou et al. 2013; Seelye et al. 2012).

For some participants the communication functionalities offered by the current ATs are rather difficult to use. They pointed out that current ATs and their functionalities are based on the needs of young people and their specific needs are not considered carefully. It is already well established fact that the needs of the PWD are different as compared to others, while current ATs are not tailored to the specific needs of elderly population in general and the PWD in particular (Cho and Lee 2016). Additionally, if the specific needs of the PWD are not tailored in ATs, then dependence on such ATs can promote aggression among them (Carrillo et al. 2009). Therefore considering the socialization and leisure needs of the PWD during AT development can yield better results and positive impacts on their lives (Leung and Lee 2005).

#### 4.1.3.2 Monitoring

The ATs for the monitoring purposes were used by nine participants. It included health reading devices, smart watches and activity monitoring systems.

The Benefits for Monitoring: Some participants used ATs for health monitoring purposes. These devices helped them to monitor their physical conditions like blood pressure, heartbeat rate, diabetes level etc. on regular basis. This continuous health monitoring helped them to adapt a healthier life style (Schikhof et al. 2010).

The smart watches also assisted users in travelling outside their homes through GPS functionalities. Furthermore, some smart watches can monitor persons' physical health conditions as well as generating alerts at detection of abnormal health conditions (McCabe and Innes 2013). The use of ATs for monitoring should be encouraged among the PWD as it will promote self-monitoring of their own health by themselves.

Challenges for Monitoring: The volume and heavy weight of smart watches used by the participants made it difficult for them to carry these all the time. Sometimes the wearing and un-wearing health monitoring devices also proved rather disturbing. The negative impacts of bulky and heavy weight smart watches are evidenced in literature as well (Lyons 2015). Therefore there is need of lightweight and small smart watches especially designed for the PWD.

Although the participants understood that monitoring systems were there for their safety, but they did not like being monitored all the time at home or outside as it affected their privacy. The privacy concerns related to monitoring are also raised by (Zhou et al. 2009). The current health monitoring ATs just monitor health conditions, but do not offer intelligent recommendations based on the health conditions. Addition of intelligent recommendations can yield better results of AT use for the PWD.

#### 4.1.3.3 Reminders

As PWD often faced cognitive challenges; two participants used ATs for reminders which helped them in their daily functioning.

The Benefits for Reminders: The reminders ATs helped the PWD family members and caregivers to set reminders for the specified times to perform important tasks. These ATs were also capable of recording audio messages and can deliver these messages as prompts on the pre-specified times. Such ATs are considered useful especially for the PWD as they often face cognitive challenges (Boger et al. 2006). The context aware ATs like HYCARE issue smart prompts and reminders based on the surrounding conditions of the PWD and can contribute to their safety and independence (Mihailidis and Fernie 2002; Du et al. 2008b).

Challenges for Reminders: The participants found learning the operations of reminders based ATs rather difficult and considered it as a challenge for getting proper benefits. The existing ATs require external support for setting reminders which is another limitation found in this study and literature as well (Martins et al. 2012b; Agree 2014). Furthermore the PWD often find the noise created by prompts as rather disturbing.

### 4.1.4 The Met and Unmet Needs of the People with Dementia

At the end of each interview the participants were asked about their specific requirements for the future ATs, which can help the developers and producers of ATs. Later on these requirements were analyzed against the ATs available in literature and commercial markets to check whether these requirements have been already implemented or not.

Most participants anticipated more user friendly interfaces from the future ATs and also requested the AT producers to make simple and easy to use functionalities. Additionally the participants further recommended tailoring the future ATs to the elderly needs.

The participants using monitoring ATs advised that the future monitoring ATs should also provide smart recommendations when they detect some abnormal health conditions. These ATs can use red alerts for making the users aware of their critical health conditions. In addition to this the future ATs should speak the health readings for elderly people to be aware of their health conditions. The AT developers should use machine learning approaches and smart algorithms to achieve these functionalities. To the best knowledge of the authors, these requirements are yet to be implemented within the discipline of ATs for the PWD and require further efforts from academia and industry. Implementation of these requirements can greatly help the PWD towards self-management of their health.

Bigger texts and larger fonts are recommended by some of the participants as these will help them in reading and following instructions easily. These requirements are partially implemented in ATs like Nourish Carer Dashboard (Nourish Care 2015) and True-Kare revolutionary telecare service (True Kare 2015).

An interesting recommendation coming from the participants was related to the development of specialized games by focusing on needs of the PWD. These specialized games can help the PWD in learning activities and adopting healthy lifestyle. These recommendations are partially implemented as currently there are few games available for the PWD like Lumosity, Dakim, Clevermind, Fit Brain Trainers, Cognifit Brain Fitness, Brain Trainer, Brain Metrix and Eidetic etc. (Nouchi et al. 2012; Huntsman 2014). Similarly the light weight smart watch recommendation is already fulfilled by (Bieber et al. 2012).

Some participants further highlighted that religion becomes more important part of their life at older age and suggested the inclusion of prayer time and religious events reminders into the future ATs. The influence of religion factor effecting the PWD is also evident from (Heese 2015). To the best of authors' knowledge, there is no work found in helping the religious activities through the use of ATs for the PWD. The development of ATs to support the religious can be a great contribution to existing body of knowledge and an excellent aid for the PWD.

Usually language understanding is also a barrier in accepting ATs; therefore the participants suggested the development of mobile applications in local languages like Urdu, Punjabi etc. The participants also advised to use the ATs in combination with human care as this combination can promote the wellbeing of the PWD. This recommendation is well supported in recent literature as it is believed that AT usage with balanced human contact can yield greater results (Asghar et al. 2017a). Other functions like voice based calling and video based training on how to operate ATs by the device itself need attention of the future researchers as well.

### 4.1.5 The Impact of Assistive Technology for the People with Dementia

The main findings of this study and the relative impacts of ATs on the lives of the PWD are summarized in Figure 4.3. The communication ATs provide improved chances of socialization through social contacts and easier interactions with other people (Doukas et al. 2011). The social interaction through ATs is considered as good as real care from the family members and caregivers (Mordoch et al. 2013). The monitoring ATs contribute to the improved safety of the PWD through decreased fear of loss and continuous monitoring of the health conditions (Meiland et al. 2014). Finally the reminders assist in the improved cognition of the PWD through decreased memory and cognition barriers (Imbeault et al. 2014).

The improved socialization, feeling of safety and enhanced cognition results into enhanced confidence and self-esteem of the PWD (Torrington 2009). It is also evident in recent literature that these supports also contribute to the quality of life for the PWD (Leroi et al. 2013; Teipel et al. 2016).

The combination of improved confidence, self-esteem and life quality motivate the PWD towards performing their daily functioning independently and contribute towards their rehabilitation (Martins et al. 2012b). In short ATs can be useful for prolonging the stay of the PWD at their own homes rather than relocating them to care homes and can save money for their families, care organizations and the Governments.

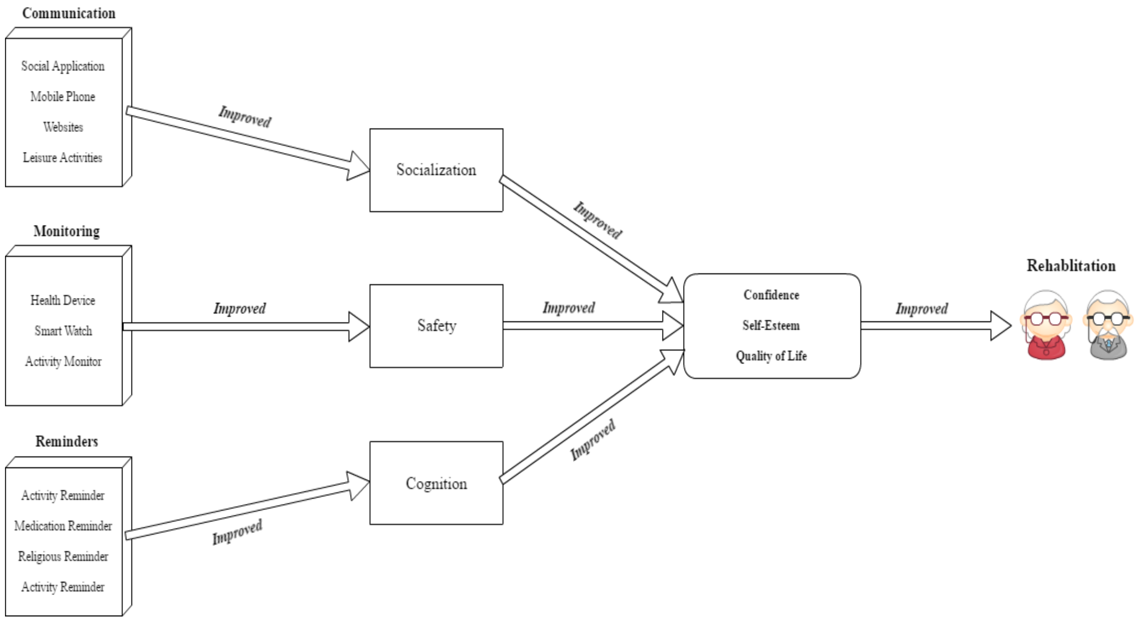


Figure 4.3: AT Support Contributing to the Rehabilitation of the PWD

### 4.1.6 Suggestions for Assistive Technology Producers

The findings of this study have established that the PWD are able to use ATs for some of their daily activities. However, the PWD have few concerns which need attention for maximizing the usability of the ATs. The key highlights of this study including interface effectiveness, simple functions, tailoring elderly needs, technology and human care combination are consistent with the current literature as often these challenges are emphasized by other researchers as well (Boman et al. 2014; Aloulou et al. 2013; Mordoch et al. 2013; Seelye et al. 2012).

The AT producers should accommodate the limitations identified in this study. It will help them in producing better quality ATs for the elderly in general and the PWD in particular. We recommend them to use to focus on user-centered approaches for AT development by involving the PWD throughout the development process. It is believed that the involvement of real users will yield their real requirements and real requirements will result into better ATs (Qadir et al. 2009). The PWD can also contribute their views during the design and development of ATs.

Moving one-step forward, the ATs should be tested through case studies by involving the PWD. These case studies will help to analyze the support and impacts of ATs on the daily activities of the PWD. These user-centered approaches will help gaining better acceptability from the PWD along with producing effective ATs. The AT effectiveness will promote AT retention for longer period of time and ultimately the high rate of AT abandonment can be decreased.

#### 4.1.7 Study limitations

One of the limitations for this study is that we were able to interview only 20 participants as the survey population was unique (the PWD who can use ATs). Additionally AT usage is not common among the older people in Pakistan, so only few older people use ATs for their daily functioning. The interviews were conducted in four major cities of Pakistan as accessing PWD who use ATs in small cities was a hard task. To generalize the results for South Asia, there is need for replicating this study in other countries of the South Asia with more number of participants.

## 4.2 The Quantitative Study for Assistive Technology Factors

The recent figures report an alarming increase in worlds' ageing population. The ageing population also leads to the increasing number of people with Alzheimer and dementia. According to 2014 statistics there are 46.8 million people affected with dementia worldwide (Pratchett 2015). The PWD often face issues in carrying out daily activities. Dementia has a strong impact on care costs, mortality rate and the lives of the carers and family members of the PWD (Association 2016). Additionally 96% of clinical trials from 2002 to 2012 for dementia treatments resulted into failures (Cummings et al. 2014). The ATs are now seen as an alternate to help and support the PWD, therefore in an ageing society, it is important to develop such ATs that can support them in their daily activities and enhance their independent living capacity (Martins et al. 2012b).

To accommodate this situation there is ever growing in the development and implementation of AT for the PWD. By acknowledging the importance of this matter, now governments are investing and companies are producing ATs on a large scale (Asghar et al. 2017a). It is common to see the PWD using ATs in their homes and outside environments. These ATs offer various types and functionalities. The commonly used ATs include socially assistive robots (Wu et al. 2013), smart walkers (Martins et al. 2012b), health information technologies (Fischer et al. 2014), mobile multimedia technologies (Donnelly et al. 2010; Boman et al. 2014), prompting technologies (Seelye et al. 2012), activity and night time monitoring technologies (Meiland et al. 2014; Rowe et al. 2009), electronic memory aids (Imbeault et al. 2014), leisure technologies (Torrington 2009), tele-care technologies (Leroi et al. 2013), GPS enabled technologies (McCabe and Innes 2013), automatic task assistance technologies (Peters et al. 2014), patient care technologies (Tung et al. 2013), software based technologies (Zhang et al. 2014), assisted living homes (Aloulou et al. 2013) and many more.

### 4.2.1 Assistive Technology Abandonment

Although many PWD use the ATs and are dependent on them, with advancements in other technologies their expectations from the ATs are also on rise. This situation contributes to a high rate of AT abandonment by the PWD (Evans and Johnston 2005). The possible reasons for abandoning the use of AT include: gaps between user requirements and AT functionalities, difficult usage and diverse user preference (Beigel 2000). AT abandonment is common among users, particularly when it does not promote better quality of life and too much use of AT may bring aggression among older adults as they feel fully dependent on these technologies (Carrillo et al. 2009). The PWD also fear social isolation by relying on AT, because they fear that their carers or family members will reduce the visits to them (Boman et al. 2014). Some recent research also highlights that although the current ATs support some daily life activities for the PWD, but their functionalities and impact are usually limited to safety only (Teipel et al. 2016). In addition to these issues the *"technological discomfort, privacy or security concerns, lack of relative advantage, and perceived distance from the user representation"* are also considered as barriers to technology adaptation (Young et al. 2014). All these facts lead to a high level of social and economic loss as the ATs usually involve big investments (Carvalho et al. 2014).

### 4.2.2 Potential Assistive Technology Abandonment Solution

As a potential solution to AT abandonment challenges discussed above the researchers have highlighted the importance to conduct empirical studies to evaluate the important factors for AT use, that impacts the lives of the PWD (Span et al. 2013; Van Hoof et al. 2010; Imbeault et al. 2014). The usability evaluation studies by directly contacting the

PWD can also be useful for enhancing the quality of future ATs (Wherton and Monk 2008).

There are few AT evaluation empirical studies available in literature. In an empirical study (Engström et al. 2006), the opinion of the relatives of the PWD was investigated regarding AT support. 22 participants were used for the experiments and two questionnaires were completed from them. The relatives showed a positive view about the AT use for the wellbeing of the PWD. Another study (Engström et al. 2005) investigated the staff members' satisfaction with AT usage for the PWD. The study also used questionnaires to collect data from 33 staff members. Data was collected before and six months after the implementation of AT support at the nursing home. The AT used include activity monitoring, alarms, internet and fall detectors. The overall results showed that the use of AT significantly improved the job satisfaction of the staff members with their work. In a similar study (Engström et al. 2009) the researchers investigated staff members' perception of Information and Communication Technology (ICT) used for the PWD. They conducted interviews with 14 staff members before, during and after ICT implementation. The considered ICT include communication technology, fall detector, alarms and computers. At start staff members have diverse perceptions, but after the ICT implementation most of the perceptions were on the positive side.

The use of an automated prompt system was analyzed by involving eight participants with dementia in 60 trials. The results showed that the PWD were able to complete more steps with the help of a prompt system. Such AT could help reduce the number of interaction required between the PWD and their caregivers (Labelle and Mihailidis 2006). Another study investigated the use of a prompter in hand washing activity by involving six participants with dementia. The results showed that the PWD completed

11% more steps independently with the help of the prompter. Additionally the number of interactions with the caregivers were also reduced by 60% (Mihailidis et al. 2008). The spoken dialogue interface provided intelligent cognitive support to PWD by detecting deviation from routine activities by focusing on task at hand (Wolters et al. 2016). The wondering problem was investigated by testing the Global Positioning System (GPS) device with the PWD and asking their future needs through a case study. The results showed that although the participants appreciated the use of GPS but their concerns were related to the shape and volume of the device (Faucounau et al. 2009).

The most comprehensive work in this field came from the Australian researchers who used a systematic review to identify empirical studies on AT use for the PWD (Fleming and Sum 2014). There extensive search efforts enabled them to identify 178 potentially relevant studies. The evaluation criteria excluded 142 studies. The remaining 32 studies received validity assessment using the approach from (Forbes 1997). The results show only eight studies as strongly relevant, nine studies as moderately and 19 studies as weakly relevant. However, the deep analysis of these shortlisted studies further indicate that only small empirical evidence of supporting the PWD through AT exist. The researchers concluded: there was still a high rate of non-acceptance of ATs, existing ATs were often unreliable and just made little difference to practical outcomes and there was critical need of better designed empirical studies based on large samples.

Further literature investigation showed that although some empirical studies were conducted recently, but their focused population was different (school children, people with disabilities, caregivers etc.). Recently, another study performed an empirical investigation based on 8 factors and 67 variables to measure AT practices from school students and their teachers (Seok and DaCosta 2014).

To the best of authors knowledge there are no empirical studies carried out in the South Asian region for evaluating AT usability from the PWD. South Asia is an important part of the world as it holds more than 25% of world's population (Rasul 2014). In 2013, Delphi consensus study reported that there was an annual 1.9% increase in the dementia population in the South Asia region, South Asia had over 4.5 million PWD (Prince et al. 2013). This alarming increase in the dementia population emphasizes the need to find alternative ways for the wellbeing of the PWD. Empirical studies can contribute towards understanding AT advantages, limitations and future needs of the PWD.

### 4.2.3 Study Objectives

The main purpose of this study is to analyse the impact of ATs in supporting the PWD by exploring the relative importance of the contributing Assistive Technology Factors (ATF). This study contributes to the body of knowledge by filling a number of research gaps in existing literature i.e. identification of new factors important for AT usability (Seok and DaCosta 2014), the relevant impact of these factors for AT effectiveness and long term retention (Span et al. 2013). Additionally this study also contributes for the identification of the requirements for future AT from the PWD (Wolters et al. 2016). The most important contribution is the application of the user centric approach throughout the research process as recommended by (Schikhof et al. 2010; Conway et al. 2016).

### 4.2.4 Results and Discussion

The statistical results are generated using SPSS. The data analysis part include demographic/characteristic information of the survey respondents, factor analysis, factor ranking and future requirements from AT for people with dementia. Table 3.2 in the previous chapter showed the demographic and characteristics properties of the survey respondents.

#### 4.2.4.1 Descriptive Statistics

Before factor analysis, it is useful to know descriptive statistics for better understanding of the gathered data. The basic results for all the 327 survey participants are presented in table 4.2. The descriptive statistics presented in table 4.2 include indicators like: minimum, maximum, mean and standard deviation (S.D) values for each variable.

Mean is one of the most popular, well known and valid measure of central tendency and often called the average. It is a single value that goes to describe a set of data by identifying the central position in the data set. It can also represent that where the data/distribution would balance. The mean can have sensitive to extreme values. In table 3, the mean values for all variables ranges from 3.04 to 3.76. The extreme mean values 3.04 and 3.76 belong to variables "AT usage learning process can be completed without depending on others" and the "AT is adaptable to my personality" respectively.

As the data contain values from 1 to 5, we can say that the variable values lay in between these ranges. Most of the variables have mean values from 3.21 to 3.39 and some have same values. Therefore, we can say that the values lay in between this range represent the central location of the given data set.

The last column of the table shows the S.D of the data. The S.D is an important measure of dispersion that provides the idea about how far the response values in the data set deviate from the mean. It is the positive square root of the variance and also known as root mean square deviation. If the value of S.D is small compared with mean, it means that the values are grouped strongly or cluster closely around the mean and the large value of S.D indicates that the values are scattered or far from the mean. Also we can check how the values are above and low the mean through $\bar{x} \pm S$ and it should covers the 68% of the values in the data and twice average difference from mean with the help of $\bar{x} \pm 2S$ and covers 95% values and so on(Bland and Altman 1996).

Table 4.2: Descriptive Statistics for Survey Variables

| Q. No | Survey Items | Min | Max | Mean | S.D |
|---|---|---|---|---|---|
| Q01 | The operation and maintenance instruction book spells out all maintenance routines | 1 | 5 | 3.65 | 1.114 |
| Q02 | The AT functions as claimed by the manufacturer | 1 | 5 | 3.66 | 1.005 |
| Q03 | Operation and maintenance manuals are included with the AT | 1 | 5 | 3.51 | 1.009 |
| Q04 | The operation and maintenance instructions are effective | 1 | 5 | 3.43 | 1.048 |
| Q05 | The AT provides environmental control | 1 | 5 | 3.30 | 0.989 |
| Q06 | The AT provides sensorial support | 1 | 5 | 3.19 | 1.037 |
| Q07 | The AT helps me carrying out daily activities independently without external physical support | 1 | 5 | 3.33 | 1.088 |
| Q08 | The AT provides mobility support | 1 | 5 | 3.34 | 1.059 |
| Q09 | By using the AT I feel safer and secure in carrying out routine activities | 1 | 5 | 3.57 | 1.057 |
| Q10 | The AT helps me to improve my self-esteem | 1 | 5 | 3.25 | 1.067 |
| Q11 | By using the AT the complexity of tasks decreases | 1 | 5 | 3.27 | 1.030 |
| Q12 | The AT helps to improve my cognitive abilities | 1 | 5 | 3.34 | 1.081 |
| Q13 | The AT helps me for more communication opportunities | 1 | 5 | 3.43 | 1.040 |
| Q14 | The AT helps me to have interaction with other people | 1 | 5 | 3.43 | 1.060 |
| Q15 | The AT helps me to get formal support through interaction with others | 1 | 5 | 3.53 | 1.126 |
| Q16 | The AT enables me to develop social networks | 1 | 5 | 3.36 | 1.093 |
| Q17 | The AT is adaptable to my personality | 1 | 5 | 3.76 | 1.032 |
| Q18 | The AT is adaptable to my life style | 1 | 5 | 3.74 | 1.082 |
| Q19 | The AT influences my dietary style | 1 | 5 | 3.64 | 1.098 |
| Q20 | The AT is compatible with my cultural beliefs | 1 | 5 | 3.54 | 1.047 |
| Q21 | There is no need to take any external help for using AT | 1 | 5 | 3.33 | 1.106 |
| Q22 | The use of AT decrease my dependence on others | 1 | 5 | 3.29 | 1.112 |
| Q23 | I can use AT on my own without the help of others | 1 | 5 | 3.07 | 1.158 |
| Q24 | The AT usage learning process can be completed without depending on others | 1 | 5 | 3.04 | 1.106 |

| | | | | | |
|---|---|---|---|---|---|
| Q25 | The price and maintenance of the AT is appropriate | 1 | 5 | 3.59 | 1.112 |
| Q26 | There are warranties with the AT | 1 | 5 | 3.33 | 1.155 |
| Q27 | The AT is dependable | 1 | 5 | 3.15 | 1.020 |
| Q28 | I can easily handle AT maintenance | 1 | 5 | 3.22 | 1.094 |
| Q29 | I can sustain my attention while using AT | 1 | 5 | 3.11 | 1.093 |
| Q30 | The angle and visual distance of AT is appropriate | 1 | 5 | 3.17 | 1.117 |
| Q31 | I was able to learn to use the AT during the orientation | 1 | 5 | 3.26 | 1.108 |
| Q32 | I have sufficient technology literacy to use the AT | 1 | 5 | 3.24 | 1.219 |
| Q33 | The AT is useful for selecting travel destinations | 1 | 5 | 3.05 | 1.139 |
| Q34 | The AT enables me to manage travel plans | 1 | 5 | 3.34 | 1.044 |
| Q35 | The AT is useful for travel activities | 1 | 5 | 3.39 | 0.966 |
| Q36 | The AT helps me during travel | 1 | 5 | 3.21 | 1.142 |
| Q37 | The use of AT has improved my achievements | 1 | 5 | 3.22 | 1.104 |
| Q38 | The AT meets my needs | 1 | 5 | 3.20 | 1.050 |
| Q39 | The interface of the AT is effective | 1 | 5 | 3.47 | 1.062 |
| Q40 | The AT helps me to become more independent | 1 | 5 | 3.40 | 1.048 |
| Q41 | I can independently go through all start-up and diagnostic routines | 1 | 5 | 3.61 | 1.132 |
| Q42 | It is reasonable to expect from me to carry out some of the repairs | 1 | 5 | 3.69 | 1.076 |
| Q43 | The AT is likely to become obsolete in the near future due to compatibility problems with new devices | 1 | 5 | 3.56 | 1.072 |
| Q44 | The AT is appropriate for future use | 1 | 5 | 3.49 | 1.082 |
| Q45 | The use of AT is cost effective | 1 | 5 | 3.32 | 1.094 |

The table values for S.D are shown for each survey item, which ranges from 0.966 to 1.219. Two variables the “AT is useful for travel activities” and the “AT provides environmental control” has smallest value of S.D 0.966 and 0.989 corresponding to the mean values 3.39 and 3.30. It means that these variables are more closely clustered or grouped around the mean rather than the rest of other variables. The variable, “I have sufficient technology literacy to use the AT” have S.D 1.219 with the mean value 3.24 indicates more deviation from the mean.

#### 4.2.4.2 Assistive Technology Factors Identification for the People with Dementia

The factor analysis results are shown in Table 4.3. The two items with the factor loading scores less than .40 are removed after running the factor analysis, the remaining values ranges from .514 to .729, which shows that these item meets the minimum requirements.

Table 4.3 also shows the results for total variance including eigenvalues, percentage of variance and cumulative percentage. The term ATF is used for Assistive Technology Factor. The eigenvalues for each factor show variance explained by that component. After rotation the ATF1 (operational support) accounts for (8.414%) of the variance, while the remaining factors account for: ATF2 (physical support) (6.388%), ATF3 (psychological support) (4.983%), ATF4 (social support) (4.914%), ATF5 (cultural match) (4.775), ATF6 (reduced external help) (4.526%), ATF7 (affordability) (4.506%), ATF8 (travel help) (4.383%), ATF9 (compatibility) (4.059%), ATF10 (effectiveness) (3.816%) and ATF11 (retention) (3.740%). The total variance gained is 54%, which is well above the acceptable limit of 40% (Dunteman, 1989). The factor analysis resulted into 11 factors.

Table 4.3: Identifying the Underline Factors Using Rotated Component Matrix

| Factors | Survey Items | Factor Loading | Factor Mean | S.D | Eigenvalue | % of Variance | Cumulative % | Cronbach's Alpha |
|---|---|---|---|---|---|---|---|---|
| (ATF1) AT Operational Support | The operation and maintenance instruction book spells out all maintenance routines | .656 | 3.56 | 1.044 | 3.702 | 8.414 | 8.414 | 0.906 |
| | The AT functions as claimed by the manufacturer | .646 | | | | | | |
| | Operation and maintenance manuals are included with the AT | .637 | | | | | | |
| | The operation and maintenance instructions are effective | .572 | | | | | | |
| (ATF2) AT Physical Support | The AT provides environmental control | .628 | 3.29 | 1.043 | 2.811 | 6.388 | 14.801 | 0.904 |
| | The AT provides sensorial support | .571 | | | | | | |
| | The AT helps me carrying out daily activities independently without external physical support | .557 | | | | | | |
| | The AT provides mobility support | .471 | | | | | | |
| (ATF3) AT Psychological Support | By using the AT I feel safer and secure in carrying out routine activities | .765 | 3.36 | 1.059 | 2.192 | 4.983 | 19.784 | 0.907 |
| | The AT helps me to improve my self-esteem | .664 | | | | | | |
| | By using the AT the complexity of tasks decreases | .531 | | | | | | |
| | The AT helps to improve my cognitive abilities | .521 | | | | | | |
| (ATF4) AT Social Support | The AT helps me for more communication opportunities | .675 | 3.44 | 1.079 | 2.162 | 4.914 | 24.699 | 0.904 |
| | The AT helps me to have interaction with other people | 618 | | | | | | |
| | The AT helps me to get formal support through interaction with others | .593 | | | | | | |
| | The AT enables me to develop social networks | .490 | | | | | | |
| (ATF5) AT Cultural Match | The AT is adaptable to my personality | 706 | 3.67 | 1.065 | 2.101 | 4.775 | 29.474 | 0.906 |
| | The AT is adaptable to my life style | .695 | | | | | | |
| | The AT is compatible with my cultural beliefs | .606 | | | | | | |
| | | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (ATF6) Reduced External Help | There is no need to take any external help for using AT | .806 | 3.18 | 1.121 | 1.991 | 4.526 | 34.000 | 0.906 |
| | The use of AT decrease my dependence on others | .754 | | | | | | |
| | I can use AT on my own without the help of others | .600 | | | | | | |
| | The AT usage learning process can be completed without depending on others | .756 | | | | | | |
| (ATF7) AT Affordability | The price and maintenance of the AT is appropriate | .719 | 3.32 | 1.095 | 1.983 | 4.506 | 38.505 | 0.905 |
| | There are warranties with the AT | .709 | | | | | | |
| | The AT is dependable | .471 | | | | | | |
| | I can easily handle AT maintenance | .426 | | | | | | |
| | use of AT is cost effective | .421 | | | | | | |
| (ATF8) AT Travel Help | The AT is useful for selecting travel destinations | .756 | 3.25 | 1.072 | 1.786 | 4.383 | 42.888 | 0.907 |
| | The AT enables me to manage travel plans | .650 | | | | | | |
| | The AT is useful for travel activities | .496 | | | | | | |
| (ATF9) AT Compatibility | I can sustain my attention while using AT | .559 | 3.20 | 1.134 | 1.929 | 4.059 | 46.948 | 0.904 |
| | The angle and visual distance of AT is appropriate | .558 | | | | | | |
| | I was able to learn to use the AT during the orientation | .471 | | | | | | |
| | I have sufficient technology literacy to use the AT | .466 | | | | | | |
| (ATF10) AT Effectiveness | The use of AT has improved my achievements | .692 | 3.32 | 1.066 | 1.679 | 3.816 | 50.764 | 0.904 |
| | The AT meets my needs | .662 | | | | | | |
| | The interface of the AT is effective | .482 | | | | | | |
| | The AT helps me to become more independent | .453 | | | | | | |
| (ATF11) AT Retention | I can independently go through all start-up and diagnostic routines | .672 | 3.59 | 1.091 | 1.646 | 3.740 | 54.504 | 0.890 |
| | It is reasonable to expect from me to carry out some of the repairs | .564 | | | | | | |
| | The AT is likely to become obsolete in future due to compatibility problems with new devices | .435 | | | | | | |
| | The AT is appropriate for future use | .422 | | | | | | |

Figure 4.4 shows the names given to these factors through the help of literature by considering the scope of our study. The next section describes details of each factor by explaining its purpose, the survey items used and their importance from the literature.

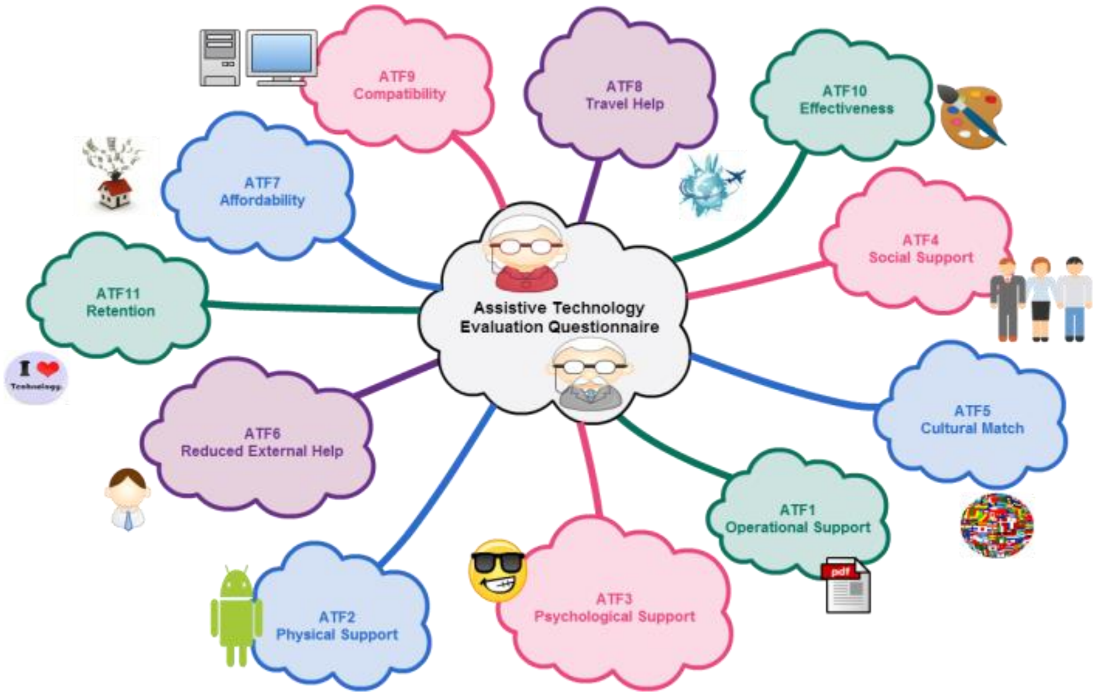


Figure 4.4: AT Factors Named in the Study

ATF1 (AT Operational Support): AT Operational support is an important factor for AT acceptance and retention. It means there are feasible conditions in place for the successful implementation of AT. AT Operational support factor basically focus on operational services by the manufacturers and relevant manuals (Bryant et al. 2010). This factor is based on four the items which are adopted from (Bryant et al. 2010; Seok and DaCosta 2014). These items include: operations and maintenance manuals, instruction book based on maintenance routines, effectiveness of operations instructions and functioning of AT as claimed by the manufacturer.

ATF2 (AT Physical Support): AT physical support means the AT devices help in mobility and assistance to the users for performing physical activities and moving from one place to another independently. Another study describes physical support provided by AT as a great contribution towards rehabilitation of the people with dementia and disabilities (Martins et al. 2012b). This factor is based on four items developed by the authors: mobility support, environmental control, sensorial support and carrying out daily activities.

ATF3 (AT Psychological Support): Supporting the PWD psychologically is one of the key elements for AT success. Psychological support means AT assistance in encouraging the AT users helping them psychologically by increasing their self-esteem and confidence (Henderson et al. 1989). According to Torrington, the psychological support play an important role in perusing the PWD to use AT for performing different activities which otherwise they are reluctant to perform (Torrington 2009). This factor is based on four items developed by the authors: improved self-esteem, improve cognitive abilities, decreasing complexity of tasks and feeling of safety.

ATF4 (AT Social Support): AT social support refers to the AT assistance in enabling the PWD to have easy social interaction. Various researchers highlights the level of social support provided by AT as a contributing mean towards AT acceptance by the PWD and its success (Doukas et al. 2011; Mordoch et al. 2013; Wu et al. 2013). This factor is based on four items developed by the authors: communication opportunities, interaction with other people, help in social networks and getting formal support through interaction.

ATF5 (AT Cultural Match): According to (Torrington 2009) the combination on AT with cultural context is also another important area of research for the wellbeing of PWD. AT cultural support mean its adaptability to adapt to different cultural aspects of the users. This factor is based on three items developed by the authors: AT adaptability to the user life style and personality and compatibility with cultural beliefs.

ATF6 (Reduced External Help): This factor relates to AT reliability on others (people, devices etc.). This reliability can be in the form of maintenance, functioning or running of that AT device. If a user is dependent on other people for functioning it, then it becomes harder to promote independence for that user. Such AT that help in reducing external help needed, will be more successful and will be retained for longer period. This factor is based on four items adopted from (Seok and DaCosta 2014): start-up and diagnostics, installation and assembling, requirement of other tools or devices.

ATF7 (AT Affordability): This factor is based on the cost of AT devices. Usually the users compare AT devices for their cost and respective advantages through their usage. According to (Gelderblom and de Witte 2002), affordability is a combination of AT device maintenance, warranties and constancy. This factor is based on five items adopted from (Gelderblom and de Witte 2002): appropriate price, warranties, dependability and maintenance of AT and cost effectiveness.

ATF8 (AT Travel Help): Another interesting area for the wellbeing of the PWD is helping them in travel through the use of AT. Recently researchers started to focus on tourism and leisure as a beneficial activity for the PWD. It creates healthy lifestyle and helps them to remain active, which in turn slows down the progress of dementia (Page et al. 2014; Innes et al. 2015). This factor is based on the three items developed by the authors: travel help, selection of travel destinations and managing travel plans.

ATF9 (AT Compatibility): AT compatibility is its ability to fit with user's strengths. According to (Bryant et al. 2002) AT devices are usually used to compensate for the people if they have some disability or challenges in doing some activities. Almost all AT devices require having some sort of training for the users for more effective usage. This factor is based on four items adopted from (Seok and DaCosta 2014): sustaining attention while using AT, learning through orientation, technology literacy, proper angle and visual of AT device.

ATF10 (AT Effectiveness): Effectiveness is often cited as the most important element for AT adaptation and retention. AT effectiveness is its consistency with increasing users' achievements and meeting their needs. According to (Hoenig et al. 2003) AT effectiveness is the primary goal and key factor of AT practices. This factor is based on four items adopted from (Seok and DaCosta 2014). AT help in increasing user achievements, meeting user need, effective user interface, and user independence.

ATF11 (AT Retention): AT retention refers to the effective lifetime of an AT device (Seok and DaCosta 2014). The effective lifetime of a device influence the users' intention to purchase that device and recommend it to others. This factor is based on four items adopted from (Seok and DaCosta 2014): AT appropriate for future use, compatibility with new devices, repairs and diagnostic routines.

#### 4.2.4.3 Factors Impact on Assistive Technology Effectiveness and Retention

This section focuses on analysing the impact of different factors on AT effectiveness and retention by using linear regression. As literature indicate that the PWD often abandon the use of AT, the relative impact of different factors will help to understand which factors can help to minimize AT abandonment rate.

The results are shown in Table 4.4. In the model summary, the $R^2$ value indicates that 51.2% and 33.4% of the variability in average AT effectiveness and AT retention can be explained by all the AT factors respectively. The F test has high significant values which indicate that there is a linear relationship between the variables for both models which show that the models are best fit for both AT effectiveness and AT retention.

Table 4.4: Overall Factor Ranking for AT Effectiveness and Retention Using Linear Regression

| Factors | ATF 10 (AT Effectiveness) | | | ATF 11 (AT Retention) | | |
|---|---|---|---|---|---|---|
| | β | t | P | B | t | P |
| ATF1 (operational) | 0.74 | 1.621 | .106 | -.023 | -.438 | .661 |
| ATF2 (physical) | .132 | 2.749 | .006** | .011 | .190 | .850 |
| ATF3 (psychological) | .277 | 6.007 | .000*** | .095 | 1.770 | .078 |
| ATF4 (social) | .344 | 7.377 | .000*** | -.020 | -.363 | .717 |
| ATF5 (cultural) | .023 | .507 | .613 | .136 | 2.618 | .009** |
| ATF6 (reduced external help) | .066 | 1.479 | .140 | .238 | 4.551 | .000*** |
| ATF7 (affordability) | .061 | 1.306 | .193 | .140 | 2.569 | .011* |
| ATF8 (travel help) | .027 | .583 | .560 | .209 | 3.818 | .000*** |
| ATF9 (compatibility) | .064 | 1.375 | .170 | .091 | 1.676 | .095 |
| Model Summary | | | | | | |
| | R | $R^2$ | Adjusted $R^2$ | S.E | F | **P** |
| ATF10 (effectiveness) | .715[a] | .512 | .498 | .586 | 36.927 | .000*** |
| ATF11 (retention) | 578[a] | .334 | .315 | .637 | 17.654 | .000*** |

Note: p<.001*** = highly significant, p< (.01** & .05*) = significant

According to the results for AT effectiveness there are two factors with high significant impact including ‘AT psychological support’ (.000***) and ‘AT social support’ (.000***) with $p<.001$ values. It means that these factors have high significant impact on AT effectiveness as compared with the rest of the factors. Additionally the ‘AT physical support’ (.006**) represents significant impact on AT effectiveness with $p<0.01$.

The results for AT Retention also have two factors with very significant impact including ‘Reduced external help’ (.000***) and ‘AT travel help’ (.000***) and two factors with significant impact including ‘AT culture match’ (.009**) and ‘Affordability’ (.011*).

From the results we conclude that the ‘AT psychological support’, ‘AT physical support’, ‘Reduced external help’ and ‘AT travel help’ factors have dominating impact on AT effectiveness and retention.

#### 4.2.4.4 Normality of the Overall Factors

As per study demand the factors identified through factor analysis are ranked for the overall survey results. Furthermore these factors are also ranked for different demographic/characteristics information of the survey respondents. Before such analysis take place the data need to be tested for what method should be adopted for testing factors against different sets of data. Usually t-test is used in situations when data follows a normal distribution. Otherwise if data does not follow normal distribution, some nonparametric method should be adopted for the analysis.

In case of data gathered on Likert scale, the data is ordinal rather than interval and such data usually does not follow normal distribution (Hinton P. R. et al. 2014). For the current study the data set is smaller than 2000 values, so the Shapiro Wilk test is more appropriate. As the 1st step we check the normality of all AT factors for all the responses of the survey. The values of Shapiro Wilk test in table 4.5 indicate that all the AT factors have significant values ($p < .001$). It means the data set in this study are not normally distributed. Therefore, to check the difference between different groups of data, some non-parametric tests are used instead of sample t test.

Table 4.5: Shapiro-Wilk Test for Overall Factors

| Factors | Shapiro-Wilk | | |
|---|---|---|---|
| | Statistic | Df | Sig. |
| ATF1 (operational) | .853 | 327 | .000*** |
| ATF2 (physical) | .832 | 327 | .000*** |
| ATF3 (psychological) | .841 | 327 | .000*** |
| ATF4 (social) | .853 | 327 | .000*** |
| ATF5 (cultural) | .874 | 327 | .000*** |
| ATF6 (reduced external help) | .874 | 327 | .000*** |
| ATF7 (affordability) | .856 | 327 | .000*** |
| ATF8 (travel help) | .858 | 327 | .000*** |
| ATF9 (compatibility) | .823 | 327 | .000*** |
| ATF10 (effectiveness) | .841 | 327 | .000*** |
| ATF11 (retention) | .846 | 327 | .000*** |

Overall Normality of Assistive Technology Factors for Effectiveness: Now we will test the normality of data for AT Effectiveness and AT Retention. As we are aware that the data set contains 327 which indicate less than 2000 samples, so we only consider the Shapiro Wilk test values for testing the normality of the data and Kolmogorov Smirnov test values are omitted. The table 4.6 shows the results for Shapiro Wilk test for normality with regard to AT Effectiveness.

Here the Shapiro Wilk test values show that all the factor levels have significant values ($p<0.05$) on the dependent factor AT Effectiveness, but Strongly Disagree level of ATF6 (.683), ATF8 (.272) and ATF9(.406) as well as Disagree level for ATF8 (.272) have insignificant value ($p>0.05$) that do not have much impact on testing the normality of data set. So we can say that all these factors are asymptotically non-normal on the dependent factor AT Effectiveness.

Table 4.6: Shapiro-Wilk Test for Normality (AT Effectiveness)

| Factors | ATF10 (Effectiveness) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Strongly Disagree | | | Disagree | | | Neutral | | | Agree | | | Strongly Agree | | |
| | Statistic | df | Sig. | Statistic | Df | Sig. | Statistic | df | Sig. | Statistic | df | Sig. | Statistic | df | Sig. |
| ATF1 (operational) | - | - | - | .915 | 27 | .030* | .847 | 146 | .000*** | .779 | 131 | .000*** | .697 | 21 | .000*** |
| ATF2 (physical) | .750 | 3 | .000*** | .875 | 21 | .012* | .859 | 107 | .000*** | .782 | 172 | .000*** | .717 | 24 | .000*** |
| ATF3 (psychological) | - | - | - | .783 | 18 | .001** | .834 | 118 | .000*** | .700 | 162 | .000*** | .660 | 27 | .000*** |
| ATF4 (social) | - | - | - | .839 | 17 | .007** | .854 | 81 | .000*** | .746 | 167 | .000*** | .778 | 60 | .000*** |
| ATF5 (cultural) | .684 | 5 | .006** | .857 | 45 | .000*** | .811 | 135 | .000*** | .817 | 124 | .000*** | .752 | 18 | .000*** |
| ATF6 (reduced external help) | .945 | 4 | .683 | .901 | 53 | .000*** | .854 | 119 | .000*** | .764 | 132 | .000*** | .803 | 19 | .001** |
| ATF7 (affordability) | - | - | - | .909 | 42 | .003** | .800 | 124 | .000*** | .811 | 142 | .000*** | .688 | 18 | .000*** |
| ATF8 (travel help) | .863 | 4 | .272 | .863 | 4 | .272 | .843 | 87 | .000*** | .805 | 162 | .000*** | .776 | 55 | .000*** |
| ATF9 (compatibility) | .895 | 4 | .406 | .836 | 23 | .002** | .823 | 129 | .000*** | .817 | 158 | .000*** | .766 | 13 | .003** |

a. Lilliefors Significance Correction

b. Effectiveness is constant when ATF1, ATF3, ATF4, ATF7 = Strongly Disagree. It has been omitted

Table 4.7: Shapiro-Wilk Test for Normality (AT Retention)

| ATF11 (Retention) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Factors | Strongly Disagree | | | Disagree | | | Neutral | | | Agree | | | Strongly Agree | | |
| | Statistic | df | Sig. | Statistic | Df | Sig. | Statistic | df | Sig. | Statistic | df | Sig. | Statistic | df | Sig. |
| ATF1 (operational) | - | - | - | .859 | 27 | .002** | .854 | 146 | .000*** | .809 | 131 | .000*** | .744 | 21 | .000*** |
| ATF2 (physical) | .750 | 3 | .000*** | .860 | 21 | .006** | .838 | 107 | .000*** | .808 | 172 | .000*** | .814 | 24 | .001** |
| ATF3 (psychological) | - | - | - | .860 | 18 | .012* | .854 | 118 | .000*** | .787 | 162 | .000*** | .860 | 27 | .002** |
| ATF4 (social) | - | - | - | .845 | 17 | .009** | .850 | 81 | .000*** | .822 | 167 | .000*** | .801 | 60 | .000*** |
| ATF5 (cultural) | .771 | 5 | .046* | .828 | 45 | .000*** | .812 | 135 | .000*** | .801 | 124 | .000*** | .818 | 18 | .003** |
| ATF6 (reduced external help) | .863 | 4 | .272 | .894 | 53 | .000*** | .835 | 119 | .000*** | .770 | 132 | .000*** | .740 | 19 | .000*** |
| ATF7 (affordability) | - | - | - | .864 | 42 | .000*** | .840 | 124 | .000*** | .793 | 142 | .000*** | .789 | 18 | .001** |
| ATF8 (travel help) | .729 | 4 | .024* | .884 | 19 | .025* | .850 | 87 | .000*** | .774 | 162 | .000*** | .825 | 55 | .000*** |
| ATF9 (compatibility) | .630 | 4 | .001** | .796 | 23 | .000*** | .860 | 129 | .000*** | .767 | 158 | .000*** | .867 | 13 | .048* |

a. Lilliefors Significance Correction
b. Retention is constant when ATF1, ATF3, ATF4, ATF7 = Strongly Disagree. It has been omitted.

Overall Normality of Assistive Technology Factors for Retention: Similarly the table 4.7 shows results of Shapiro-Wilk Test for Normality with regard to AT Retention. Here the Shapiro Wilk test values show that all the factor levels have significant values ($p<0.05$) on the dependent factor AT Retention, but Strongly Disagree level of ATF6 (.272) has insignificant value ($p>0.05$) that does not have much impact on testing the normality of the data set. So we can say that all these factors are asymptotically non-normal on the dependent factor AT Retention.

#### 4.2.4.5 Testing the Significant Difference among Dependent and Independent Groups through Kruskal Wallis H Test

The Mean Rank of the ATF10 (AT Effectiveness) for each level of the independent factors (ATF1 to ATF9) can be used to compare the effect of the different levels of these factors. The Kruskal Wallis H test results are present to check whether these levels of AT factors have different Effectiveness. The results are shown in table 4.8.

The p-value is .000 ($p<0.05$) indicates that there is statistically significant difference in the AT Effectiveness of the depending on the respondent answers of these factors. By seeing the highest chi-square values, we can also find the impact of these factors on the dependent factor. Here, the highest chi square values of ATF3 and ATF4 are 96.325 and 102.020 with corresponding impact of 29.55% and 31.29% respectively. It means that, 29.55% and 31.29% of the variability in AT Effectiveness was accounted for by the factors ATF3 and ATF4 as respondent answers respectively.

Similarly the Mean Rank of the ATF11 (AT Retention) for each level of the independent factors (ATF1 to ATF9) can be used to compare the effect of the different levels of these factors. The Kruskal Wallis H test results are present to check whether these levels of AT factors have different impact on AT Retention.

Table 4.8: Kruskal Wallis H test for Effectiveness

| | | ATF10 (Effectiveness) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | ATF1 (operational) | ATF2 (physical) | ATF3 (psychological) | ATF4 (social) | ATF5 (cultural) | ATF6 (reduced) | ATF7 (affordability) | ATF8 (travel) | ATF9 (compatibility) |
| Mean Rank | Strongly Disagree | 17.50 | 48.00 | 9.75 | 71.00 | 148.10 | 89.75 | 17.50 | 76.38 | 85.88 |
| | Disagree | 82.04 | 74.64 | 93.03 | 57.24 | 116.41 | 127.85 | 110.40 | 109.24 | 91.83 |
| | Neutral | 153.27 | 137.16 | 118.81 | 105.34 | 153.59 | 156.75 | 146.28 | 123.86 | 147.50 |
| | Agree | 190.74 | 184.38 | 192.44 | 184.07 | 182.72 | 180.18 | 189.71 | 184.12 | 185.10 |
| | Strongly Agree | 191.55 | 230.31 | 249.57 | 220.68 | 236.50 | 213.47 | 216.47 | 193.53 | 223.00 |
| Kruskal Wallis Test | Chi-Square | 47.741 | 62.867 | 96.325 | 102.020 | 34.812 | 24.307 | 44.146 | 46.456 | 40.136 |
| | Df | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| | Asymp. Sig. | .000*** | .000*** | .000*** | .000*** | .000*** | .000*** | .000*** | .000*** | .000*** |

a. Kruskal Wallis Test
b. Grouping Variable: ATF1 to ATF9

Table 4.9: Kruskal Wallis H test for Retention

| | | ATF11 (Retention) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | ATF1 (operational) | ATF2 (physical) | ATF3 (psychological) | ATF4 (social) | ATF5 (cultural) | ATF6 (reduced) | ATF7 (affordability) | ATF8 (travel) | ATF9 (compatibility) |
| Mean Rank | Strongly Disagree | 18.50 | 70.83 | 57.75 | 127.00 | 77.60 | 92.38 | 18.50 | 57.75 | 77.38 |
| | Disagree | 123.69 | 105.98 | 120.44 | 112.59 | 105.62 | 109.80 | 97.86 | 91.89 | 91.39 |
| | Neutral | 153.95 | 147.14 | 134.47 | 137.40 | 158.32 | 148.58 | 157.13 | 134.76 | 146.52 |
| | Agree | 178.28 | 175.94 | 187.06 | 178.72 | 186.69 | 191.11 | 182.10 | 177.40 | 188.09 |
| | Strongly Agree | 210.48 | 215.98 | 191.63 | 174.73 | 220.22 | 238.50 | 230.97 | 203.41 | 199.69 |
| Kruskal Wallis Test | Chi-Square | 22.941 | 28.702 | 35.315 | 19.636 | 41.863 | 53.943 | 44.812 | 44.125 | 39.632 |
| | Df | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| | Asymp. Sig. | .000*** | .000*** | .000*** | .001** | .000*** | .000*** | .000*** | .000*** | .000*** |

a. Kruskal Wallis Test
b. Grouping Variable: ATF1 to ATF9

The results are shown in table 4.9. The p-value .000 ($p<0.001$) indicates that there is a statistically significant difference between different levels of all AT factors on the AT Retention.

By looking at the highest chi-square values, we can find the impact of these factors on dependent factor. Here, the highest chi square values of ATF6 and ATF7 are 53.943 and 44.812 with corresponding impact of 16.54% and 13.74% respectively. It means that, 16.54% and 13.74% of the variability in AT Retention was accounted by the factors ATF6 and ATF7 respectively.

From these results, we conclude that ATF3 and ATF4 are top significant factors for AT Effectiveness and ATF6 and ATF7 for AT Retention. It means that people with dementia feel more comfortable with the use of AT if they get AT psychological support and AT social support for AT Effectiveness. Similarly the people with dementia are more motivated to retain AT if the price is affordable and if AT reduces the need of external help.

#### 4.2.4.6 Factors Impact study in terms of Demographic and Characteristic

In many technological domains the researchers have analysed the impact based on demographic and characteristic properties of the survey respondents (Burton-Jones and Hubona 2006; Morris et al. 2005). The literature has two points of views about such type of research. Some researchers believe that demographic and characteristic properties of the survey participants have strong impact on the usage, adaptation and retention of technologies (Ahuja and Thatcher 2005; Venkatesh et al. 2000). For example, a previous study investigated the factors for technology adaptation and compared the results for older adults with young people. The study findings suggest that technology adaptation is influenced by different demographic factors like age groups (Czaja et al. 2006). The gender also plays an important role for technology adaptation and retention for a longer period of time (Brigman and Cherry 2002). The other group of researchers believe that demographic and characteristic properties of the survey respondents do not impact their motivation regarding adaptation and retention of technologies (Shaw and Marlow 1999; Wynekoop and Walz 1998; Capretz 2003).

To the best of authors' knowledge, this is the first study to analyse the impact of different factors in terms of demographic and characterises properties of the PWD. Previous researchers used types of respondents, types of technologies and living place effecting AT acceptance by the users (Schepers and Wetzels 2007). We included these three dimensions in our analysis alongside gender, age and funding used by the survey respondents for acquiring ATs. Such analysis can be useful in gaining a fine-grained understanding for the AT users' motivation regarding AT effectiveness and retention. The methodology used for factor impact analysis is adapted from previous studies (Singh 2008; Kim and Lee 2013; Donate and de Pablo 2015).

Normality of the Demographic/Characteristic Information: For testing the impact of different factors based on demographic and characteristics information of the survey respondents, first we check whether data is normally distributed for the survey or not. Table 4.10 shows the results for Shapiro-Wilk Test for demographic and characteristics information of the survey respondents.

Table 4.10: Shapiro-Wilk Test for Demographic/Characteristics Information

| Demographic/Characteristics | Shapiro-Wilk | | |
|---|---|---|---|
| | Statistic | df | Sig. |
| Survey Respondent | .388 | 327 | .000*** |
| Gender | .435 | 327 | .000*** |
| Age | .632 | 327 | .000*** |
| Living Situation | .704 | 327 | .000*** |
| Functional Difficulty | .788 | 327 | .000*** |
| AT Type | .869 | 327 | .000*** |
| Funding Mechanism | .664 | 327 | .000*** |

The values of Shapiro Wilk test indicate that all the demographic and characteristic information variables have significant values ($p<0.001$). It means that the data set in this study for demographic/characteristic information of the respondents is not normally distributed. Therefore, to check the difference between different groups of data, some non-parametric tests are used instead of sample t test.

Now for testing the significance difference between different levels of AT factors for dependent factors, some non-parametric tests are used. Firstly, Mann Whitney U test is used for testing the difference of demographic and characteristic variables on the dependent variables because they have only two possible values (like gender: male or female etc). Secondly, Kruskal Wallis H test is used for finding the difference between different groups of independent variables on dependent variables because they all have more than two categories (like functional difficulty: mobility, remembering. Seeing and learning etc.).

#### 4.2.4.7 Testing the Impact of Demographic/Characteristic Information Variables through Mann-Whitney U Test

These demographic information variables have two categories of each variable that's why Mann Whitney U test is used to check the significant impact of the factors on variables like: Survey Respondent (who filled the survey), Gender and Age of the Respondent.

Survey Respondent: This section shows results of different factors their relative impacts with respect to the respondents who filled the questionnaires.

There are two categories of the respondents who filled the survey. The AT users ($N=286$) themselves filled the questionnaires while their caregivers ($N=41$) filled the questionnaires on their behalf. Table 4.11 show Mann Whitney U test results for the survey respondents.

Table 4.11: Mann Whitney U test for the Survey Respondents

| Respondent | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Factors | | ATF1 (operational) | ATF2 (physical) | ATF3 (psychological) | ATF4 (social) | ATF5 (cultural) | ATF6 (reduced) | ATF7 (affordability) | ATF8 (travel) | ATF9 (compatibility) |
| Mean Rank | AT User | 165.88 | 165.40 | 164.27 | 167.84 | 166.30 | 164.62 | 166.31 | 165.81 | 163.22 |
| | Care Giver | 150.88 | 154.24 | 162.10 | 137.20 | 147.98 | 159.71 | 147.90 | 151.37 | 169.46 |
| Mann-Whitney | | 5325.00 | 5463.00 | 5785.00 | 4764.00 | 5206.00 | 5687.00 | 5203.00 | 5345.00 | 5639.00 |
| Z | | -1.033 | 0.781 | -.151 | -2.111 | -1.243 | -.331 | -1.256 | -.990 | -.436 |
| Asymp. Sig. | | .301 | .435 | .880 | .035* | .214 | .741 | .209 | .322 | .663 |

a. Grouping Variable: Who is completing the survey?

The results of the Mann Whitney U test indicate the significant value ($p< .05$) for ATF4 (.035) on the respondents. It means that the AT Social Support factor has significant impact on the respondents who filled the survey.

Gender: This section describes gender based analysis for different factors and their relative impact. The results for male and female survey respondents along their impact are shown in table 4.12.

There are ($N=276$) questionnaires filled by the male respondents and ($N=51$) questionnaires filled by the female respondents. With the help of Mann Whitney U test results, all the values are insignificant ($p> .05$) on gender of the respondents. It means that there are no factors that have significant impact with respect to the gender of the respondents.

Age Groups: The results in this section are based on the age groups of the survey respondents. All the respondents for this survey are elderly people, so all of them aged above 55 years. The survey respondents are divided into two main age groups for the current study. There are ($N=182$) respondents aged between 56-70 years, we call them as Group 1 and there are ($N=145$) respondents aged between 71-85 years, we call them as Group 2. The results for Group 1 and Group 2 survey respondents along their impacts are shown in table 4.13.

By using the Mann Whitney U test values, the only significant value of ($p< .01$) is for ATF3 (.007) with respect to the age of the respondents. It means that the AT Psychological Support factor has significant impact with respect to the age of the respondents.

Table 4.12: Mann Whitney U test for Gender

| Gender | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Factors | | ATF1 (operational) | ATF2 (physical) | ATF3 (psychological) | ATF4 (social) | ATF5 (cultural) | ATF6 (reduced) | ATF7 (affordability) | ATF8 (travel) | ATF9 (compatibility) |
| Mean Rank | Male | 162.63 | 160.74 | 160.98 | 161.29 | 165.25 | 162.04 | 164.47 | 163.97 | 162.69 |
| | Female | 171.40 | 181.64 | 180.32 | 178.67 | 157.24 | 174.61 | 161.46 | 164.17 | 171.08 |
| Mann-Whitney | | 6660.50 | 6138.50 | 6205.50 | 6290.00 | 6693.00 | 6497.00 | 6908.50 | 1029.50 | 6677.00 |
| Z | | -.662 | -1.603 | -1.473 | -1.312 | -.596 | -.929 | -.225 | -.015 | -.641 |
| Asymp. Sig. | | .508 | .109 | .141 | .190 | .552 | .353 | .822 | .988 | .522 |

a. Grouping Variable: Gender of Respondent

Table 4.13: Mann Whitney U test for Age

| Age | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Factors | | ATF1 (operational) | ATF2 (physical) | ATF3 (psychological) | ATF4 (social) | ATF5 (cultural) | ATF6 (reduced) | ATF7 (affordability) | ATF8 (travel) | ATF9 (compatibility) |
| Mean Rank | 56-70 Years | 169.99 | 161.85 | 175.45 | 165.20 | 167.82 | 157.06 | 168.39 | 162.30 | 171.14 |
| | 71-85 Years | 156.48 | 166.69 | 149.63 | 162.50 | 159.21 | 172.71 | 158.49 | 166.13 | 155.03 |
| Mann-Whitney | | 12104.50 | 12804.50 | 11111.50 | 12977.00 | 12500.00 | 11931.50 | 12396.00 | 12886.00 | 11895.00 |
| Z | | -1.396 | -.508 | -2.692 | -.279 | -.876 | -1.584 | -1.014 | -.394 | -1.685 |
| Asymp. Sig. | | .163 | .611 | .007** | .780 | .381 | .113 | .311 | .694 | .092 |

a: Grouping Variable: Age of Respondent

#### 4.2.4.8 Testing the Impact of demographic/characteristic Information Variables through Kruskal Wallis H Test

The demographic/characteristics information variables covered in this section have more than two categories for each variable. That's why Kruskal Wallis H test is used to check the significant impact of factors on variables like: Living Situation, Function difficulty, AT Type, and AT Funding Mechanism.

Living Situation of the Respondents: The results in this section are based on different living conditions of the survey respondents. The respondents are divided into three categories based on their living conditions, living alone (N=60), living with family (N=211) and living at care homes (N=54). The results for the living situation of the survey participants along their impact are shown in table 4.14.

By using Kruskal Wallis H test, the significant values ($p< .05$) are of ATF2 (.024), ATF4 (.000) and ATF8 (.038) with respect to the living situation of the survey respondents. It means that the AT Physical Support, AT Social Support and Travel Help factors have significant impact on the living situation, while AT Social Support being the most dominating factor.

Functional Difficulties faced by the Respondents: The results in this section are based on different functional difficulties faced by the survey respondents. The respondents are divided into five major categories based on their functional difficulties: Remembering (N=141), Learning (N=40), Physical (N=36), Hearing/Seeing (N=37) and Interaction with Others (N=73). The results for functional difficulties are shown in table 4.15.

By using Kruskal Wallis H test results, there are two significant values ($p< .01$) for ATF3 (.004) and ATF7 (.012) with regard to functional difficulties faced by the survey respondents. It means that AT Psychological Support and AT Affordability factors have significant impact with respect to functional difficulty.

Table 4.14: Kruskal Wallis H test for Living Situation

| Living Situation | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Factors | | ATF1 (operational) | ATF2 (physical) | ATF3 (psychological) | ATF4 (social) | ATF5 (cultural) | ATF6 (reduced) | ATF7 (affordability) | ATF8 (travel) | ATF9 (compatibility) |
| Mean Rank | Living Alone | 153.93 | 132.63 | 147.43 | 114.55 | 161.98 | 152.37 | 150.74 | 134.28 | 164.94 |
| | With Family | 159.53 | 164.74 | 161.87 | 173.28 | 155.25 | 157.13 | 160.60 | 163.48 | 159.76 |
| | Care Home | 163.20 | 167.04 | 160.95 | 151.46 | 172.33 | 176.22 | 162.45 | 170.67 | 147.77 |
| Kruskal Wallis Test | Chi-Square | .338 | 7.485 | 1.421 | 23.118 | 1.590 | 2.292 | .715 | 6.556 | 1.159 |
| | Df | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| | Asymp. Sig. | .845 | .024* | .491 | .000*** | .452 | .318 | .700 | .038* | .560 |

a. Kruskal Wallis Test
b. Grouping Variable: What is your current living situation?

Table 4.15: Kruskal Wallis H test for Functional Difficulty

| | | Functional Difficulty | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Factors | | ATF1 (operational) | ATF2 (physical) | ATF3 (psychological) | ATF4 (social) | ATF5 (cultural) | ATF6 (reduced) | ATF7 (affordability) | ATF8 (travel) | ATF9 (compatibility) |
| Mean Rank | Seeing | 168.29 | 169.56 | 164.91 | 165.95 | 165.18 | 164.15 | 157.43 | 159.80 | 165.69 |
| | Remembering | 143.63 | 149.74 | 118.61 | 145.82 | 132.61 | 145.61 | 136.28 | 140.96 | 162.11 |
| | Learning | 174.35 | 158.54 | 158.75 | 168.47 | 160.86 | 162.14 | 156.22 | 167.06 | 167.76 |
| | Lifting | 166.97 | 177.34 | 178.78 | 179.84 | 185.27 | 177.58 | 171.31 | 180.81 | 156.03 |
| | Hearing | 160.27 | 157.01 | 182.20 | 159.96 | 169.68 | 167.82 | 192.02 | 174.70 | 163.95 |
| Kruskal Wallis Test | Chi- Square | 3.227 | 3.240 | 15.593 | 3.301 | 7.574 | 2.734 | 12.771 | 5.611 | .462 |
| | Df | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| | Asymp. Sig. | .521 | .519 | .004** | .509 | .108 | .603 | .012** | .230 | .997 |

a. Kruskal Wallis Test
b. Grouping Variable: Do you have any functional difficulty

AT Types used by the Respondents: The results in this section are based on different types of AT used by the survey respondents. The respondents are divided into five categories based on the AT they use: Mobility Devices (N=23), Tablet/ iPad (N=56), Reminder /Prompter (N=55), Social Applications (N=147) and Software/Websites (N=41). The results for AT types used by the survey respondents are shown in table 4.16.

The Kruskal Wallis H test results indicate the significant values ($p<.05$) for ATF4 (.000) and ATF8 (.024) on AT types used by the respondents. It means that the AT Social Support and AT Travel Help factors have significant impact with respect to AT types.

Funding Mechanism used by the Respondents: The results in this section are based on different funding mechanisms used by the survey respondents to acquire AT. The respondents are divided into three categories based on the funding mechanisms they used for AT: Insurance Money (N=36), Personal Money (N=249), and Donation Money (N=42). The results for AT funding mechanisms are shown in table 4.17. By using Kruskal Wallis H test values, ATF4 (.027), ATF6 (.004) and ATF8 (.043) have the significant values ($p< .05$) on AT funding. It means that the AT Social Support, Reduced External Help and AT Travel Help factors have significant impact with regard to AT funding.

### 4.2.4.9 Factor Ranking for Demographic/Characteristic Summary

Table 4.18 shows summarized results for factor ranking based on demographic and characteristic information of the survey respondents. The factors with most significant impact are highlighted in green against each characteristic of the respondents.

Table 4.16: Kruskal Wallis H test for AT Type

| | | AT Types Used | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Factors | | ATF1 (operational) | ATF2 (physical) | ATF3 (psychological) | ATF4 (social) | ATF5 (cultural) | ATF6 (reduced) | ATF7 (affordability) | ATF8 (travel) | ATF9 (compatibility) |
| Mean Rank | Mobility Devices | 148.71 | 131.35 | 161.29 | 114.06 | 173.58 | 164.60 | 172.54 | 118.17 | 158.27 |
| | Tablet or iPad | 165.05 | 164.78 | 183.03 | 174.49 | 169.69 | 170.51 | 165.26 | 166.04 | 181.56 |
| | Reminder or Prompter | 157.63 | 157.93 | 159.81 | 130.37 | 159.92 | 166.17 | 147.95 | 150.90 | 155.41 |
| | Social Apps | 167.71 | 171.03 | 157.79 | 179.90 | 161.31 | 161.03 | 163.59 | 176.19 | 157.89 |
| | SW/Web | 167.44 | 166.56 | 166.71 | 168.91 | 165.00 | 162.15 | 179.82 | 164.02 | 176.23 |
| Kruskal Wallis Test | Chi-Square | 1.440 | 5.099 | 3.789 | 22.713 | .806 | .528 | 3.435 | 11.277 | 4.666 |
| | Df | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| | Asymp. Sig. | .837 | .277 | .435 | .000*** | .938 | .971 | .488 | .024* | .323 |

a. Kruskal Wallis Test
b. Grouping Variable: What type of AT do you use?

Table 4.17: Kruskal Wallis H test for AT Funding

| AT Funding Mechanism Used | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Factors | | ATF1 (operational) | ATF2 (physical) | ATF3 (psychological) | ATF4 (social) | ATF5 (cultural) | ATF6 (reduced) | ATF7 (affordability) | ATF8 (travel) | ATF9 (compatibility) |
| Mean Rank | Insurance | 163.67 | 131.72 | 145.08 | 128.53 | 144.82 | 150.11 | 157.44 | 130.61 | 135.50 |
| | Personal | 161.76 | 167.50 | 165.94 | 169.88 | 164.69 | 159.02 | 163.76 | 169.44 | 168.23 |
| | Donation | 177.60 | 170.92 | 168.69 | 159.52 | 176.36 | 205.45 | 171.07 | 160.39 | 163.35 |
| Kruskal Wallis Test | Chi-Square | 1.193 | 5.816 | 1.986 | 7.248 | 2.536 | 10.825 | .476 | 6.289 | 4.570 |
| | Df | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| | Asymp. Sig. | .551 | .055 | .370 | .027* | .281 | .004** | .788 | .043* | .102 |

a. Kruskal Wallis Test
b. Grouping Variable: What funding mechanism you use while purchasing AT

Table 4.18: Summary of Overall vs Demographic/Characteristic Information based Top Factors

| Result Type | ATF1 (operational) | ATF2 (physical) | **ATF3 (psychological)** | **ATF4 (social)** | ATF5 (cultural) | **ATF6 (reduced)** | ATF7 (affordability) | **ATF8 (travel)** | ATF9 (compatibility) |
|---|---|---|---|---|---|---|---|---|---|
| Overall Results | — | — | ✓ | ✓ | — | ✓ | — | ✓ | — |
| Respondents | — | — | — | ✓ | — | — | — | — | — |
| Gender | — | — | — | — | — | — | — | — | — |
| Age | — | — | ✓ | — | — | — | — | — | — |
| Living Situation | — | ✓ | — | ✓ | — | — | — | ✓ | — |
| Functional Difficulty | — | — | ✓ | — | — | — | ✓ | — | — |
| AT Type | — | — | — | ✓ | — | — | — | ✓ | — |
| Funding Used | — | — | — | ✓ | — | ✓ | — | ✓ | — |

Note: Significant Impact (✓), No Significant Impact (—)

The summarized table 4.18 shows that the ranking results for the demographics and characteristics do not significantly differentiate from the overall ranking results. Therefore the top factors with most significant impact for the current study remains: ATF3 (AT Psychological Support), ATF4 (AT Social Support), ATF6 (Reduced External Help) and ATF8 (AT Travel Help).

#### 4.2.4.10 Discussion

The factor ranking results for the current study is also well supported by the literature. According to the survey results, the PWD mostly prefer to use AT for social interaction. By using AT they can stay in touch to their loved ones. The literature also indicates social interaction to be the most important factor for the PWD (Doukas et al. 2011; Wu et al. 2013). Additionally social interaction through ATs can be as good as real care through the presence of the caregivers and the family members (Mordoch et al. 2013). The social interaction using ATs enhances the feeling of safety and sense of safety can improve independent living among the PWD (Leroi et al. 2013).

According to Torrington, the psychological support through ATs also helps the PWD to perform different activities, which otherwise they are reluctant to perform (Torrington 2009). This factor is usually ignored in literature (Aloulou et al. 2013; Leroi et al.; 2013). The results of this study indicate that psychological support through ATs can the improve self-esteem, confidence and sense of being safe among the PWD.

There are also many researchers who believe that reduced external help in the use of ATs is also a critical factor for AT being retained for longer period of time (Martins et al. 2012b; Agree 2014). The possible reason for this high importance is that the PWD prefer to use ATs that do not require external help from their family members or caregivers. They want such ATs that they can operate themselves, as needing external help is considered a dependence on family members by the PWD. The reduced need of external help increases the independence of the PWD and can also motivate them psychologically to do activities which otherwise they are reluctant to perform.

AT travel help is highlighted as important service for the PWD by some researchers (Page et al. 2014; Innes et al. 2015). Still in the literature, the work related to AT help in travelling for the PWD is limited. Therefore, we included this factor in the current study. The results indicate AT help in travelling amongst top factors, which open new ways for the future research on ATs being helpful for travelling with focus on the PWD.

In conclusion, the PWD are more motivated by using such ATs which provides social interaction opportunities without the need of external help. Additionally the ATs should also help the PWD in travelling independently. This independence resultantly will increase the self-confidence of the PWD. The increased self-confidence will go a long way into rehabilitation and independent living of the PWD.

#### 4.2.4.11 Requirements for future Assistive Technology form the People with Dementia

Another objective of the survey was to enquire from the PWD, what type of ATs they would like to use in future, so that we may know what type of AT will be in fashion in near future. The 3rd section of the questionnaire asks the respondents about what type of ATs they will use in the future. Table 4.19 presents distribution of the AT types selected by respondents for the future use. The social applications emerged as top choice as exactly half of the respondents (50%) indicated to use social applications. Another (24%) respondents indicated to use leisure supportive ATs. The interest shown in using other ATs in future is distributed as: mobility supportive ATs are selected by (10%), cognitive games are selected by (6%), and reminders or prompters are selected by (10%) of the survey respondents. Usually the leisure supportive ATs are also used for socialization. Therefore, almost ¾ of the survey respondents would like to use ATs which offer easy to use socialization functionalities.

Table 4.19: Future AT Types Recommended by Respondents

| Future AT Type | Frequency | Percentage |
|---|---|---|
| Mobility Support | 32 | 10% |
| Cognitive Games | 18 | 6% |
| Reminder or Prompter | 32 | 10% |
| Social Applications | 166 | 50% |
| Leisure Support | 79 | 24% |

The literature investigation further showed that the people with physical disabilities prefer to use ATs for emergency purposes rather than for socialization or leisure. It indicates that the needs of the PWD are different as compared to people with physical disabilities (Cho and Lee 2016). This gives the idea that in near future the researchers and AT producers should focus on the development of more socialization and leisure based ATs tailored to the needs of the PWD. Another study highlighted that social support and leisure activities have direct positive impact of the quality of life as well connected people enjoy better quality of life (Leung and Lee 2005).

#### 4.2.4.12 Research Impact and Study Limitations

This study presents a novel approach of user centric empirical research for the PWD. The quantitative survey helped to explore and add new factors for AT usability. The factor ranking through statistical analysis identified relatively important factors for AT effectiveness and retention. Further research into these factors and the identified requirements of the PWD can help to reduce AT abandonment. Another major highlight of this study is that to the best of authors knowledge this is the largest study so far involving 327 people with mild dementia in a questionnaire based survey.

There are few limitations associated with the results of the current study. The results of this study are based on a single survey conducted in central and northern parts of Pakistan. There in need of such studies in other South Asian countries for results generalization. Involving the PWD into healthy talks through interviews can also be useful to know their preferences and requirements for the future ATs.

## 4.3 Assistive Technology Support for Travel and Tourism

Currently tourism is regarded as one of the largest industries in the world and with an estimated annual increase of over 4%. The tourist figures reached a record breaking $1.2 billion during 2015. This industry has a strong global impact with 10% of the total Gross Domestic Product (GDP). Tourism is also ranked as the largest job global provider as it provides a job to one person out of 11. The total exports involved in tourism industry has risen to a record $1.5 trillion annually (Tourism Market Trends UNWTO 2016).

Among other aspects, the technological progress is one of the key factors for this sharp rise in increasing number of tourists. Technologies have changed the global picture of the tourism and made it easy for people to travel. The technologies have given more opportunities for the people around the world to interact with each other as well (Buhalis and Law 2008).

The interaction between technologies and tourism industry can be used for promoting travel and tourism opportunities for the people with special needs as well. Promoting tourism opportunities for the people with special needs can contribute further to the tourism market and can also help these people to enjoy the moments of their lives.

### 4.3.1 Dementia, Travel and Tourism

The people with disabilities are a distinct group of travel and tourism market (Huh and Singh 2007) as they have to face more economic, intrinsic, environment and interaction barriers (McKercher et al. 2003). The term people with disabilities is used according to the United Nations definition "Persons with disabilities include those who have long-term physical, mental, intellectual or sensory impairments which in interaction with various barriers may hinder their full and effective participation in society on an equal basis with others"(Enable 2006). The people with disabilities also show stronger desire for ease of access in travelling and at the tourism destinations. Therefore the fastest evolving market segment for travel and tourism industry is the people aged 55 and above (Cook et al. 2006).

Although the PWD should not be labelled as disabled people, yet they face many cognitive challenges. Therefore, they could be considered as a distinct group for the travel and tourism market. The most famous tourism destinations are in the developed countries and their dementia population is also on the rise. Therefore, the research should be carried out to know about the barriers faced by the PWD in the travel and tourism while focusing on the possible alternatives to help them.

### 4.3.2 Motivation

The history of AT was dated back to March 1874 when the first "Audio-phone Bone Conduction Amplifier" for hearing aid was invented (Berger 1976). Since then ATs (from basic to advanced level) have been used for helping the people to cope with their disabilities or functional difficulties. It is just in recent years that the researchers have started to focus on the use of ATs to help the PWD during their daily activities. The ATs are useful for supporting the PWD to live more independent lives, which resultantly increase the production of ATs at larger scales (Tchalla et al. 2012; Fardoun et al. 2015).

These days the PWD are commonly seen using ATs at different places (markets, care homes, hospitals, public places etc.). The existing ATs offer several functionalities like; smart walkers for physical mobility (Martins et al. 2012b), mobile multimedia technologies for easier communication (Donnelly et al. 2010; Boman et al. 2014), prompt technologies for reminders (Seelye et al. 2012), activity monitoring technologies for analysing the PWD movements (Meiland et al. 2014; Rowe et al. 2009), electronic memory aids for daily activities management (Imbeault et al. 2014), leisure technologies for enjoyment activities (Torrington 2009), GPS enabled technologies for safe walking (McCabe and Innes 2013), automatic task assistance technologies for completion of tasks in right order (Peters et al. 2014) and many more. All these ATs have varying scopes to help the PWD. The literature still lacks studies focused on evaluating the usability and impacts of ATs in assisting the PWD for travel and tourism. Due to the scope of this study, we include the studies focused on AT facilitated travel and tourism activities for the people with disabilities and functional difficulties.

The Korean researchers studied the motivation for tourism and related activities with focus on 161 families of the disabled people. The analysis revealed five motivational factors “children’s intellectual competence, socializing, physical competence (mastery) of disabled children, relaxation and escape and family closeness” and seven activity factors “sports, nature appreciation, socializing/special events, active outdoor activities, entertainments, sedentary outdoor activities and wellness activities”. The “physical competence (mastery) of disabled children” appeared as the most significant motivational factor for disabled people families, whereas“ sedentary outdoor activities” appeared as the most significant activity during the family trips (Kim and Lehto 2013).

The motivations of the people with mobility impairments for travelling were analysed through the focus groups. The results generated by the Crompton's push and pull model revealed that factors like "independence, accessibility, adventure and natural environment" motivated the impaired people for leisure based travelling (Shi et al. 2012).

The attitudes of the physically impaired tourists for facilitated access to natural places were investigated. The researchers conducted a survey with 400 participants (physically impaired and normal) tourists. The results indicated that physically impaired group show significant desire for facilitated access to natural places as compared to the able-bodied group (Lovelock 2010).

The accessible tourism competitiveness for the disabled tourism market was studied in Australia and Spain. Factor and cluster analysis revealed that the competitiveness factors for Australia (infrastructure, brand and quality of service) were different as compared with those of Spain (tourist structure, location and climate). Spain already has better accessible facilities due to its long term tourism tradition, therefore it has become one of the leading tourist attractions in the world (Vila et al. 2015).

An interesting study in Hong Kong focused on the role of travel agent for the people with disabilities. According to the perceptions of the people with disabilities the travel agents usually lacked in fulfilling their special needs. In most cases the travel agents themselves didn't understand the needs of this special tourism market segment (McKercher et al. 2003).

Recently the researchers in Spain identified the variables affecting the travelling frequency of the people older than 55 years. The results through the count model showed that time availability, economic situation and gender have strong impact of the travelling frequency among the older people (Losada et al. 2016).

The constraints and related negotiations of pleasure travel were discussed in another study. The comparative pattern analysis systematically analysed the disabled travellers written narratives and resulted into six intrapersonal themes: “physical/sensory constraint, physical/sensory negotiation, emotional constraint, emotional negotiation, knowledge constraint and knowledge negotiation”, six interpersonal themes: “travel companion constraint, travel companion negotiation, service provider constraint , service provider negotiation, stranger constraint, stranger negotiation” and eight structural themes: “transportation constraint, transportation negotiation, facility constraint, facility negotiation, environment/geography constraint, environment/geography negotiation, financial constraint and financial negotiation”. The study concluded that involving the people with disabilities during travel aid development process can also improve the travel services for them (Daniels et al. 2005). The qualitative study involving 40 vision impaired tourists reported their experiences regarding accessible tourism. The findings suggested that the tourism industry in specific and the community in general should understand the sensory needs of the people with disabilities to make tourism more accessible for them (Small et al. 2012).

Another survey showed that the tourism needs of the disabled people are far more complex as we currently understood. More studies should involve the disabled people to explore about their needs for the tourism activities (Shaw and Coles 2004). In response to this there were several studies initiated to know the needs of the people with disabilities for AT assisted travel and tourism. There were also several studies focused on the barriers related to the leisure activities for the PWD (Innes et al. 2015), music based therapies (Wall and Duffy 2010), dementia friendly communities through stakeholders involvement (Heward et al. 2016), dementia friendly societies for improved independent living (Innes and Director 2013), dementia friendly tourism

(Page et al. 2014) and social tourism for the PWD (Diekmann and McCabe 2011). Despite all these research efforts, to the best of authors' knowledge, there is no study focused on analysing the impacts of AT assisted travel and tourism for the PWD. Therefore the present study is to investigate the AT needs, usability and impacts of travel and tourism with focus on the PWD through the research question highlighted in the introduction section.

#### 4.3.3 Objectives of the Study

AT is an alternate to help the PWD in their daily activities (Martins et al. 2012b). However, the usability of existing ATs should be investigated (Asghar et al. 2015). Although there are a few studies focused on helping the people with disabilities in AT assisted travel and tourism, yet there is limited work on analysing the usability of ATs for helping the PWD in this domain (Rumetshofer and Wöß 2004). Tourism is believed to improve psychological and mental health of the general people (McConkey and Adams 2000). Similarly taking part in tourism activities promotes healthy life style and is considered useful in reducing the progress of dementia in the older people (Page et al. 2014). This paper therefore aims at analysing the usability of ATs in helping the PWD in travel and tourism.

#### 4.3.4 Exploratory Factor Analysis for Travel and Tourism

The ordinal data gathered on likert scale usually presents non normal distribution (Hinton et al. 2014). The Shapiro Wilk test results for this study also show that the data set are not normally distributed. As the nature of this study was exploratory, therefore two EFA were performed on the data collected (N=327) samples by using the principal component method with VARIMAX rotations. The EFA1 resulted travel and tourism motivation factors are presented in table 4.20, whereas the EFA2 resulted travel and tourism achievements are presented in table 4.21.

Table 4.20: EFA for Travel and Tourism Motivators using ATs

| Factor | Factor Loading | Mean | Eigen Value | Variance Explained % |
|---|---|---|---|---|
| *Facilitated Travel & Tourism* | | 3.60 | 3.545 | 17.453 |
| Useful for selecting tourist attractions | 0.762 | 3.56 | | |
| Helpful during travelling | 0.643 | 3.69 | | |
| Useful for tourism activities | 0.627 | 3.61 | | |
| Manages leisure activities | 0.610 | 3.49 | | |
| Improved mobility support | 0.540 | 3.67 | | |
| *Cost Effectiveness* | | 3.25 | 2.736 | 14.289 |
| Warranties with the AT | 0.725 | 3.34 | | |
| The price and maintenance is affordable | 0.701 | 3.05 | | |
| Easy to handle AT maintenance | 0.576 | 3.22 | | |
| The AT is dependable | 0.524 | 3.39 | | |
| *Easier Communication* | | 3.51 | 1.897 | 11.191 |
| More communication opportunities | 0.712 | 3.76 | | |
| Helps in interaction with other people | 0.672 | 3.45 | | |
| Develop social networks | 0.609 | 3.26 | | |
| Helps to understand different cultures through communication | 0.567 | 3.57 | | |
| *Needs Compatibility* | | 3.47 | 2.344 | 9.127 |
| The AT functions as claimed by the manufacturer | 0.742 | 3.71 | | |
| The AT is adaptable to my personality | 0.698 | 3.48 | | |
| The AT is adaptable to my life style | 0.632 | 3.23 | | |
| Total variance explained | | | | 52.060% |

For factor extraction the Eigen value greater than one rule was followed (Cliff 1988). The values for the Cronbach's Alpha ranged from .890 to .907 and all values were greater than generally accepted lower limit of .70 (Hair et al. 2006b). Similarly all factor loading scores ranged from .417 to .762 which fulfilled the acceptable threshold of factor loading score of .40 (Hair et al. 2006a).

The variance gained through factor analysis for motivational factors was distributed as; factor 1 (17.5%), factor 2 (14.3%), factor 3 (11.1%)' factor 4 (9.1%) and for achievements factors; factor 1(19.7%), factor 2 (16.9%), factor 3 (12.1%). The accumulated total variance gained was 52% and 48% respectively which easily fulfilled the acceptable requirement of at least 40% (Dunteman 1989). Table 4.20 shows the EFA1 results for motivational factors which are based on the survey variables that motivate the PWD to use ATs for travel and tourism. The EFA1 results in four factors below:

Factor 1: The 1$^{st}$ motivational factor "facilitated travel & tourism" is based on the maximum number of variables related to the help of ATs in travelling and tourism. The AT support theme of helping the PWD during travel and tourism activities is closely related to this factor.

Factor 2: The 2$^{nd}$ motivational factor "cost effectiveness" includes the variables related to the appropriate costs of ATs used for travel and tourism. The AT support theme of helping the PWD at affordable prices is closely related to this factor.

Factor 3: The 3$^{rd}$ motivational factor "easier communication" is related to the variables about improved opportunities of communication and interaction with other people through the use of ATs during travel and tourism. The AT support theme of accessible tourism by improved communication through the use of ATs is relevant to this factor.

Factor 4: The 4th motivational factor named "needs compatibility" is based on variables related to the functions of the ATs and their compatibility with the needs of the PWD. The AT support theme of customer requirements matching is closely related to this factor.

For this group the factor "facilitated travel & tourism" has the highest average mean score of 3.60, which shows this factor as the major motivator for AT assisted travel and tourism for the PWD. Table 4.21 shows the EFA2 results for achievement factors. These factors are based on the survey variables related to the achievements of the PWD gained through AT assisted travel and tourism. The EFA2 results in three factors:

Factor 1: The 1st achievements factor named as "improved achievements" contains four variables. The AT support theme of feeling something accomplished through the use of ATs is closely related to the 1st factor.

Factor 2: The 2nd achievements factor "improved independence" is associated with the outputs of the AT usage for travel and tourism in the form of improved independence for the users. The AT support theme of increased independence is relevant to this factor.

Factor 3: The 3rd achievements factor named as "improved safety" is related to feeling secure during travel and tourism through AT assistance. The theme that AT support enhances the safety of PWD is closely relevant to this factor.

For this group the factor "improved achievements" presents the highest mean average score of 3.57, which indicates that the sense of feeling something accomplished, is the prominent achievement from the AT assisted travel and tourism.

Table 4.21: EFA Travel and Tourism Achievements using ATs

| Factor | Factor Loading | Mean | Eigen Value | Variance Explained% |
|---|---|---|---|---|
| *Improved Achievements* | | 3.57 | 2.756 | 19.673 |
| Improved achievements through AT | 0.743 | 3.65 | | |
| The AT helps to meet my needs | 0.644 | 3.66 | | |
| The interface of the AT is effective | 0.464 | 3.57 | | |
| Decreased complexity of tasks | 0.458 | 3.41 | | |
| *Improved Independence* | | 3.44 | 2.434 | 16.916 |
| Daily activities independently without external physical support | 0.654 | 3.38 | | |
| Provides sensorial support | 0.621 | 3.45 | | |
| Provides environmental control | 0.608 | 3.47 | | |
| Helps in reduced dependence | 0.466 | 3.40 | | |
| Helps get formal support through interaction with others | 0.417 | 3.52 | | |
| *Improved Safety* | | 3.41 | 1.912 | 12.137 |
| Improved sense of security | 0.725 | 3.49 | | |
| I feel safer in carrying out routine activities | 0.623 | 3.41 | | |
| Helps to decrease fear of loss | 0.598 | 3.43 | | |
| The AT considers appropriate safety measures | 0.559 | 3.29 | | |
| Total variance explained | | | | 48.726% |

### 4.3.5 Correlation Analysis for Assistive Technology Motivators and Achievements

In addition to EFA, this study also tried to examining the relationships between the motivators and achievements for the PWD who use AT assistance in travel and tourism activities. The CCA was applied on the survey data to deeply understand the relationships between what motivations resulted in what specific achievements. The CCA is a "technique for finding the correlations between one set of variables (multiple dependent variables) and a second set of variables (multiple independent variables)" (Christensen 1983). This method is usually applied to analyse the degree of independent dimensions of the relationship between the two variable sets. The 1stportion of table 4.22 presents four multivariate tests to estimate either the model is statistical significant or not. In all these tests, the Wilk's lambda (λ) is frequently used because it has the tendency of the maximum universal applicability. The results show that all tests are statistically significant with $p < .05$. Therefore, the overall canonical model is statistically significant for this study.

Table 4.22: Statistical Significance Tests for the Full CCA Model

| Test Name | Value | Approx. F | Hypoth. DF | Error DF | Sig. |
|---|---|---|---|---|---|
| Pillai's | 1.4973 | 2.76217 | 192 | 3720 | .000 |
| Hotelling' s | 2.59937 | 4.02315 | 192 | 3566 | .000 |
| Wilk's | 0.14956 | 3.29921 | 192 | 2914.1 | .000 |
| Roy's | 0.60785 | | | | |

### 4.3.6 Canonical Correlations for Each Function Separately

Table 4 presents each canonical root or function separately along its canonical correlation and eigenvalues. There are many ways to combine independent and dependent variables for making functions based on the variables in the sets. The popular canonical loadings are used for interpreting the canonical variates meanings. The variables having (canonical loadings > .32) are used for the variates interpretation (Lee and Comrey 1992). The 1stcanonical function is selected to maximize the relationships between the two synthetic variables and it always has the largest value. Similarly, the next canonical function is created to maximize another association between two other synthetic variables (under the condition that these variables must be perfectly uncorrelated with all other proceeding variables) by using the remaining variance. This procedure continued until the functions are uncorrelated. We came up with 12 canonical functions in the output but we kept only four of them as these functions explain enough variance between the variables and are uncorrelated as shown in table 4.23.

Table 4.23: Eigenvalues and Canonical Correlations

| Root No. | Eigenvalue | % | Cumulative % | Canonical Correlation | Squared Correlation |
|---|---|---|---|---|---|
| 1 | 1.55008 | 59.63284 | 59.63284 | 0.77965 | 0.60785 |
| 2 | 0.29927 | 11.51325 | 71.1461 | 0.47994 | 0.23034 |
| 3 | 0.22948 | 8.82833 | 79.97443 | 0.43203 | 0.18665 |
| 4 | 0.16212 | 6.23707 | 86.2115 | 0.37351 | 0.13951 |

The 1$^{st}$ column indicates the rank of eigenvalues (largest to smallest). The 2$^{nd}$ column shows the eigenvalues. The 3$^{rd}$ and 4$^{th}$ columns indicate the percentage and cumulative sum of percentage of the eigenvalues respectively. The 5$^{th}$ column presents the canonical correlation of the pairs of canonical variates. The first pair of the variates is the linear combination of the tourism ‘motivational’ measurements and the linear combination of tourism ‘achievements’ measurements. All values of the correlation coefficients show that both measurements have positive correlation between the pairs. The last column shows the squared correlation (percentage of variability in all dependent variables that can be explained by all the independent variables). These four functions explained 60.8%, 23%, 18.7% and 13.9% variance within their functions respectively. The remaining functions were discarded as each of them explained tiny variability within their functions.

### 4.3.7 Hierarchal Statistical Significance Tests

In this section we test the significance of each canonical function by testing whether each dependent variable is significantly related to the independent variable. Table 4.24 presents dimension reduction analysis through the hierarchal statistical significance tests.

The 1st column shows different sets of roots which help to describe the relationship between two sets of variables for determining the required number of dimensions. The 1st function contains full set of roots (1 to 12), then this procedure continues to test subgroups created by neglecting the extreme root in the preceding group. Firstly all roots are tested, and then 2 to 12 roots and so forth, until the last root tested itself. Only those roots that show significant results are considered for this study. The roots 1 to 12 are statistically significant with $p < .05$ as we already identified. Similarly, the effects of roots 2 to 12 (eliminate the 1st root), 3 to 12 (eliminate the 1st and 2nd roots) and 4 to 12 (eliminate the 1st, 2nd and 3rd roots) also show statistical significant. The remaining roots don't show statistically significant effect as $p \geq .05$.

Table 4.24: Dimension Reduction Analysis

| Roots | Wilks L. | F | Hypoth. DF | Error DF | Sig. |
|---|---|---|---|---|---|
| 1 to 12 | 0.14956 | 3.29921 | 192 | 2914.1 | .000 |
| 2 to 12 | 0.38138 | 1.86537 | 165 | 2701.63 | .000 |
| 3 to 12 | 0.49551 | 1.58706 | 140 | 2487.2 | .000 |
| 4 to 12 | 0.60922 | 1.33043 | 117 | 2270.58 | .012 |

### 4.3.8 Canonical Solution for all Functions for Dependent and Independent Variable Sets

Table 4.25 presents the standardized canonical coefficients (i.e. weights) for each canonical variate across all four functions for both dependent and independent variable sets.

Table 4.25: Canonical Weights for all Canonical Functions

| *Standardized canonical coefficients for the dependent variables* | Canonical Weights | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| Improved achievements through AT | 0.2882 | -0.1954 | -0.2029 | 0.6169 |
| The AT helps to meet my needs | 0.1639 | 0.2447 | 0.8603 | -0.1708 |
| The interface of the AT is effective | 0.1807 | -0.4250 | -0.1620 | -0.0512 |
| Decreased complexity of tasks | 0.1294 | -0.4142 | -0.0030 | 0.0713 |
| Daily activities independently without external physical support | 0.0748 | -0.2266 | -0.1848 | -0.4669 |
| Provides sensorial support | 0.0854 | 0.2882 | -0.3469 | 0.1468 |
| Provides environmental control | 0.0189 | -0.2610 | -0.3782 | -0.5296 |
| Helps in reduced dependence | 0.1368 | -0.0465 | -0.0895 | 0.4524 |
| Helps get formal support through interaction with others | 0.1335 | -0.0314 | 0.2531 | -0.2965 |
| Improved sense of security | 0.1210 | 0.0104 | 0.0627 | -0.1101 |
| I feel safer in carrying out routine activities | 0.1905 | 0.4414 | 0.1505 | -0.2216 |
| Helps to decrease fear of loss | 0.2398 | 0.7181 | -0.3319 | 0.1527 |
| *Standardized canonical coefficients for the independent variables* | | | | |
| Useful for selecting tourist attractions | 0.0390 | -0.4539 | -0.1832 | -0.0912 |
| Helpful during travelling | -0.0428 | 0.1354 | 0.4955 | -0.0730 |
| Useful for tourism activities | 0.1200 | 0.0242 | -0.1674 | 0.1671 |
| Manages leisure activities | 0.1672 | 0.3648 | 0.1664 | -0.1978 |
| Improved mobility support | 0.1992 | -0.2154 | -0.3252 | 0.3211 |
| Warranties with the AT | 0.1542 | 0.2861 | 0.1082 | 0.1775 |
| The price and maintenance is affordable | 0.0776 | -0.1859 | -0.1956 | -0.2381 |
| Easy to handle AT maintenance | 0.1050 | 0.1897 | -0.2288 | 0.0187 |
| The AT is dependable | 0.1684 | 0.1199 | 0.0850 | -0.2501 |
| More communication opportunities | 0.2328 | -0.2782 | 0.1968 | 0.5358 |
| Helps in interaction with other people | 0.1153 | -0.2588 | 0.6075 | -0.5579 |
| Develop social networks | 0.1555 | 0.1076 | -0.3320 | 0.2252 |
| Helps to understand different cultures through communication | 0.1105 | -0.0419 | -0.3187 | -0.6354 |
| The AT functions as claimed by the manufacturer | 0.1814 | 0.6354 | -0.0788 | 0.0743 |
| The AT is adaptable to my personality | 0.1107 | 0.0034 | 0.3761 | 0.0835 |
| The AT is adaptable to my life style | 0.0315 | -0.4098 | -0.2914 | -0.0806 |

The size of the coefficients denotes their comparative contribution towards the variate. The larger weights of the variables show the more influence on the dependent or independent variates. Similarly, the positive and negative signs of the weights show direct and inverse relationship with each other respectively.

The canonical weights for the dependent variable show that 'improved achievement through AT' significantly contributes to functions 1 and 4. The 'help in decreasing fear of loss' and 'help to meet the needs' are more prompting variables towards functions 2 and 3 respectively. Similarly, the 2nd part of table shows the output of predictor variables on all functions. The results indicate that 'more communication opportunities' have primary contribution for the canonical functions 1 and 4. The 'AT functions as claimed by the manufacturer' and 'help in interaction with other people' are major contributors for functions 2 and 3 respectively.

Table 4.26 illustrates the canonical loadings that measure simple linear correlation between canonical variates and the variables in dependent and independent set for all functions. For evaluating the comparative role of individual variable to each canonical function, these loadings indicate the variance that the variable (either independent or dependent) shares by the canonical variates. Similarly, to the canonical weights the larger value of the coefficient has more importance in deriving the canonical variate.

The 'improved achievement through AT' reflects the largest correlation for maximizing the variates of functions 1 and 4. The 'help in decreasing fear of loss' and 'helps to meet the needs' indicates high degree of inter-correlation between the variables for functions 2 and 3 respectively. Similarly, the 2nd part of the table shows the canonical loadings for predictor variables on all functions. Here the highest loadings on the independent variate are 'more communication opportunities' for functions 1 and 4, whereas 'AT functions as claimed by the manufacturer' and 'help in interaction with other people' have largest correlation value for functions 2 and 3 respectively. All the variables with high shared variance and having largest inter-correlation among them demonstrate the importance of travel and tourism achievements and motivations using AT support.

Table 4.26: Canonical Structure for all Canonical Functions

| Correlations between the dependent variables and their canonical variates | Canonical Loadings | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| Improved achievements through AT | 0.7264 | -0.2253 | 0.0616 | 0.3604 |
| The AT helps to meet my needs | 0.6607 | 0.0343 | 0.5039 | -0.0419 |
| The interface of the AT is effective | 0.6511 | -0.3300 | -0.1544 | 0.0590 |
| Decreased complexity of tasks | 0.5602 | -0.3575 | 0.1248 | 0.0765 |
| Daily activities independently without external physical support | 0.4240 | -0.1712 | -0.1846 | -0.4662 |
| Provides sensorial support | 0.3601 | 0.1579 | -0.4158 | -0.0167 |
| Provides environmental control | 0.3590 | -0.1114 | -0.4348 | -0.5022 |
| Helps in reduced dependence | 0.5316 | -0.1084 | -0.1389 | 0.2439 |
| Helps get formal support through interaction with others | 0.5264 | -0.0810 | 0.1557 | -0.3537 |
| Improved sense of security | 0.4297 | -0.0089 | 0.1012 | -0.1361 |
| I feel safer in carrying out routine activities | 0.5511 | 0.3143 | 0.2196 | -0.2425 |
| Helps to decrease fear of loss | 0.5133 | 0.5566 | -0.3624 | 0.0198 |
| Correlations between the independent variables and their canonical variates | | | | |
| Useful for selecting tourist attractions | 0.4403 | -0.2997 | -0.0109 | 0.0082 |
| Helpful during travelling | 0.4241 | 0.0018 | 0.3709 | 0.0090 |
| Useful for tourism activities | 0.5430 | -0.0533 | 0.0152 | 0.1060 |
| Manages leisure activities | 0.4768 | 0.1792 | 0.1314 | -0.1658 |
| Improved mobility support | 0.5944 | -0.2066 | -0.2541 | 0.2201 |
| Warranties with the AT | 0.5396 | 0.1938 | 0.0350 | 0.0526 |
| The price and maintenance is affordable | 0.4922 | 0.0129 | -0.2410 | -0.2402 |
| Easy to handle AT maintenance | 0.4551 | 0.2252 | -0.2382 | -0.1311 |
| The AT is dependable | 0.4874 | 0.1575 | 0.0479 | -0.2683 |
| More communication opportunities | 0.6483 | -0.2910 | 0.2439 | 0.3873 |
| Helps in interaction with other people | 0.5374 | -0.1927 | 0.5508 | -0.1945 |
| Develop social networks | 0.5706 | 0.0161 | 0.0016 | 0.1975 |
| Helps to understand different cultures through communication | 0.3122 | -0.1248 | -0.3813 | -0.6009 |
| The AT functions as claimed by the manufacturer | 0.4885 | 0.5028 | -0.0735 | 0.1314 |
| The AT is adaptable to my personality | 0.4431 | -0.2484 | 0.1216 | -0.1144 |
| The AT is adaptable to my life style | 0.4025 | -0.4493 | -0.1634 | -0.0805 |

### 4.3.9 Discussion

This study is distinctive as it treated the PWD as unique population for AT assisted travel and tourism. As evident from literature this distinct population requires more attention and easy to use AT functionalities, which makes this population different from the typical AT users. Moreover the motivations of the PWD for AT assisted travel and tourism and their resulting impacts are worth investigating. This research further argues that the requirements of the PWD should be considered while developing AT for this population as studies based on general population cannot yield the original requirements of the PWD. The empirical nature of this study gives better insights into the needs, expectations, experiences and impacts of AT assisted travel and tourism for the target population.

As literature lacks theoretical and practical support regarding AT assisted travel and tourism specifically for the PWD, the findings of this research add values to the present literature. These findings also present the first step for the development of a framework related to the motivations and achievements factors for AT assisted travel and tourism. The linkage between motivations and achievements has both conceptual and theoretical implications.

#### 4.3.9.1 Assistive Technology Supported Travel and Tourism Motivations

The AT assisted travel and tourism motivations are basically the driving factors that are internally oriented and drive the PWD to use ATs. The statistical results revealed four motivational dimensions among the PWD. Basically these motivations uncover the level of needs of the PWD as depicted in figure 4.5. The 'facilitated travel and tourism' (order based on factor mean values) appeared as the main motivation as ATs offer various facilities to them for the travel and tourism activities. In figure 4.5 the inner layer indicates more importance and outer later least importance in shaping the overall results. These facilities include (order based on mean values of each variable) 'help during travel', 'mobility support', 'tourism activities', 'selection of tourist attraction' and 'managing leisure activities'. The upper variable and the bottom variable show most and least importance respectively in shaping the overall results.

The 2nd level of motivation ‘easier communication’ is linked to the ease and frequency of communication offered by the ATs for them for planning and during travel and tourism activities. These opportunities include ‘more communication opportunities’, ‘understanding different cultures through communication’, ‘develop social networks’ and ‘help in interaction with other people’.

The next level of motivation is concerned with ‘needs compatibility’ that focuses on the compatibility of the ATs with the needs and requirements of the PWD, which is very important for the success and retentions of those ATs in use. This level is based on variables like ‘the AT functions as claimed by the manufacturer’, ‘the AT is adaptable to my personality’ and ‘the AT is adaptable to my life style’.

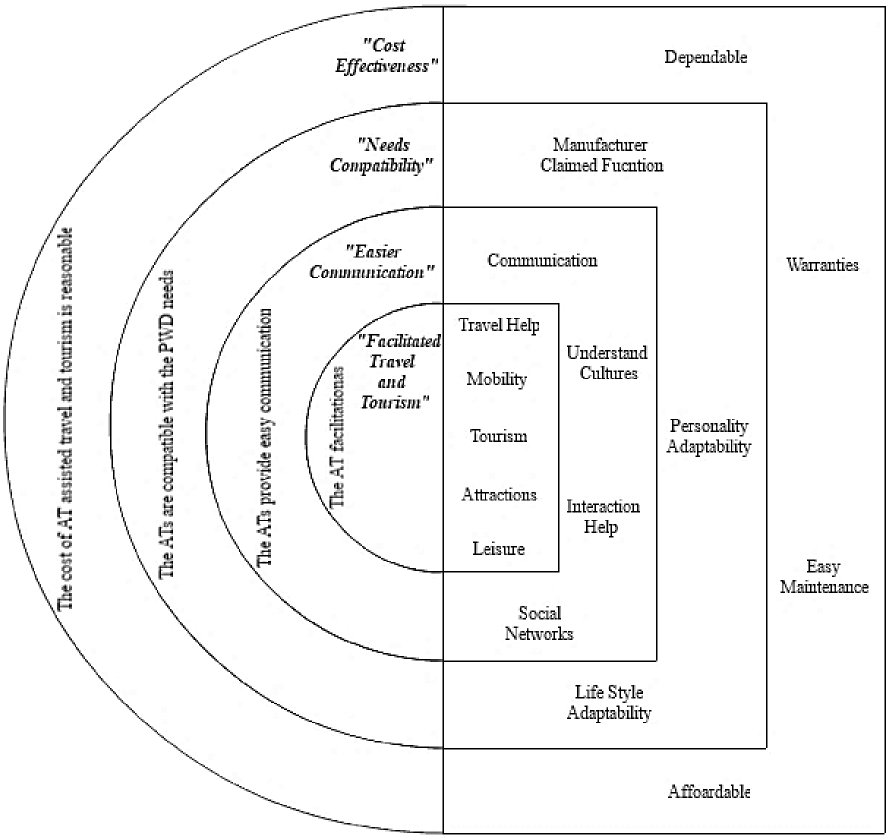


Figure 4.5: The Layered Depiction of the PWD Needs for the AT Assisted Travel and Tourism

The 4th motivation level is related to ‘cost effectiveness’ which means the ATs should provide travel and tourism support at reasonable and affordable prices. This level revolves around the variables ‘the AT is dependable’, ‘warranties with the AT’, ‘easy to handle AT maintenance’ and ‘the price and maintenance is affordable’.

### 4.3.9.2 Assistive Technology Supported Travel and Tourism Achievements

The achievements are linked to the outcomes, improvements and benefits of using AT support for travel and tourism activities. The results of this study indicate that there are lot of positive effects of AT assisted travel and tourism for the PWD which can resultantly help them in overcoming their limitations and increase the feeling independence. The results further revealed three achievement dimensions for the PWD as depicted in figure 4.6. Expending on the same criteria used for the motivational dimensions the ‘improved achievements’ emerged as the top dimension for this section, which focuses on the accomplishments of the PWD through the use of ATs. The achievements of the PWD increased due to ‘the AT helps to meet their needs’, ‘improved successes through AT use’, ‘the interface effectiveness of the AT’ and ‘decreased complexity of tasks’.

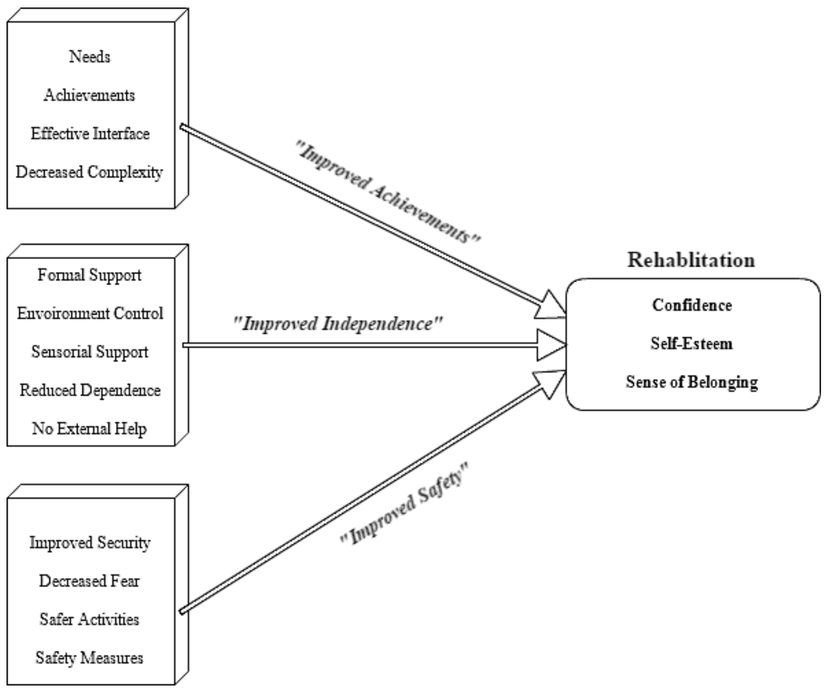


Figure 4.6: The AT Assisted Achievements and Their Impact of Rehabilitation

The 2nd level of achievements belongs to 'improved independence' which indicate that the use of ATs for the travel and tourism activities enhances the independence of the PWD as they don't have to rely so much on the external help. The contribution of different variables towards improved independence is based on the 'help to get formal support through interaction with others', 'environmental control', and 'sensorial support', 'reduced dependence' and 'doing daily activities independently without external physical support'.

The 3rd achievements level is related to the feeling of 'improved safety' through the use of ATs. This level indicates that the PWD feel safer and secure while travelling for tourism activities when they use ATs for this purpose. The contributing variables for this factor are the 'improved sense of security', 'help to decrease fear of loss', 'sense of feeling safer in carrying out routine activities' and 'the appropriate safety measures' offered by the ATs.

AT travel and tourism help is highlighted as important service for the PWD by many researchers (Page et al. 2014; Innes et al. 2015). The achievement outcomes through the use of ATs in travel and tourism increase the confidence, self-esteem and sense of belonging for the PWD. All the facets lead towards better rehabilitation opportunities for the PWD as they feel themselves to be part of the society. The results are well supported by literature as well as research shows that physical support provided by ATs has great contribution towards rehabilitation of the PWD with disabilities (Martins et al. 2012b).

Psychological support is another important area of AT assistance for the PWD by helping them psychologically through increasing their self-esteem and confidence (Henderson et al. 1989). According to (Torrington 2009), the psychological support plays an important role in perusing the PWD to use ATs for performing different activities which otherwise they are reluctant to perform.

The AT assistance in travel and tourism contributes to the wellbeing of the PWD (McCabe and Innes 2013; Cortés et al. 2008). Resultantly active participation in these activities along with timely medication and better eating would help in their rehabilitation and in adopting a healthy life style (Kamel Boulos et al. 2009). Therefore, we conclude that AT assisted travel and tourism contribute towards the rehabilitation and independent living of the PWD.

### 4.3.10 Implications

This study provides finer empirical understanding of the needs, motivations and achievements of the PWD who use ATs for travel and tourism. The research leading to this study suggests that the PWD should be studied as a distinct group for the travel and tourism market. It is also evident that the people aged 55 and above are the fastest growing group of travellers and tourists, therefore this distinct group of the PWD can contribute significantly to the further success of travel and tourism market (Cook et al. 2006).Since this group has different motivations and accessibility needs, their travel and tourism related behaviours might also differ from the people not identified as having dementia. Therefore tourism managers need to further to understand the PWD attitudes, behaviour and psychology which would benefit the tourism industry by generating new ideas for promotion of their business.

The AT facilitated travel & tourism, AT cost effectiveness, AT supported easier communication and needs compatibility are identified as motivational factors the PWD should be focused during the development of PWD specific ATs. These factors will allow the PWD to better plan their travel and tourism activities without the help of their caregivers or family members. The ATs provide communication and socialization opportunities for the PWD as well, which will help them to eliminate the feeling of social isolation from rest of the community (Gössling et al. 2016).

Additionally this research points out that AT supported travel and tourism results into sense of improved achievements, improved independence and improved safety on the part of the PWD. Resultantly they feel more motivated to do activities which otherwise they might be reluctant to perform. The sense of safety, independence and achievements impact the PWD psychologically and would help them towards rehabilitation. The results of this study potentially offer the tourism industry better means to understand the needs of the PWD for AT supported travel and tourism to improve their business. The AT supported travel and tourism is economically efficient, as it saves the costs of caregivers and other human resources. Despite so many benefits, the research on AT supported travel and tourism is still primitive and needs more efforts from the academic researchers and professionals.

### 4.3.11 Impact and Limitations of the Study

The current study presents a user centric approach to investigate the usability of ATs in travel and tourism by involving the PWD. The questionnaire based survey explored factors influencing the usability of ATs. The study also explored the motivations and relevant achievements of the PWD through AT assisted travel and tourism. Such assistance can contribute towards their safety, independence and rehabilitation.

This study also has some associated limitations with it. The results are based on a single survey conducted with 327 participants, in future there is need of more such surveys in different environments and regions. This study only targeted the people with mild dementia. This study only highlights the point of view of the PWD who use ATs. There is need of including the PWD who don’t use ATs in future surveys as well.

### 4.4 Summary

In this chapter, the findings of qualitative and quantitative studies were presented in two sections. In the 1st section the highlights and results the qualitative study were discussed. Based on thematic analysis three themes (the happy users, the non-happy users, technology and human care) and six sub themes (facilitated communication facilitated travel timely medication and activities social isolation and aggression not tailored to the user needs special training needed) are discussed in details. Furthermore AT categorization and its relevant impacts are also discussed. Some suggestions for AT producers are also highlighted.

In the 2nd section, the highlights and results of the quantitative study were presented. Based on factor analysis 11 important factors (AT Operational Support, AT Physical Support, AT Psychological Support, AT Social Support, AT Cultural Match, Reduced External Help, AT Affordability, AT Travel Help, AT Compatibility, AT Effectiveness and AT Retention) were identified. After that factor ranking has been performed to analyze the relative importance each factor with respect to AT effective and long term retention. Future Requirements of the PWD were also discussed in detail.

The next chapter is focused the requirements gathered through qualitative and quantitative surveys. The chapter further discusses new requirements analysis technique and the development of assistive software application.

# CHAPTER FIVE

## Requirements Analysis, Design, Development and Testing of the Assistive Software Application

***Declaration:*** *Parts of this chapter are published in journals/conferences, which is the original work of the author for this PhD thesis. Other co-authors have important supervisory role in producing these publications. Detail of publications is as follows:*

Asghar, I., Cang, S. and Yu, H., 2017b. Usability Evaluation of Assistive Technologies through Qualitative Research Focusing on People with Mild Dementia. *Computers in Human Behavior,* 79**,** 192-201.
Asghar, I., Cang, S. and Yu, H., 2018a. Impact evaluation of assistive technology support for the people with dementia. *Assistive Technology,* UATY #1411405.

***Submitted/Under review:***

Asghar, I., Cang, S. and Yu, H., 2018c. Assistive Software Application to Facilitate the People with Dementia: Case Studies. *International Journal of Human-Computer Studies*.
Asghar, I., Cang, S. and Yu, H., 2018d. A Study on the Requirements Elicitation, Analysis and Development of an Assistive Mobile Application for the People with Dementia. *Requirements Engineering*.

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This chapter focuses on the requirements analysis, development and testing of assistive software application. The requirements gathered through qualitative and quantitative surveys are analyzed in this chapter. The detailed process of assistive software application design and development is also part of this chapter. Last part of the chapter is based on the testing of assistive software application through case studies. Overall this chapter is focused of the following research objectives:

OB9: “To highlight how usable current ATs are for the PWD and to understand their requirements for the future ATs”

OB10: “To design and develop assistive software application for the PWD based on their real needs”

OB11: “To experiment with the use of assistive software application by involving the PWD”

Objective 12: “To analyse the impacts of assistive software application on the lives of the PWD”

OB13: “To propose guidelines for improving AT productivity and user friendliness”

## 5.1 Requirements Study

Requirements Engineering (RE) is one of the critical parts in the software engineering domain which is defined as *“the process of defining, documenting and maintaining requirements”*. Traditionally RE was considered as the first phase of software project development, but later on the software development methods including the Scrum, Extreme programming and rational Unified Process assumed that it’s a continuous process throughout the system life time.

Another study analyzed existing available ATs from literature and mapped them against the ATs available commercially (Asghar et al. 2015). Based on that study and further literature the templates for the semi-structured interviews and the questionnaire based surveys for eliciting AT usability information from the PWD were developed. The usability information can act as a roadmap for the development of new ATs, as it encourages the involvement of the PWD throughout the development process. Effective requirements elicitation is amongst the most important practices for the success of a project as it involves learning and understanding about the needs of the users (Hofmann and Lehner 2001). Therefore eliciting firsthand information from the real users can help the elicitation process to be more reliable.

### 5.1.2 Requirements Mapping Analysis Technique

In software engineering usually the requirements are elicited by using one or a combination of the many available requirements elicitations techniques. These techniques include: brainstorming, document analysis, focus groups, interface analysis, interviews, observation, process modeling, prototyping, requirements workshop, scenarios, ethnography and questionnaire based surveys etc. For the current study we used interviews and questionnaires, which are discussed in the previous section.

Once the requirements are elicited, then different analysis techniques are applied on the elicited requirements for defining the scope and documentation of the requirements. This study proposes a new technique for requirements analysis. This technique is based on the idea of systematic mapping from within the software engineering field; therefore it is named as RE mapping analysis (Petersen et al. 2015). Figure 5.1 shows the process used for the RE mapping analysis.

This technique is based on four major phases; groundwork, requirements elicitation, requirements mapping analysis and scope and documentation of the requirements.

Groundwork: The ground work includes identifying and selecting an appropriate RE process, planning and work before collecting the actual requirements. For setting strong groundwork for our study we performed through literature investigation to identify research problems, methods used to solve research problems and the ways of execution of such research. The templates for the interviews and the questionnaire were also developed during this phase.

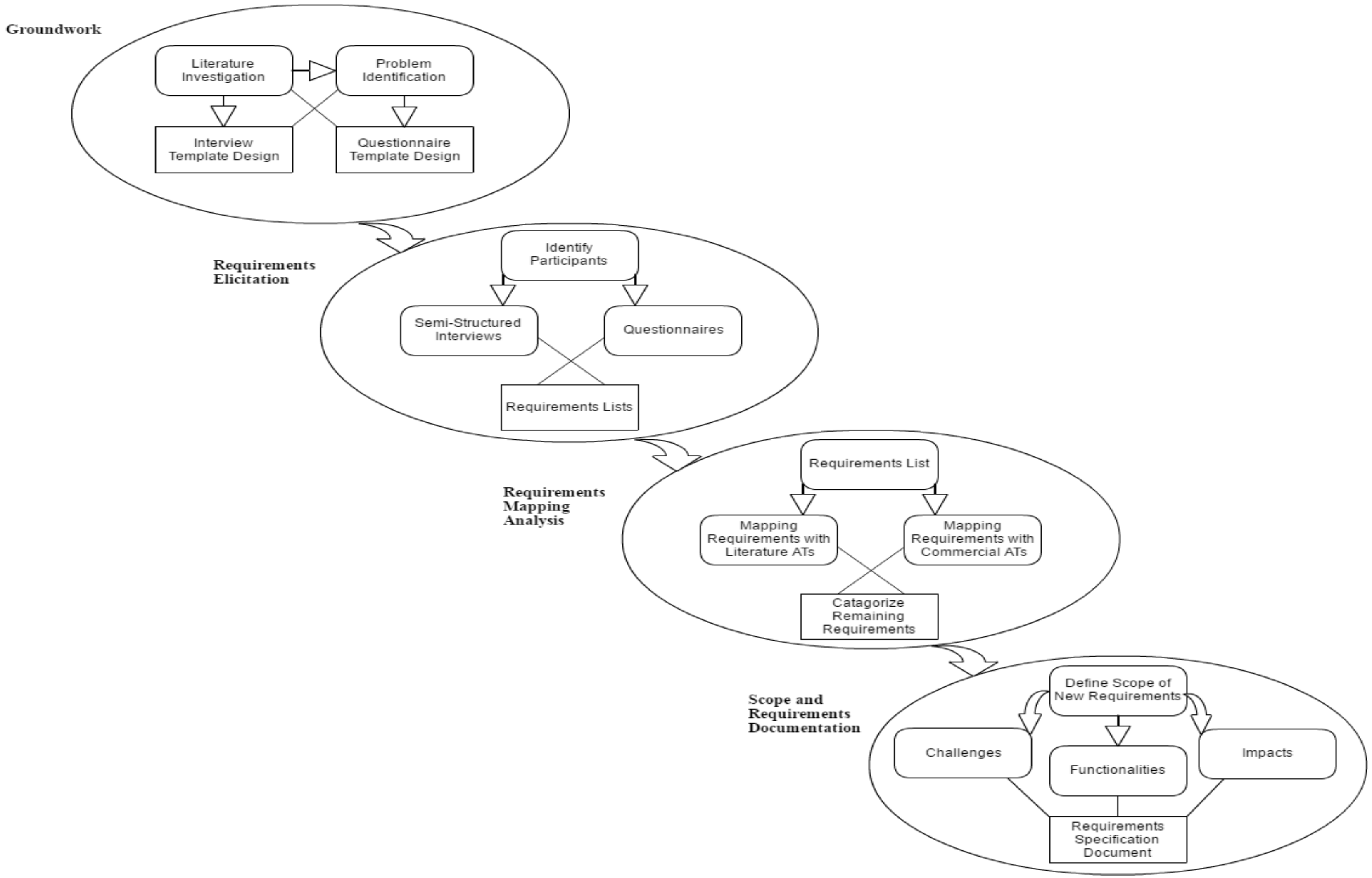


Figure 5.1: The Process Used for the Requirements Mapping Analysis

Requirements Elicitation: This phase revolves around understanding the boundaries of the system and identifying the relevant stakeholders. At this stage the actual requirements elicitation process was carried out. For this study we elicited requirements from 20 PWD through semi-structured interviews and from another 327 through paper based questionnaires. Later on all the elicited requirements are listed for further analysis.

Requirements Mapping Analysis: In software development the analysis is a repetitive activity. The analysis phase answers the questions like: what, why, who, when and how for testing the accuracy and feasibility of the elicited requirements. The requirements list from the previous phase was an input for this phase. Later on we performed mapping analysis (idea taken from the systematic mapping) by analysing each requirement of the PWD against the already available assistive software applications in the literature. The same requirements were also mapped against the commercially available assistive software applications. This process helped us to identify the requirements which were already implemented in the existing assistive software applications. Additionally the mapping process helped to categorize the remaining requirements into six major categories.

Scope and Requirements Documentation: The final phase helped to identify the system activities and functions of the system, the information flow between different activities and the user interaction with the system. Additionally the challenges for the implementation of the new requirements, their functionalities and the possible impacts are also the output of the phase in the form of documented requirements.

### 5.1.3 Requirements Elicitation, Analysis and Prioritization

Both quantitative and qualitative methods of data collection were used for eliciting requirements from the PWD. For the quantitative survey we designed a questionnaire based on 43 questions. The questionnaire was tested through the academic experts, researchers and a pilot study. In total we received 327 responses from the PWD. There were both male and female participants in the survey. All the participants aged over 55 years. The participation came from the PWD living at their homes, care homes and hospitals etc. The participants used different types of ATs such as: mobility support, cognitive games, reminder or prompter, social applications and leisure support etc. During the quantitative survey the ethical guidelines of engaging with the PWD are followed from (Mahoney et al. 2007).

The elicited requirements through the questionnaires are shown in table 5.1. The 1$^{st}$ part of the table shows the requirements identified through the quantitative survey. Later on the similar requirements are grouped and compared against literature and commercially available assistive software applications to investigate which requirements are already implemented, which requirements our study will implement and which requirements need further research efforts.

For the qualitative survey a semi-structured interview template based on 15 questions was designed. The template was then tested by the academic experts and research colleagues. A total of 20 interviews were conducted by involving the PWD. Each interview was recorded with the permission of the interviewees and their family members. The guidelines for interviews were followed from (Jones 2004). The focus of the interviews was on eliciting information on AT performance, advantages and limitations of existing ATs. At the end of each interview the participants were asked about their requirements for the future ATs.

The requirements elicited through interviews are listed and investigated in the 2nd part of table 5.1. The 1st column shows the number of the survey participants against each requirement. The requirements of the PWD are mentioned in the 2nd column. The respondents advised these requirements based on their experiences with the existing assistive software applications and the challenges they faced in using them. There are very diverse requirements highlighted by the survey respondents. As the PWD often have cognitive challenges they usually use assistive reminders for daily activities. Based on their experience they advise to add easy to use reminding functions in future assistive software applications. Due to aging the PWD also have eyesight issues, so larger fonts and digits are recommended for easier call making and messaging.

During the interview, the participants emphasized that religion becomes more important at the older age, so future assistive software applications should include functions for helping them in religious activities. Such help could be in the form of prayer time and religious events reminders. The same points were highlighted by the questionnaire respondents as well. Additionally current assistive software applications offer quite complicated interface which is hard to understand by the elderly PWD, resultantly one of the most emphasized points in both the surveys is related to the interface simplicity. The interface should be user friendly with self-explanatory icons, simple commands and easily visible functions.

Data privacy and communication safety is also seen as a big challenge in convincing the PWD to use the ATs. Therefore, they suggested the future ATs to be more efficient in providing safe communication with enhanced reliability, data safety and improved privacy.

Although in the qualitative survey the respondents didn’t bothered about the costs of the assistive software applications, still some respondents in the quantitative survey show concerns about the costs and recommend for cost effective, less expensive solutions. From both surveys, the most highlighted future requirements are related to helping the PWD through socialization. This help can be in the form of simple to use social applications, which assist the users to stay in contact with family and friends. The simpler functions for socialization can help the users to remove the sense of social isolation while living alone or living at a care home.

Other requirements include: smart assistive software applications using artificial intelligence, simpler GPS for travel help, activity monitoring, health conditions monitoring, larger buttons, local language support assistive software applications, wearable, light weight and light volume smart watches, dementia friendly games, picture based calling etc.

All these requirements are analyzed with literature and commercially available assistive software applications for investigating which of these requirements are already implemented by the assistive software applications producers; the requirements which are going to be implemented in our study and the requirements that need further research. This information is shown in last three columns of table 5.1.

The proposed requirements mapping technique will save time, resources and cost as well, as it promotes the idea of using the components of the shelf, rather than re-inventing the wheel. The requirements mapping analysis show that the new assistive software application will focus on six major requirements of the PWD, shown in table 5.2. The following sections explain these needs in details including the challenges faced, functionalities offered and their relative impact.

Table 5.1: The Met and Unmet Requirements of the People with Mild Dementia

| **Requirements from the Questionnaire based Survey** | | | | |
|---|---|---|---|---|
| **No. of Respondents** | **Requirements** | **Implemented** | **Current Study** | **Future Work** |
| 23 | Easy to use reminders, activity calendars | (Boger et al. 2006; Sjogreen 2006) | ✓ | |
| 17 | Large digits for call dialing, Large fonts for messaging | (Boman et al. 2014; de Oliveira Assis et al. 2010) | | |
| 22 | Religions activities support through AT, reminders for religious activates | | ✓ | |
| 45 | Simple UI, easy to use interface, user friendly UI, User friendly, Easy interface, Self-explanatory icons on the interface | (Hashimoto et al. 2006a; Alm et al. 2007) | ✓ | |
| 4 | Simple interaction between users | | ✓ | |
| 7 | Medical use purposes | (Donnelly et al. 2010) | | |
| 15 | Safe communication, improved reliability, privacy concerns, privacy, Improved security | (Li et al. 2016; Liu and Chung 2016) | | ✓ |
| 12 | Cost effective, Less costly AT | | ✓ | |
| 16 | Accessibility | | ✓ | |
| 67 | Help in socialization, Social support for friends and family, connection to loved ones, staying connected to family through social applications, simple to use social applications | (Boman et al. 2014; Meiland et al. 2014) | ✓ | |
| 8 | Smart AT, Use artificial intelligence | (Si et al. 2007) | | |
| 13 | User centric (operations controlled by the users) | | ✓ | |
| 8 | Improved overall infrastructure, Improved networks | | | ✓ |
| 7 | Use of GPS should be easy, Improved GPS travel help | (McCabe and Innes 2013; Cortés et al. 2008) | | |
| 14 | AT should help cultural celebrations | | ✓ | |
| 7 | Separate AT standards for elderly AT, Improved quality of life | | | ✓ |
| 22 | Simple and easy to use functions | (Torrington 2009; Tchalla et al. 2012) | ✓ | |
| 8 | Activity monitoring, Sensors for activity monitoring | (Boger et al. 2006; de Oliveira Assis et al. 2010; Tchalla et al. 2012) | | |
| 9 | Internet security concerns, Improved security | | | ✓ |
| 4 | Wrist wearable AT | (Mihailidis and Fernie 2002) | | |
| 16 | Adapted to elderly requirements | (Meiland et al. 2014) | ✓ | ✓ |
| 3 | Larger buttons | (Service 2015; Nourish Care 2015) | ✓ | |
| 11 | Languages support other than English | | ✓ | |

| Requirements from the Semi-Structured Interviews based Survey | | | | |
|---|---|---|---|---|
| **No. of Respondents** | **Requirements** | **Implemented** | **Current Study** | **Future Work** |
| 4 | User friendly interface, simple commands | (Hashimoto et al. 2006a; Alm et al. 2007) | ✓ | |
| 7 | Use of social application for helping the elderly needs | (Boman et al. 2014; Meiland et al. 2014) | ✓ | |
| 3 | Health Monitoring AT | (Donnelly et al. 2010) | | |
| 2 | Bigger texts and larger fonts | (Service 2015; Nourish Care 2015) | | |
| 3 | Specialized games based on needs of people with mild dementia | (Huntsman 2014) | | |
| 4 | Prayer time and religious events reminders | | ✓ | |
| 1 | Light weight smart watches | (Bieber et al. 2012) | | |
| 3 | Picture based calling | | ✓ | |
| 2 | Software application in local languages like Urdu | | ✓ | |

Table 5.2: Categorization of the Requirements for Assistive software application

| Needs | Challenge | Functionality | Impact |
|---|---|---|---|
| Daily needs at a click | ○ Connectivity between the people with mild dementia and local community.<br>○ Finding volunteers for participation. | ○ Pressing the icon "Daily Needs on a Click" will open a list of household things.<br>○ The people with mild dementia can press the needed item and an automatic message will spread around the community.<br>○ The user and the volunteers can see status of each other's communication.<br>○ A log will be maintained of the communication. | ○ The assistive software application will make interaction between the users and the local communities more friendly, efficient cost effective. |
| Calling and messaging functions | ○ Finding ways to facilitate the people with mild dementia in calling and messaging as often they forgets the names and numbers of family and friends due to cognitive issues. | ○ The icons "Calls" and "Messaging" will use image based facilitates.<br>○ The people with mild dementia don't need to remember the names and numbers of the loved ones.<br>○ The call dialing and message written will be spoken to the people with mild dementia, so that they can make sure they are doing the right thing. | ○ Staying in touch through calling and messaging with the loved ones will reduce the social isolation of the people with mild dementia.<br>○ They will feel themselves as being a part of society. |
| Reminders and prompts | ○ There are various types of reminders and prompts identified in literature for the people with mild dementia, but issuing too many reminders can have negative effect and can bring aggression in the people with mild dementia.<br>○ Determining the most important reminders and prompts. | ○ The icons "Daily Activities" and "Cultural & Religious Events" will facilitates reminders and prompts functionalities.<br>○ The daily activities will include reminders about medication, food, sleep etc.<br>○ The cultural and religious events will include reminders and explanations about Christmas, Eid, Easter, New Year, Birthdays of loved ones etc. | ○ These functionalities will help to the people with mild dementia to take proper medication, on time meals and rest.<br>○ The people with mild dementia will have more chance to participate in religious and cultural events and can prepare themselves well in advance. |

| | | | |
|---|---|---|---|
| Refreshing the memories | ○ More often the memories are the most important thing for the elderly people.<br>○ Usually the people with mild dementia lose their memories due to cognitive issues.<br>○ Refreshing their memories can be quite critical for their rehabilitation. | ○ The icons "Picture Memories", "Video Memories" and "Paint Your Memories" will be used for reflecting the memories of the people with mild dementia.<br>○ In the 1st two functions, they can visit their memories in the form of pictures and videos and later on they can paint these memories to remember these for a longer period. | ○ Memory visits can have pleasant effect on the thinking and emotions of the people with mild dementia, as often they find themselves lost while trying to remember days gone by.<br>○ It can increase their confidence and self-esteem by showing them what things they were able to do just like other people and can motivate them in doing again. |
| News and weather updates | ○ Usually the PWD are cut off from what's happening around them.<br>○ It's very important to keep them enabled and informed about recent developments around them. | ○ The icons "News Updates" and "Weather Updates" will be used for providing the summarized information about recent headlines, weather, and entertainment to the people with mild dementia. | ○ By remaining updated and well informed the people with mild dementia will find themselves as being a part of the everyday events and happening around the world. |
| Travel Tutor | ○ The PWD face lot of challenges in independent travel due to cognitive and memory issues.<br>○ They often forget their way back home and can even get lost outside their home. | ○ The Travel Tutor will help the PWD to walk outside their homes independently.<br>○ If the user goes more than 200 meters away from his location, the application will alert him and guide him to go back home. | ○ This function will enable the PWD to travel outside their homes safely and independently. |

Additionally at the end of each questionnaire the respondents were asked about what type of assistive software applications they would advise the assistive software applications producers to develop in future. Out of 327 participants, production of mobility support are recommended by 32 (10%), cognitive support by 18 (6%), reminders and prompters by 32 (10%), social applications by 166 (50%) and leisure support 79 (24%) of the respondents. Usually reminders and prompters and leisure supportive assistive software applications are also used for socialization, therefore overall almost ¾ survey respondents advised to develop assistive software applications supporting socialization. All these facets motivated us to come up with the idea of designing the interface of an assistive software application for providing formal and informal support to the PWD through socialization.

## 5.2 The Design and Development of the Assistive Software Application

The interface design is one of the most important part during the development of software applications as it is the process of *"creating a specification of a software artifact, intended to accomplish goals, using a set of primitive components and subject to constraints"* (Ralph and Wand 2009). In software engineering (SE) process usually the design part comes after requirements elicitation and before programming. Its purpose is to solve the problem and to help in the plan for software solution (Freeman and Hart 2004). The design of the ECD application is distributed into functional diagram, class diagram and architectural diagram for better understanding.

Functional Diagram: The functional diagram in figure 5.2 shows the ECD application functions, their relationship with each other, functional sequences and paths.

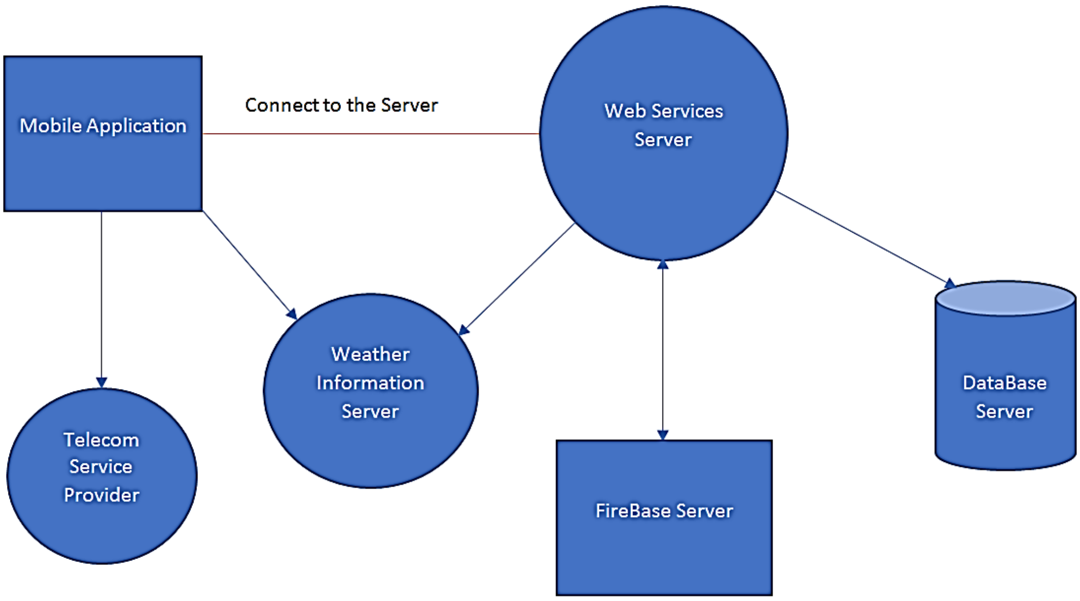


Figure 5.2: Functional Diagram for the ECD Application

Class Diagram: The class diagram usually describes the structure of a system by showing the system's classes, their attributes, operations and the relationships among objects. The working of the main classes used in ECD application is summarized in figure 5.3 and explained below:

C1. Need Activity: This class deals with needs operation that the user input into the system. C2. My Location: This class deals with geo location of the users and also keep track of the changing location.

C3. Firebase instance: This is class to deal with backend server calls and its reacting on it responses.

C4. News Activity: This class is use to deal with news alerts that user receives from the server

C5. Call and Messaging: All the calling and messaging operations are performed from this class.

C6. Login: Connect to server to log in and fetch the records

C7. Weather Activity: Shows current weather conditions to the user

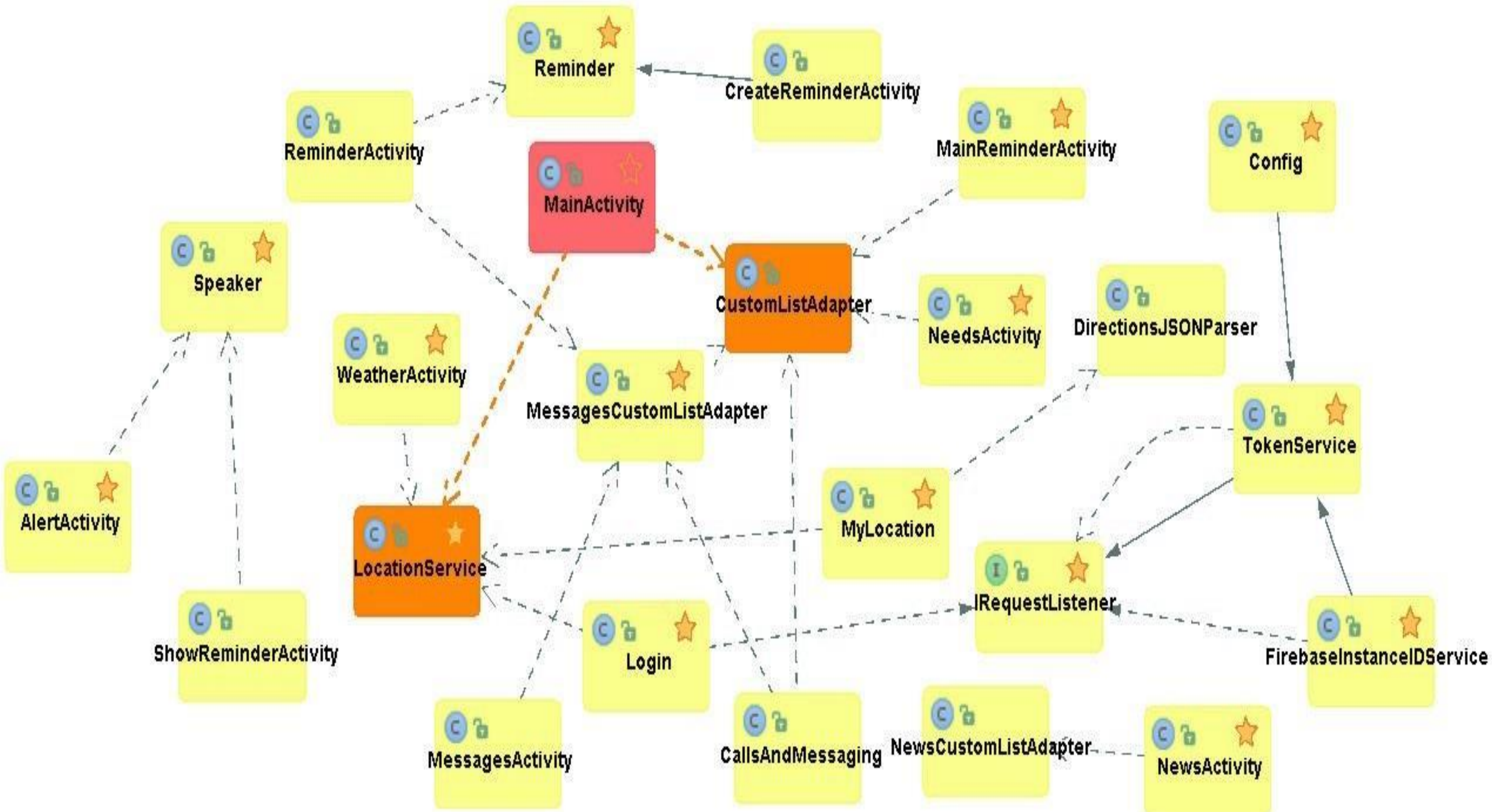


Figure 5.3: Class Diagram for the ECD Application

C8. Reminder: Keep the records of the reminder of the users that are saved in the mobile application.

C9. Text To Speech: This class converts any text to speech

System Architecture Diagram: The system architecture diagram helps to graphically model the applications of the system, and the externals that they interface with and data stores that they use or provide information to. Usually the system architecture diagram presents the conceptual model that defines the structure, behaviour, and more views of a system. The architecture of the ABC application is depicted in figure 5.4.

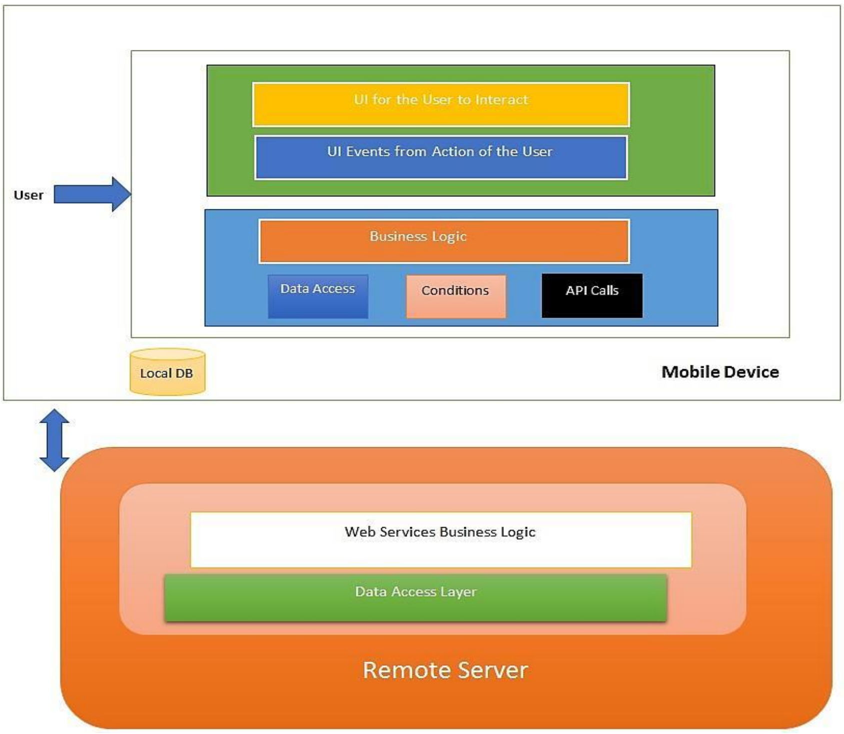


Figure 5.4: System Architecture Diagram for the ECD Application

All these diagrams helped to design the interface and realize the functionalities of the ECD application as per the PWD requirements. The next section underlines the details of the ECD application interface and different functionalities.

Main Interface of Assistive software application: The proposed interface for the assistive software application is depicted in figure 5.5.

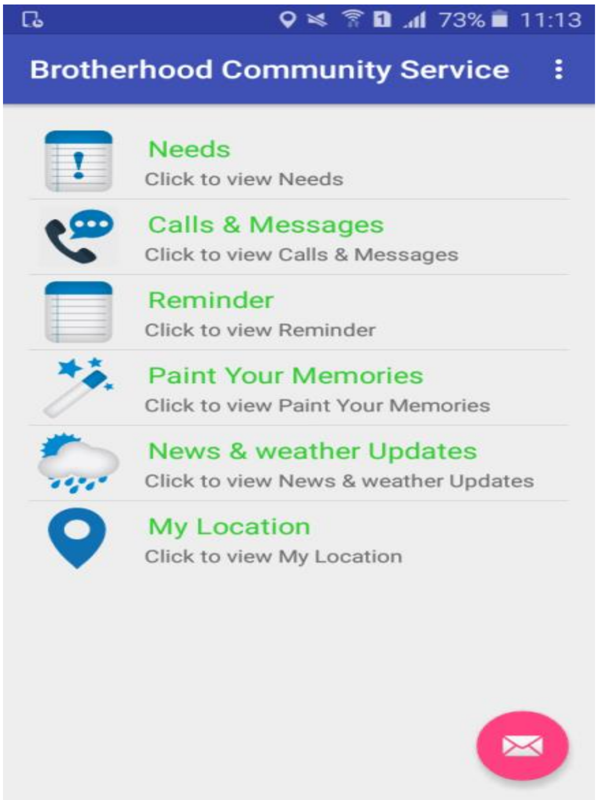


Figure 5.5: ECD Application Interface

The main interface presents the tabs for the six major functional categories offered by the ASA. The user can use either of these categories by just a single click which will take him to the respective functions of that category. The left bottom corner displays the conversational logs of the different users made recently along with date, time and text.

Daily Needs at a Click: The basic aim behind the daily needs at a click is to promote the idea for dementia friendly brotherhood communities, where the people within streets help their neighbors suffering with dementia and living alone at their homes. The PWD are usually aged people and they often have physical challenges in mobility and going out for shopping themselves. By entering into the first functional category the user can see the list of different daily household items needed for everyday use.

Figure 5.6 shows the list of daily household items. These items include milk, bread, fruits, vegetables, water, chicken, eggs and rice. The user needing any of these things just clicks on the relevant icon (for example, the milk icon). This click generates a message and this message is sent to all other users who also have installed the same assistive software application on their devices. They can reply and are able to see each other's communication as well. It will enable stronger understanding within communities and a much quick and cost effective response as compared with services from the care giving companies.

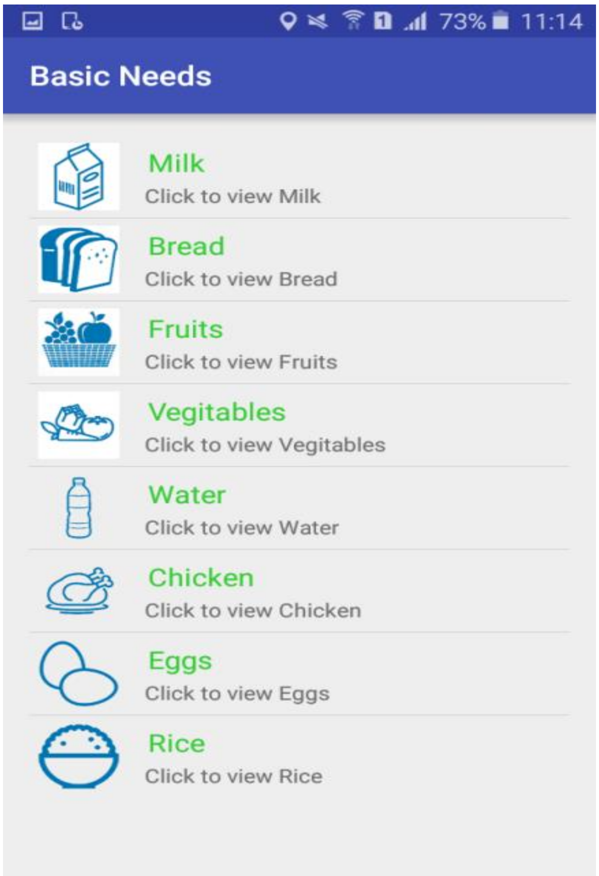


Figure 5.6: Daily Needs at a Click

Simple to Use Calling and Messaging Functions: This facility provides an easy way of interaction for the PWD as they often forgets the names and mobile numbers of the family members and friends. The picture based calling function will be useful for cognitive challenge of making a right call to the right person.

The text to speech function used for messaging enables the PWD to listen whether they are writing the right text or not. These easy to use functions will impact psychologically on the PWD as being the part of society through social interaction. Resultantly their social isolation which is often cited as a major challenge can be reduced (Boman et al. 2014). The single touch calls and messaging function is shown in figure 5.7.

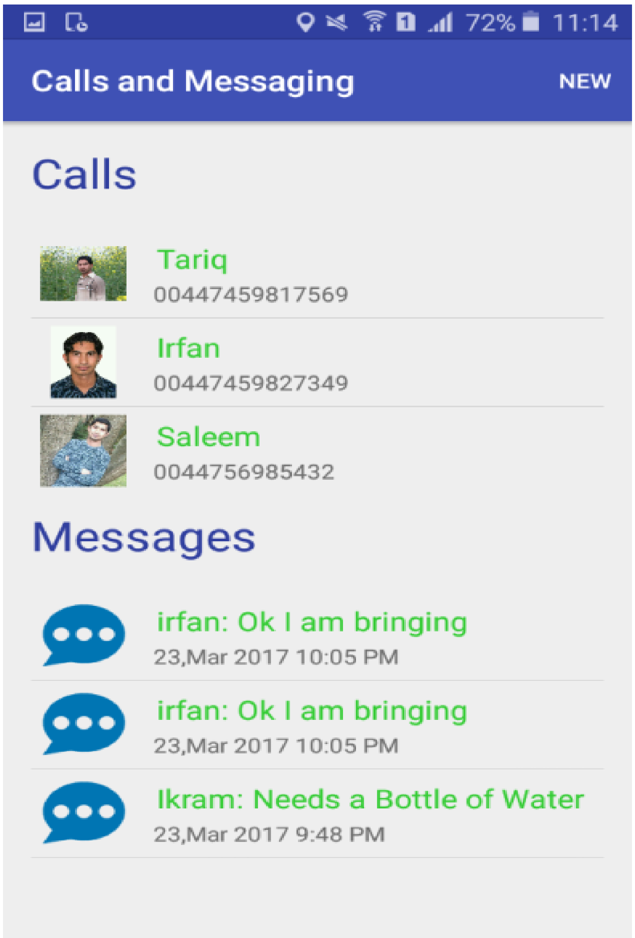


Figure 5.7: One Touch Calls and Messaging

Reminders and Prompts: Due to the nature of dementia the PWD has to face continuous decline in their memory and remembering capabilities. They often forget to do their daily life activities. The reminders functionality helps them through friendly reminders and prompts on pre specified times. This function is shown in figures 5.8 and 5.9.

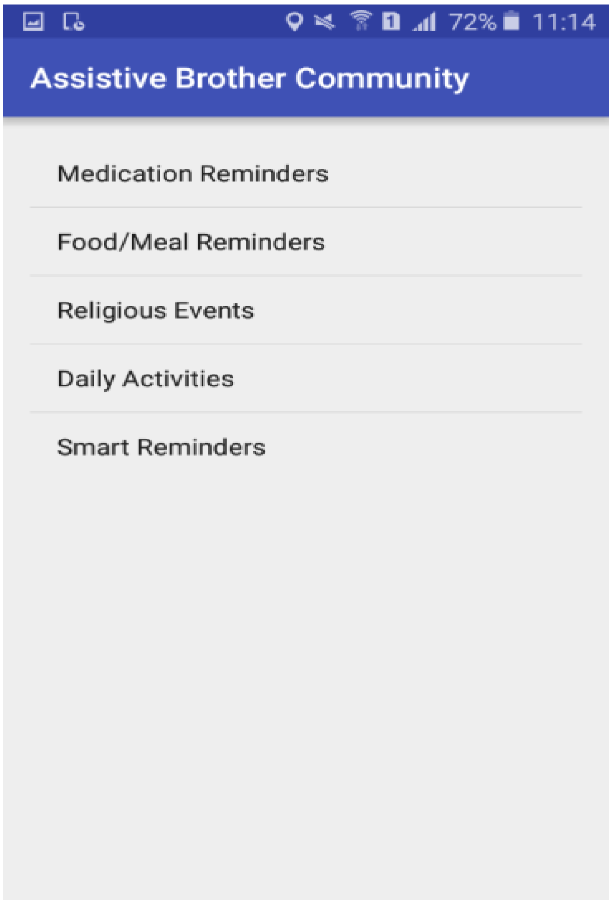


Figure 5.8: Reminders for Activities

The literature shows that although many reminders and prompts based ATs were available in literature, but their overuse could have adverse effect on the users. Therefore the balance between reminders and the needs of the PWD is desirable. The user centric approach used for this study is a potential solution for this problem. A limited set of reminders and prompts include: medication reminders (these remind the user to take medicine on pre specified time), food/meal reminders (these remind the user to take food on pre specified time), religious events (these remind them about prayer times, church visits, Christmas etc.), daily activities (these remind them about any specific activity set for that day) and smart reminders (these reminders issue warnings related to weather like rain, snow, wind and time of the day like night etc.). This active participation along with timely medication and eating would help in their rehabilitation and in adopting a healthy life style.


Figure 5.9: Reminders for Activities

Refreshing the Memories: The past moments and memories are also forgotten by the PWD due to cognitive challenges. The previous researchers that refreshing the memories of the PWD can have positive and pleasant effect on them. It can help to boost them and increase their confidence in themselves. The paint your memories function helps the PWD to load their black and white picture into the ASA and at single click they can change the color combination of the picture. This function is shown in figure 5.10.

The memories are always a critical part of any ones' life, so refreshing these memories will have a pleasant impact on the PWD. Additionally their memories can help them psychologically in improving their confidence through the things they did in the past and can motivate them in trying to do these things again.

Figure 5.10: Paint Your Memories

News and Weather Updates: The PWD living at their own homes and care homes are usually not well connected to the rest of the society; therefore they are not up to date of what's happening around them. The news function provides them updates related to recent news from around the world.

The weather function generates recent updates related to the behavior of weather on hourly basis. Resultantly the PWD will remain more informed and will increase their feeling as being the part of society. These functions are shown in figure 5.11 and figure 5.12.


Figure 5.11: News Updates

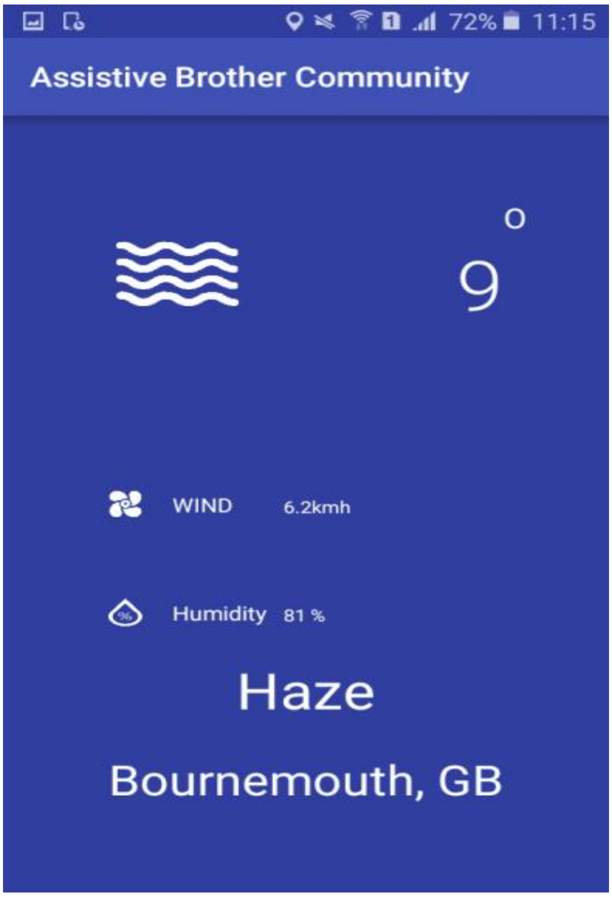


Figure 5.12: Weather Updates

Travel Tutor: Independent travelling is one of the critical challenges associated with dementia. Due to cognitive issues the PWD are usually not able to travel from one place to another independently and safely. They can also forget their way back home as well. The travel tutor function helps the user to go out from his home and walk around the neighbourhood independently. Whenever the user goes more than 200 meters away from the location set as their home, an automatic alarm is generated warning them and asking them to go back home. The travel tutor guide the way back home to the user as well. This function is shown in figure 5.13.


Figure 5.13: Travel Help

### 5.2.1 Case Study Example

The proposed assistive software application will be used for implementation of the 'E-Community for Dementia' idea. The people within the community will help the PWD in their daily needs. For example: an old person with mild dementia "Mr. Ali" is living alone at his own home and he is in fragile condition, can't go to the market to purchase goods. He needs a packet of bread. He just opens his assistive software application, go to daily household section and just press the picture of the 'BREAD'. A message "Mr. Ali needs a packet of bread" will spread across the E-Community for Dementia. Other people can response like: Mr. Lee "I am studying", Ms. Ana "I am about to drive my car" and Mr. Dev "I am bringing the packet of bread in five minutes".

All these people can see each other's communication as well. In this way people within the community can help each other without involving any care giving company or service provider. Furthermore the response within the community will be more quick and friendly as well. This idea is going to be tested through several case studies. The case studies settings will involve assistive software application, people with dementia, the volunteers and the researcher. A conceptual idea of intended ECD is depicted in figure 5.14.

The support from the community will result into helping people with mild dementia to live longer period at their own homes and communities rather than transferring them to a care home or a hospital. Such assistive software applications can also reduce economic burden on the governments for supporting care homes and hospitals.

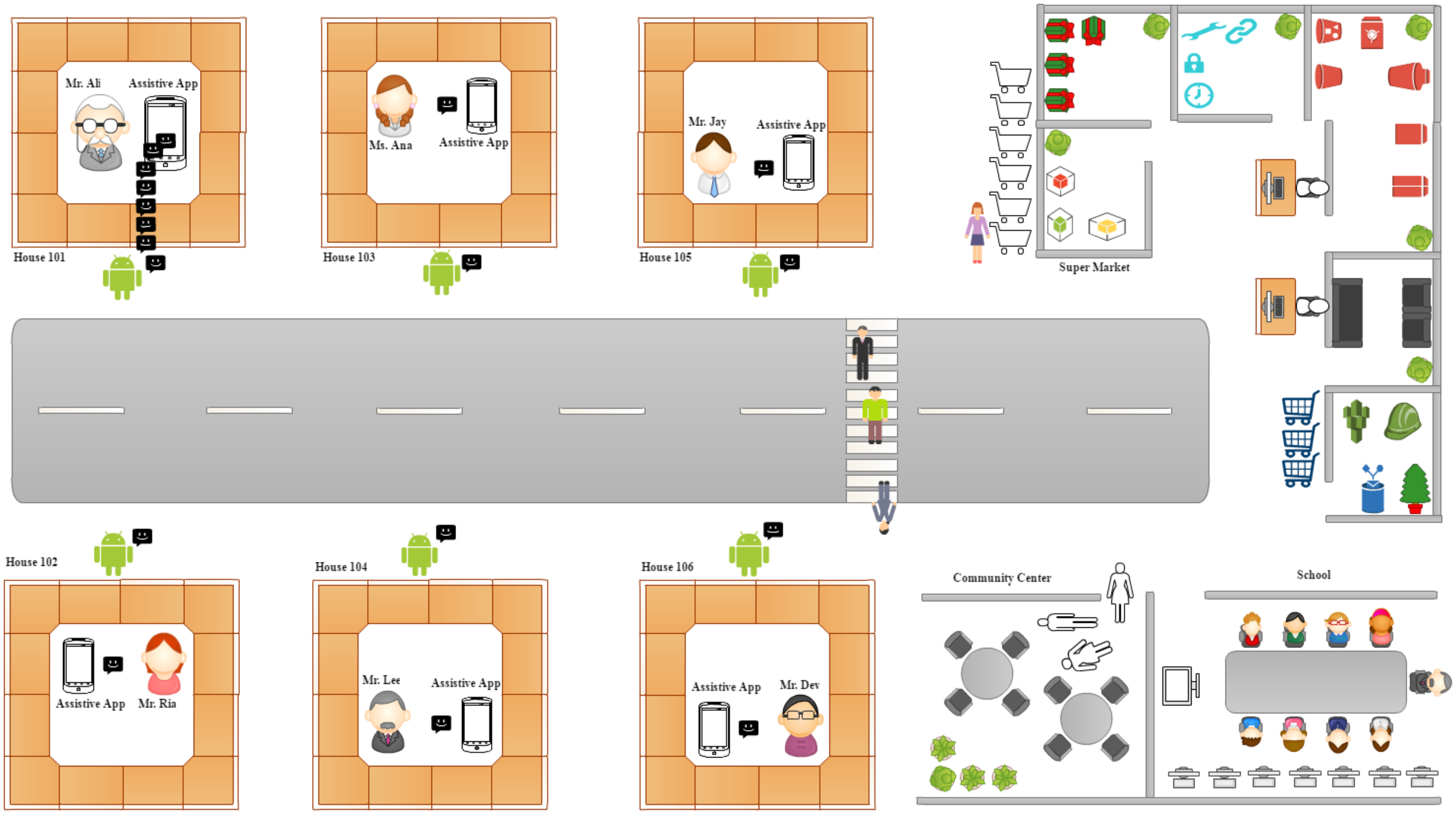


Figure 5.14: The Case Study Scenario Developed by the Researcher

The community based care can be useful in many ways:

- ✓ Use of local communities in combination with care providing organizations
- ✓ A stronger understanding among street, town level communities through collaboration
- ✓ By using assistive software applications and connecting to local people, the PWD will not feel social isolation.

The Activities Tested Through the Case Studies: The case studies will test the following activities with the PWD living at their own homes.

- The activity log will show the requests made, the responses and communication of the PWD and volunteers, example is shown in figure 5.15.

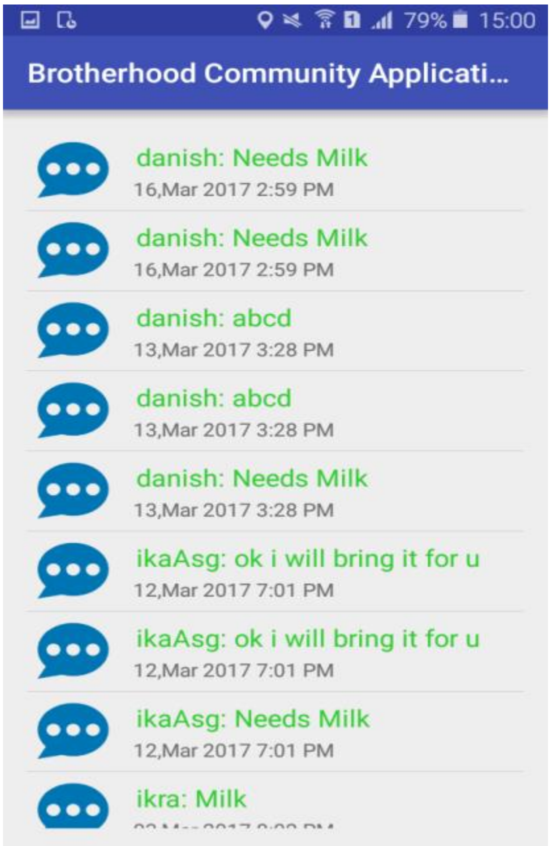


Figure 5.15: Log of Records

- It will show the amount of time spent for fulfilling each request for daily needs like milk, fruits, bread, rice etc.

- The researcher will observe and note the number of reminders like medication, food time; prayer time etc. and how many times the PWD did the task successfully without any help from the caregivers or the family members.
- The researchers will note the comments and behaviour of the PWD while they look at their old pictures and apply colour arrangements on those pictures.
- The researcher will go with the PWD outside their homes for more than 200 meters and will analyses and note the reactions of the PWD at the stop alarm and returning their way back home.
- The activities and their recording time will be set with the consent of the PWD, which may include 30 minutes sessions 2 to 3 times a day.

### 5.2.2 Study Contributions and Limitations

Overall the purpose of this study is to analyze the requirements of the PWD for the assistive software applications. A user centric approach following qualitative and quantitative surveys is used for this purpose. These surveys resulted into a list of requirements. A systematic mapping requirements analysis technique is proposed which analyzed these requirements against literature and commercially available assistive software applications. Then the design of an assistive software application is proposed. The functions of the assistive software application will help the PWD in an active and healthy life style.

This study has a few limitations as well. The assistive software applications usability and requirements of the people with mild dementia are based on only two (qualitative and quantitative) surveys conducted by the researchers. Therefore the results cannot be generalized. Only the people with mild dementia who can use assistive software applications are considered as the participants. Additionally all requirements of the participants cannot be fulfilled by a single assistive software application, therefore more efforts are needed on the researchers part to come up with more assistive functionalities.

## 5.3 Case Studies for Validation

The case studies section focuses on the testing part of the project. The newly developed assistive software application is tested by involving the PWD through case studies.

### 5.3.1 Study Background

As dementia often limits communication opportunities for the PWD, finding new communication ways can be a great contribution towards their rehabilitation. For this purpose the software based solutions can be used as communication medium between the PWD their friends, families and communities.

As dementia effects short-term memory, it is difficult for the person to perform various activities on time and often it is hard for them to remember the right order of activities as well (Nugent et al. 2007). The software based solutions have the potential to assist the PWD in issuing task reminders and step by step completion of that task.

The advances in this digital age have increased the use of internet by the older people which can also contribute towards better utilization of the software based solutions for their own betterment and increased independence. Although software solutions are used in almost all fields of research including education, medicine, aerospace, flight operations, sports and geography etc. Yet the literature indicates that there are gaps available in helping the PWD through the use of software solutions. Therefore researchers also emphasize the need to develop software solutions for the PWD based on their specific needs (Aloulou et al. 2013; Topo 2009). The recently proposed technological combination of software based assistive technologies (SWAT) can be usefully implemented to help minimize the impacts of current worldwide challenges of aging and dementia which resultantly can decrease the medical costs (Asghar et al. 2016).

The SWAT can help the people with dementia in performing different daily life activities like; health monitoring, reminders, cognitive help, social assistance, travel and entertainment etc. (Agree 2014). Additionally SWAT can also be useful for the early diagnosis and prevention of dementia (Sawyer et al. 2015). These advantages emphasize the importance of software as a potential cost effective solution for the PWD that the world is looking for.

The literature investigation showed that although some empirical studies were conducted recently, but their focused population was different (school children, people with disabilities, caregivers etc.). There are no studies focused on analyzing the usability of software based technology for the PWD. To the best of authors knowledge there are no empirical studies carried out in the South Asian region for evaluating the usability of technology from the PWD. Empirical studies can contribute towards understanding technology advantages, limitations and impacts on the lives of the PWD.

### 5.3.2 Case Study Settings

The proposed ECD application is used for implementation of the 'E-Community for Dementia' idea. In these communities the people within the community help the PWD in their daily needs. A conceptual idea of the E-Community for Dementia is depicted in figure 5.14.

### 5.3.3 The Activities Tested Through Case Studies

The case studies involved testing of different activities with the PWD living at their own homes or care homes. The tested activities are summarized in table 5.3.

The following scenarios are followed to record the activities and their outcome during the case studies:

• The activity log recorded the requests made, the responses and communication of the PWD and volunteers.

Table 5.3: Activities Tested During Case Studies

| Category | Activity Name | Number of Repetitions |
|---|---|---|
| Daily Needs | Request to bring milk | At least three items for each PWD each day |
| | Request to bring bread | |
| | Request to bring fruits | |
| | Request to bring vegetables | |
| | Request to bring water | |
| | Request to bring chicken | |
| | Request to bring eggs | |
| | Request to bring rice | |
| Calls | Calling a family member or friend | At least two calls for each PWD each day |
| Reminders | Medication Reminders | Morning, afternoon, night medication reminders for each day |
| | Food/Meal Reminders | Breakfast, lunch, dinner reminders for each day |
| | Religious Events | Five time prayers reminders for each day |
| | Daily Activities | At least two activity reminders each day (e.g. watch TV, go for walk etc.) |
| Painting Memories | Upload black and white pictures | Use at least two pictures for uploading, coloring and saving each day |
| | Color the pictures | |
| | Save the colored pictures | |
| News and Weather | Read news updates | Use both functions at least once for each day |
| | See weather updates | |
| Travel Tutor | Travel outside home | Travel outside home for more than 200 meters each day |
| | Return back home | |

- It showed the amount of time spent for fulfilling each request for daily needs like milk, fruits, bread, rice etc.
- The researcher observed and took notes of the number of reminders like medication, food time; prayer time etc. and how many times the PWD did the task successfully without any help from the caregivers or the family members.

- The researchers noted the comments and behaviour of the PWD while they look at their old pictures and apply colour arrangements on those pictures.
- The researcher went with the PWD outside their homes for more than 200 meters, analysed and noted the reactions of the PWD at the stop alarm and returning their way back home.

### 5.3.4 Results and Discussion

The demographic information of the PWD who participated in case studies is presented in table 3.3 in the third chapter.

#### 5.3.4.1 Interviews with the People with Dementia to Access Functionalities

During semi-structured interviews the functionalities and usage of the ECD application were discussed with the PWD. The functionalities mentioned as most useful and relevant by all the PWD were 'daily needs at click' and 'travel tutor'. The least preferred functionality by the PWD was weather updates.

At the start of the research activity some family members and care givers showed their concerns whether the PWD will be able to use the ECD functionalities as some of them have vision, hearing and physical mobility challenges. They also wondered whether the PWD will easily learn to use the new application. Another concern was whether the PWD will like and remember to take mobile device with them, when going outside their home with sufficient charge in the mobile. Interestingly none of the concerns turned into reality as all the PWD learned to use the ECD application easily and took sufficiently charged mobile with them while walking outside their home.

#### 5.3.4.2 Opinions Regarding E-Community for Dementia Application

The opinions of the PWD about the functionalities of the ECD application are the major outcome for this study. The following section discusses these opinions for every function one by one.

Needs Support: Daily Needs at Click: The PWD highly appreciated this functionality and considered it very useful for their daily activities. One of the PWD termed it as "comforting" as this functionality helped him to get his desired needs on just a single click. Another PWD liked it because it provided him the opportunity to not only get his desired goods but also the chance to "meet people" from their neighbourhood. The female participant termed it as "life changing" as it helped her in minimizing social isolation. When the people within the neighbourhood brought her desired goods, they also stayed at her home for few minutes, made and took tea with her.

Social Contacts: Single Touch Calls and Messaging: Although some of the PWD were able to use normal mobile phones for making calls to their family and friends, yet they face issues like remembering the names and phone numbers of the intended persons. Therefore they considered picture based call dealing function to be "useful" as well. One PWD mentioned that he can choose the picture according to his "mood", just touch it and here goes the ring to that person. He really enjoyed this "touch and get connected" concept. Another PWD said, although this functionality is available in other applications as well, but the "large and clear photos" within ECD application make it easier for him to use it. Even though some of the PWD appreciated the one touch messaging as well, but they were more attracted to once touch calling.

Cognitive Support: Friendly Reminders: Almost all PWD told stories about how sometimes they forgot to do activities on time and in the correct sequence. Therefore all of them were interested in testing the support of the reminder functionality. The "medication reminders" are appreciated by most of the participants. These reminders helped them to take "timely and correct" medicine, as these remind them the medication time as well as the dosage details. The "meals" reminders are termed interesting as these can help them to maintain "good health" through proper and timely food. The religious minded participants termed that religion becomes very important part of everyday life, especially at the old age. They loved the "prayers reminders" and stated that it can help them to bring "closer to GOD". In fact one of the PWD "thanked" the researcher for putting prayers reminders into the ECD application. The daily activities reminders (go for walk, have rest, check blood pressure etc.) are also perceived useful by the participants.

Memory Support: Paint Your Memories: Usually the interesting memories of the PWD are lost due to continuous decline in cognition. The paint your memories functionality is therefore intended to refresh their memories from the glorious past. Overall the PWD liked this function from uploading black and white pictures to giving colours to these pictures. One PWD termed as "confidence building" activity as he can get confidence seeing his old pictures of performing different activities. He gets the feeling that if he put some effort he can do the activities like gardening, shopping, travel independently at this age as well. Some other PWD labelled this functionality to have "pleasant effect" on their mood and memories and made their day happier.

Information Support: News and Weather Updates: Remaining informed and up to date regarding the happenings around is important for everyone, but it is a hard task for the PWD due to challenges discussed earlier. The ECD application therefore intends to provide up to date news headlines and weather updates for the PWD. The PWD liked the news updates and said they feel “well connected” to the world around them, as the news make them aware of the happenings around them. Although they liked the weather updates as well, but this functionality was least discussed during the interviews.

Travel Support: Travel Tutor: Independent travelling is desired on the part of the PWD, but previous research shows that it is one of the hard tasks for the PWD due to the nature of dementia. Forgetting ways, getting lost and falls are few of the many challenges associated with travel for the PWD. The travel tutor functionality therefore is intended to facilitate the PWD to travel independently outside their homes and insures they come back home safely. The PWD highly rated this functionality and all the participants used it with lot of interest. One participant expressed his point of view that he “loved travel tutor” when it asked him to “stop” at 200 meters through spoken interaction and guided him the way back home. Another PWD termed it as being a “travel friend”. Overall they all agreed that this functionality contributes to their independence and will reduce the need of external support while travelling outside their homes.

### 5.3.5 The Functional Ratings for the E-Community for Dementia Application

At the end of each interview the PWD were asked to rate each functionality of the ECD application. The functional ratings are based on their firsthand experience of the ECD application usage during their daily activities. The functional ratings choices given to the PWD were: 1 for strongly disagree, 2 for disagree, 3 for neutral, 4 for agree and 5 for strongly agree. The factors considered for ratings include: easy to use function (simplicity), increase user productivity (effectivity), according to the needs of the users (compatibility) work efficiently (efficiency), appropriate cost (affordability), trustworthy and consistent in performance (reliability) and will user like to retain this function for long term use (retention). The data related to functional ratings is summarized in table 5.4.

Table 5.4: The Ratings about the ECD Application Functionalities

| Functionality | Rating Scale | Participant | | | | | | | | Scale Score | Functionality Score |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | P01 | P02 | P03 | P04 | P05 | P06 | P07 | P08 | | |
| Daily Needs | Simplicity | 4 | 5 | 4 | 5 | 5 | 5 | 5 | 5 | 38 | 269 |
| | Effectivity | 5 | 5 | 5 | 4 | 5 | 5 | 5 | 5 | 39 | |
| | Compatibility | 5 | 4 | 5 | 5 | 4 | 5 | 4 | 4 | 36 | |
| | Efficiency | 5 | 5 | 4 | 5 | 5 | 5 | 4 | 5 | 38 | |
| | Affordability | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 40 | |
| | Reliability | 5 | 5 | 5 | 5 | 5 | 4 | 5 | 4 | 38 | |
| | Retention | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 40 | |
| Calls/Messages | Simplicity | 3 | 5 | 5 | 4 | 5 | 5 | 4 | 5 | 36 | 255 |
| | Effectivity | 5 | 4 | 5 | 4 | 5 | 5 | 4 | 5 | 37 | |
| | Compatibility | 4 | 5 | 5 | 4 | 4 | 4 | 3 | 5 | 34 | |
| | Efficiency | 5 | 5 | 5 | 4 | 5 | 5 | 4 | 4 | 37 | |
| | Affordability | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 40 | |
| | Reliability | 4 | 4 | 4 | 5 | 4 | 5 | 4 | 4 | 34 | |
| | Retention | 5 | 4 | 5 | 5 | 4 | 5 | 5 | 4 | 37 | |
| Reminders | Simplicity | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 4 | 39 | 262 |
| | Effectivity | 4 | 5 | 5 | 4 | 5 | 5 | 4 | 5 | 37 | |
| | Compatibility | 4 | 5 | 4 | 4 | 3 | 5 | 5 | 5 | 35 | |
| | Efficiency | 5 | 4 | 5 | 5 | 5 | 4 | 4 | 5 | 37 | |
| | Affordability | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 40 | |
| | Reliability | 4 | 5 | 5 | 5 | 4 | 5 | 4 | 4 | 36 | |
| | Retention | 5 | 5 | 5 | 5 | 5 | 5 | 4 | 4 | 38 | |
| Paint Memories | Simplicity | 4 | 5 | 5 | 4 | 5 | 5 | 5 | 4 | 38 | 259 |
| | Effectivity | 5 | 4 | 5 | 5 | 4 | 4 | 5 | 4 | 36 | |
| | Compatibility | 5 | 4 | 5 | 4 | 5 | 3 | 5 | 5 | 36 | |
| | Efficiency | 5 | 5 | 4 | 5 | 4 | 5 | 5 | 5 | 38 | |
| | Affordability | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 40 | |
| | Reliability | 4 | 5 | 4 | 4 | 5 | 4 | 4 | 4 | 34 | |
| | Retention | 4 | 5 | 5 | 4 | 5 | 5 | 5 | 4 | 37 | |
| News/Weather | Simplicity | 4 | 5 | 4 | 3 | 4 | 5 | 4 | 4 | 33 | 247 |
| | Effectivity | 4 | 5 | 3 | 4 | 5 | 5 | 4 | 5 | 35 | |
| | Compatibility | 5 | 4 | 5 | 4 | 4 | 4 | 4 | 5 | 35 | |
| | Efficiency | 5 | 5 | 4 | 4 | 4 | 4 | 5 | 4 | 35 | |
| | Affordability | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 40 | |
| | Reliability | 4 | 5 | 5 | 4 | 4 | 4 | 4 | 4 | 34 | |
| | Retention | 4 | 5 | 4 | 4 | 5 | 5 | 4 | 4 | 35 | |
| Travel Tutor | Simplicity | 4 | 5 | 5 | 5 | 5 | 4 | 5 | 5 | 38 | 268 |
| | Effectivity | 5 | 5 | 4 | 4 | 4 | 4 | 5 | 5 | 36 | |
| | Compatibility | 5 | 4 | 5 | 5 | 5 | 5 | 4 | 5 | 38 | |
| | Efficiency | 5 | 5 | 5 | 4 | 5 | 4 | 5 | 5 | 38 | |
| | Affordability | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 40 | |
| | Reliability | 5 | 4 | 5 | 5 | 5 | 4 | 5 | 5 | 38 | |
| | Retention | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 40 | |

The daily needs functionality emerged as top rated function by all the participants by securing 269 rating points. Travel tutor got 2nd highest rating by securing 268 rating points. The remaining functionalities scored as: reminders secured 262 rating points, paint your memories got 259 rating points, calls and messages secured 255 rating points and weather and news updates secured 247 rating points. Overall almost all rating scales got good feedback, the daily needs and travel tutor scored 100% for retention, which indicates that the PWD want to keep on using the ECD application during their daily activities mostly due to these two functionalities.

### 5.3.6 Discussion

This article describes the participation and experiences of the PWD for testing the usability of ECD application specifically developed for them. The PWD participated in this research through case studies and semi-structured interviews. Previously developed software applications and the requirements of the PWD were taken as the starting point for the development of ECD application. The ECD application functionalities are well appreciated by the PWD. The most preferred functionalities include daily needs at click and travel tutor while weather updates is the least mentioned functionality.

Some of the functionalities have already been included in other technologies like: smart walkers and GPS enabled technologies for physical mobility (Martins et al. 2012b; McCabe and Innes 2013), mobile multimedia technologies for easier communication (Donnelly et al. 2010; Boman et al. 2014), prompt technologies for reminders (Seelye et al. 2012), electronic memory aids for daily activities management (Imbeault et al. 2014), leisure technologies for enjoyment activities (Torrington 2009) and automatic task assistance technologies for completion of tasks in right order (Peters et al. 2014). However most of the previous technologies developed did not follow user centric approach, therefore the technology abandonment rate is still high on the part of the PWD. Previously the family members and caregivers also expressed doubts that the PWD will like and adopt technologies (Sixsmith et al. 2007). As this research followed user centric approach throughout the project and all functionalities were added according to the wishes of the PWD. Therefore the concerns of the family members and caregivers regarding technology acceptance did not applied to our research, as all PWD were happy to use the ECD application and showed their interest in adopting it permanently.

Another research highlighted that although there are many attempts to develop technologies for the memory problems of the PWD like (daily activities, forgetfulness, appointments, eating etc.), but these did not proved completely successful as their study designs were rather weak (Lauriks et al. 2007). Therefore, for this research the researchers followed their recommendations and the involvement of the PWD throughout the research proved to be successful.

The proposed ECD application has several advantages as compared with existing software applications for the PWD. It provides many modules of functionalities and the users can use the modules they like to use. The ECD application offer a low cost solution as multiple functions are integrated into a single application. The ECD application is easily installed on smart phone and the user don't have to carry heavy devices or wear the traditional (alarms, GPS, security) systems around their neck.

From the societal point of view, the ECD application provides an alternate solution for fulfilling the needs of the PWD and it will be beneficial for the growing population of dementia. The solution involves the combination of technology and human care, which resultantly will help the PWD from social isolation (Asghar et al. 2017a). As with progression of dementia, the PWD are usually transferred to long term care facilities. Therefore the world is looking at alternate ways to prolong the PWD stay at their own homes.

The functionalities of the ECD application can go a long way in supporting the PWD functioning in multiple ways as summarized in figure 5.16. The daily needs facilitate the

PWD in fulfilling their needs while staying at their own homes through the help of their neighbors. The one touch calls and messages facilitate chances of more social interaction for the PWD.

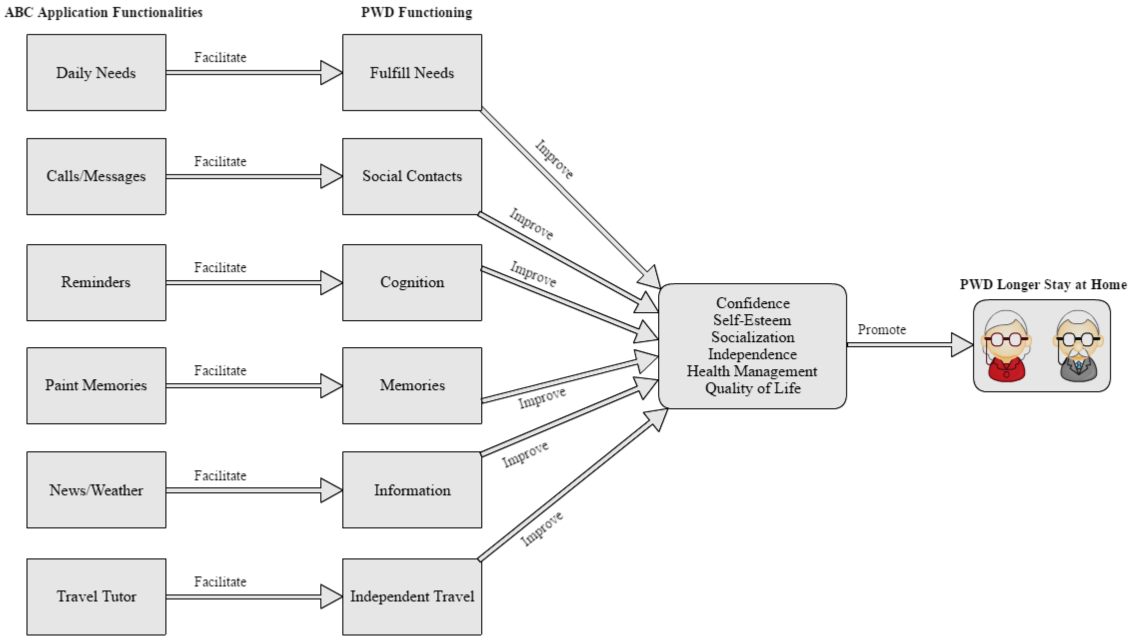

Figure 5.16: ECD Application Support for the PWD

Various types of reminders embedded in the ECD application facilitate the cognition of the PWD, and encourage them to do activities on time. The paint your memories facility help the PWD to revise and rewind their memories from the old days and help them to feel pride on what they did during their young days. The news and weather section help them to get firsthand information related to latest happenings around the world and weather situation. The travel tutor facilitates the PWD in going outside their home and makes sure their safe return home without any help from others.

When combined all these functionalities help the PWD in increasing their confidence and self-esteem, provide more chances for socialization, promote independence, support in self-health management and contribute to their quality of life. In short technologies such as ECD application can help the PWD to stay longer at their own home, based on all the support they can get within their neighborhood. Their prolonged stay at their own homes is also preferred by their families (Petrovic 2013). Therefore the use of the ECD application offers win-win situation for the PWD in particular, their families in general and the society at large.

### 5.3.7 Study Contributions and Limitations

This study contributes to scientific research by providing insights into software solution that is developed based on the needs of the target population. The Case studies and semi-structured interviews proved to be useful methods for collecting relevant data. Overall the purpose of this study is to analyze the usability of ECD application from the PWD point of view. A user centric approach involving the PWD and volunteers is followed throughout the research process. The functions of the ECD application are tested by the PWD through the help of volunteers. This study promotes the idea of assistive brotherhood communities, where people within the community help the PWD through the software support. The support from the community will result into helping PWD to live longer period at their own homes rather than transferring them to a care home or a hospital. The ECD application can also reduce economic burden on the governments for supporting care homes and hospitals. The community based care is useful in many ways:

- ✓ Use of local communities in combination with care providing organizations
- ✓ A stronger understanding among street, town level communities through collaboration
- ✓ By using ECD application and connecting to local people, the PWD will not feel social isolation

This study has a few limitations as well. The sample size is rather small and is based on convenience samples. The ECD application is tested with the PWD having mild dementia only, the moderate and severe dementia population is not tested. Additionally all requirements of the PWD cannot be fulfilled by a single software application, therefore more efforts are needed on the researchers part to come up with more assistive functionalities. The future studies can also include care givers and family members along with PWD in the case studies.

## 5.4 Summary

This chapter was dedicated to requirements analysis, development, testing and evaluating the usability of assistive software application which was developed on the real needs of the PWD. The chapter started with the explanation of newly proposed requirements mapping analysis technique. Later on this technique was applied on the overall requirements which resulted into six major requirements (Daily needs at a click, Simple to use calling and messaging functions, Reminders and prompts, Refreshing the memories, News and weather updates and Travel Tutor). Subsequently an assistive software application was designed and developed which help the PWD to fulfill their six major requirements.

The chapter further explained case study settings followed by the activities tested through case studies. The later part of the chapter was focused on explaining the opinions of the PWD regarding ECD application functionalities. For evaluating the usability of the new application the functional ratings of the ECD Application was also discussed.

The next chapter is focused on concluding the thesis through visiting the research objectives, empirical findings, research limitations and discussing some future research directions.

# CHAPTER SIX

## Conclusions and Future Works

***Declaration:*** *Parts of this chapter are published in journals/conferences, which is the original work of the author for this PhD thesis. Other co-authors have important supervisory role in producing these publications. Detail of publications is as follows:*


Asghar, I., Cang, S. and Yu, H., 2017a. Assistive technology for people with dementia: an overview and bibliometric study. *Health Information & Libraries Journal,* 34**,** 5-19.

Asghar, I., Cang, S. and Yu, H., 2017b. Usability Evaluation of Assistive Technologies through Qualitative Research Focusing on People with Mild Dementia. *Computers in Human Behavior,* 79**,** 192-201.

Asghar, I., Cang, S. and Yu, H., 2018a. Impact evaluation of assistive technology support for the people with dementia. *Assistive Technology,* UATY #1411405.

Asghar, I., Cang, S. and Yu, H., 2017c. September. Empirical analysis of assistive technology support to the people with dementia. *In: 23rd International Conference* on *Automation and Computing (ICAC), 2017,* Huddersfield, United Kingdom. IEEE, 1-6.

Asghar, I., Cang, S. and Yu, H., 2016. Software based assistive technologies for people with dementia: Current achievements and future trends. *In: 10th International Conference on Software, Knowledge, Information Management & Applications, 2016*. Chengdu, China. IEEE, 162-168.

Asghar, I., Cang, S. and Yu, H., 2015. A systematic mapping study on assitive technologies for people with dementia. *In: 9th International Conference on Software, Knowledge, Information Management and Applications, 2015*. Khatmandu, Nepal IEEE, 1-8.


***Submitted/Under review:***


Asghar, I., Cang, S. and Yu, H., 2018c. Assistive Software Application to Facilitate the People with Dementia: Case Studies. *International Journal of Human-Computer Studies*.

Asghar, I., Cang, S. and Yu, H., 2018d. A Study on the Requirements Elicitation, Analysis and Development of an Assistive Mobile Application for the People with Dementia. *Requirements Engineering*.


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This study is carried out to investigate the usability and impacts of ATs in helping the PWD. As the world population is aging, the number of PWD around the globe has increased rapidly. These trends have major effects on healthcare, high demand of caregivers, increase in medical costs and lack of life quality among the PWD. The ATs can be used as an alternate to support the PWD in becoming independent, decrease caregivers' burden and save costs for the families and the governments at large.

There are many ATs available for the PWD, however most of them are not fulfilling their potential capabilities as practical aspects such as AT acceptance and usability testing are mostly ignored in literature and practice. The practicality of any AT is a crucial factor as it shows whether the AT is useful in reality or not and whether the AT will be retained for longer period of time or will be abandoned overtime. This research is aimed at developing user friendly AT, which considers both practical and technical aspects through user centered approach by involving the real users throughout the research process.

This chapter revisits research objectives and presents the summary of achieving these objectives one by one. The chapter further highlights main conclusions from for the thesis and identifies potential future research directions.

## 6.1 Objectives Revisited

The aim of the study is to empirically investigate (by following user centric approach) the impacts of ATs to support the PWD. This study proposed a user friendly assistive software application to increase the positive impacts of AT on the lives of PWD. This section revisits the objectives set out at the beginning of the study and explains how these objectives are achieved one by one:

**OB1:** "To investigate different ATs available in literature for the PWD"

This objective has been achieved through a comprehensive literature review of research studies related to ATs. The studies focused on the design, development and implementation of ATs for the PWD are considered for this part of the thesis. The reviews start with the important definitions of ATs and related concepts. Then history and classifications of ATs is explained in detail. After that the popular ATs for the PWD are summarized in the form of a table. In total we were able to find 47 general AT and 18 SWAT based studies from literature. These studies helped to identify relevant research gaps in this field of research. The output of this objective directly helps in answering RQ1.

**OB2:** "To investigate different ATs available commercially for the PWD"

This objective has been achieved by industrial and commercial surveys. The industrial survey is performed by visiting different AT exhibitions held in 2015 and 2016. The commercial survey is performed by exploring online sources to elicit information related to SWAT for the PWD. We were able to find 15 general ATs and 33 SWAT from the commercial surveys. The output of this objective along with OB1 helps in answering RQ1.

**OB3:** "To analyze different ATs for their respective advantages and limitations"

Two systematic mapping studies have been conducted by following an AT evaluation criteria for listing the advantages and limitations of AT from literature and commercial surveys. The working of ATs is compared against the basic definitions of their relevant category to achieve this. The findings of this objectives helps in answering RQ2.

**OB4:** "To categorize ATs based on the systematic mapping study results"

This objective has been achieved through the systematic mapping process by using AT types and their functionalities for AT categorization. Mapping results reveals five categories for the general ATs (1- Robotics, 2- Health Monitoring, 3- Prompts and Reminders, 4- Communication and 5- Software) and nine categories for the SWAT (1- Cognitive Help, 2- Reminders, 3- Health/Activity Monitoring, 4- Socialization, 5-

Leisure, 6- Travel Help, 7- Dementia Detection, 8- Dementia Prevention and 9- Rehabilitation). The findings of this objective directly help in answering RQ2.

**OB5:** "To explore the state of AT based research for the PWD in different countries"

This objective has been achieved through a bibliometric study by exploring the research output of world leading countries in this domain. The bibliometric study highlights the research contributions of world leading countries (USA, UK, Canada, Sweden, Italy, Germany, Netherlands, France, Australia and Spain) along with their research specialities, national dementia strategies and collaborative research outputs. The study further reveals many open research areas for the interest of the researchers. The findings of this objective indirectly help in accomplishing RQ1.

**OB6:** "To identify important factors for ATs being used by the PWD"

For this objective semi-structured interviews and questionnaire based surveys have been performed by involving the PWD. The interviews revealed three themes: the happy users, the non-happy users, Technology and human care and six sub-themes: Facilitated communication, Facilitated travel, Timely medication and activities, Promote social isolation and aggression, Not tailored to the user needs, Special training needed. The questionnaires were based on AT usability questions, which helped to identify 11 important factors with respect to AT use for the PWD. These factors include: operational support, physical support, psychological support, social support, cultural match, reduced external help, affordability, travel help, compatibility, effectiveness and retention. The information gathered through this objective contributes significantly for answering RQ3.

**OB7:** "To explore the support of ATs in travel and tourism for the PWD"

The questionnaire data is used through SPSS for exploration of AT support in travel and tourism. This section of the thesis investigated what motivates the PWD to use AT support for travel and tourism. It further explains how AT support in travel and tourism add to the achievements of the PWD. The motivational and achievement factors resulted from this objective add into RQ3.

**OB8:** "To investigate the impacts of different factors on AT acceptance and retention"

The questionnaire data was used through SPSS and AMOS tools for factor ranking and analyzing their impact on AT acceptance and retention by the PWD. The factors are also investigated based on the demographic and characteristics of the survey participants. The factor ranking results for the demographics and characteristics do not significantly differentiate from the overall ranking results. Therefore the top factors with most significant impact for the current study remains: ATF3 (AT Psychological Support), ATF4 (AT Social Support), ATF6 (Reduced External Help) and ATF8 (AT Travel Help). These factors contribute both the RQ3 and RQ4.

**OB9:** "To highlight how usable current ATs are for the PWD and to understand their requirements for the future ATs"

The data gathered through semi-structured interviews and questionnaires not only helped to understand the usability of the ATs based on the experiences of the PWD, but also helped to elicit their requirements for the future ATs. The participants were encouraged to tell about their needs and preferences from the future ATs. Later on the requirements mapping analysis technique is applied on the gathered requirements to shortlist the functionalities for the news assistive software application developed for this project. The findings of this objective act as input to answering RQ4.

**OB10:** "To design and develop assistive software application for the PWD based on their real needs"

For this objective, an assistive software application named E-Community for Dementia (ECD) application has been designed and developed. The ECD application is based on the actual requirements of the people PWD, elicited through questionnaires and semi-structured interviews based surveys. The ECD application fulfills six major requirements of the PWD: daily needs at a click, simple to use calling and messaging functions, reminders and prompt, refreshing the memories, news and weather updates and travel tutor. These functionalities helped answering RQ4.

**OB11:** "To experiment with the use of assistive software application by involving the PWD"

The case study based experiments have been conducted to test the usability of the ECD application. Eight case studies involving eight PWD and 40 volunteers have been performed by providing them the ECD application in different cities of Pakistan. These experiments contribute towards the realization of the idea of the "E-communities for dementia". The case studies and their results helped in answering RQ4 and RQ5.

**OB12:** "To analyze the impacts of assistive software application on the lives of the PWD"

The results of the case studies are analyzed to check the impacts of the ECD application on the daily routines and behavior of the PWD. The attributes related to the daily needs of the PWD, calls and messages, reminders and prompts, refreshing their memories, keeping them updates regarding latest news and weather updates and safe travel outside their home are tested through the case studies. These findings help in answering RQ5.

**OB13:** “To propose guidelines for improving AT productivity and user friendliness”

The results from the mapping studies, questionnaire, semi-structured interviews and case studies are used to propose guidelines for improving AT productivity and user friendliness. The AT producers should follow user centric approaches throughout the development lifecycle which include (requirements, design, development and testing). The user centric approaches will help significantly in delivering quality ATs. The guidelines presented in different sections of the thesis helped in achieving overall goal of the thesis.

## 6.2 Empirical Findings

The main research problem is to analyze the usability, support and impacts of existing ATs and the ECD application on the lives of the PWD. This section presents summaries of the findings against each research question.

**RQ1:** What ATs are there to help the PWD?

To answer this research question extensive literature review is performed for synthesising information related to the AT available in literature. The literature review (chapter two) involves papers based on AT with focus on the PWD. The evidence is documented from different studies with respect to what challenges the researchers investigated, which research methods they used, what are their major findings and what future research directions they identified. These findings have been published in papers [2, 5 and 6].

**RQ2:** What differences do these ATs have from each other?

The answer of this research question is found using systematic mapping studies, which are based on the ATs listed from 1$^{st}$ research question and ATs available commercially for the PWD (chapter two). Using the systematic mapping process we classified AT into different categories based on their types and functionalities. For that we developed AT evaluation criteria based on the established definitions of different ATs from literature. Furthermore AT functionality and their respective advantages and limitations are also analysed to have better understanding about their possible uses and impacts. Some parts of the results have been published in papers [2, 5 and 6].

**RQ3:** What are the experiences of the PWD from the existing ATs?

To answer this research question data is collected through the semi-structured interviews and questionnaire based surveys (chapter four) from the PWD. These surveys are focused to understand the usability of existing ATs and to elicit the requirements of the PWD for future ATs. The results are available in papers [1, 3, 7 and 9].

**RQ4:** How can we help the PWD through the use of AT?

The results of 3rd research question helped to identify the ways to support the PWD through the use of AT. The qualitative, quantitative and requirements analysis showed that the AT help in social, psychological, travel and in reducing dependence on others were highly desirable by the PWD. Based on their priorities this thesis focused on helping them in six ways including (daily needs, calls and messages, reminders and prompts, refreshing memories, news and weather updates and safe travel). The results for this research question are available in papers [4, 7 and 9].

**RQ5:** What are the impacts of ATs on daily lives of the PWD?

This is the most important research question for this study. The answer to this research question involves data from all previous research questions. The results are validated by conducting case studies through the involvement of the PWD. In the case studies the PWD are provided the ECD application to use for daily functioning and the impacts of this software application are analysed qualitative process. The results are presented in paper [8 and 9].

## 6.3 Research Limitations

This section discusses the research limitations in three steps. Firstly, the limitations are identified and their impact on the results of this study is discussed. Secondly, a reflection on the limitations the justifications of the choices made during the research is presented. Thirdly, the ideas to overcome these limitations in future studies are presented.

**RL1:** Data collected from limited (literature, exhibitions, online) resources

Although the researchers tried to cover as many AT and SWAT related studies from literature as possible, but the data used for this research is mainly gathered from studies published after 2000. Based on the inclusion/exclusion criteria, only those papers discussing the AT or SWAT design, development and implementation with focus on the PWD are considered for this study. The commercially available ATs are identified based only few visits to AT exhibitions held at different parts of the UK. The online survey for the SWAT was limited to only on popular websites, with good feedback from the users. In return the researcher was able to elicit 47 general AT based studies and 18 SWAT based studies from the literature. The exhibition visits resulted into short listing of 15 general ATs popularly used by the PWD. The online survey resulted into 33 SWAT for the PWD.

The researcher has taken every care to include the general ATs and SWAT which are useful for the PWD. The aggregated number of general ATs and SWAT gathered through all three surveys is 113, which makes it one of the largest studies so far.
The future researchers can include ATs and SWAT developed for disabled and normal population as well to increase the number of technologies they want to investigate.

**RL2:** Survey participants only from few cities

Based on literature recommendations by using confidence level 95% and confidence interval of 7%, a minimum sample size of 196 was considered enough for the current study. As this study involved 20 participants through semi-structured interviews and 327 participants through questionnaires therefore the criteria for the minimum sample size is easily met. However, most of the questionnaires are filled from six major cities of Pakistan. The researcher travelled more than 3000 kilometres for data collection, still unable to cover all Pakistan due to time and budget constraints. There is little representation of smaller cities from Pakistan. At some places the participants had issues with the English language of the questionnaire due to their academic qualification. To overcome this limitation those participants were provided with the questionnaires translated into Urdu.

**RL3:** The ECD application supports only in few activities

The PWD may require the assistance of software applications in many of their daily activities. However, the scope of the ECD application to support the PWD is limited to six major activities of the PWD. The scope of the ECD application is defined based on the needs of this study and as per requirements of the PWD. The current ECD application supports the PWD to fulfill their daily needs like grocery at a single click, one touch calls and messaging, reminders for activities like medication, meals, prayers, events etc., refresh their memories through old pictures and allow them to color these, keeping them updated about recent news and weather updates and help them in independent travel outside their home.

The researcher tried to support as many functions of the PWD as possible, but he limited the functionalities as per recommendations and preferences of the PWD.

**RL4:** Case studies with limited number of participants

Although there is no magic number that how many case studies should be performed for testing the usability and impacts of software applications, yet eight case studies looks like less in number. The lack in number of case studies performed for this study is due to the nature of the project. This study required the participation of the PWD for the case studies, which made it difficult to involve many PWD. Each case study continued for two days, which made it difficult to rum more than eight due to time and budget constraints. Although only eight PWD were involved in case studies, there were 40 volunteers involved as well.

## 6.4 Future Research Directions

This research is focused on analyzing the impacts of AT support for the PWD through user centric approach. Future research could be conducted on the topics highlighted as limitations for this research. Additionally, future research could be focused in various directions outlined below:

**RD1:** Need for Close Cooperation between Academia and Industry Regarding AT Development

The results of the mapping studies show that most of the research done in the academia is based on robotics, whereas the commercial companies are mostly producing monitoring ATs. In reality most of the PWD use ATs for socialization and communication. These dimensions show that there is need to fill this gap between academia, industry and the actual users. The academic research and user surveys can be used by the industry for producing better and reliable ATs for the PWD. This close cooperation will definitely result into better quality products (Asghar et al. 2015).

**RD2:** Dementia Prevention through ATs

Like any other disease dementia prevention can be more useful as compared to helping the people with this disease. Usually dementia is an age related disease and its severity continues with the increase in the age of the person affected with it. The ATs can be used to help the elderly people with their cognitive abilities and can improve the chances of dementia prevention (Hanada et al. 2014). The ATs can use intelligent algorithms and machine learning approaches to help the elderly people with their memory issues as well (Asghar et al. 2016).

**RD3:** Gaming for Cognitive Fitness

Another emerging area of research for helping the cognitive abilities of the PWD is using the cognitive fitness games. Currently there are some brain fitness games available for the elderly people. These games include Lumosity, Clevermind, Fit Brain Trainers, Brain Trainer, and Eidetic etc. (Nouchi et al. 2012; Huntsman 2014). As we already discussed earlier that the requirements of the PWD are different as compared to general elderly people. Therefore the game developers should make more efforts for specialized cognitive games for the PWD with the help of the academic researchers, psychologist and caregivers (Asghar et al. 2016).

**RD4:** More Case Studies by Using ATs with Real Population

There is much work available on the design and development of ATs for the PWD, but there is clear lack of validating the impacts of ATs through case studies (Alzheimer's Disease International 2014). This research is one step in this direction. However, the future studies should also focus on involving the PWD in case studies related to AT usage and analyze the impacts of ATs on their daily lives.

**RD5:** The Qualitative and Quantitative Combination of AT Usability

Future research can also focus on analyzing the usability of ATs by using both qualitative and quantitative methods. It would be interesting to compare qualitative and quantitative results for better AT usability evaluation (Asghar et al. 2017b).

**RD6:** Eastern and Western AT Usability View

It is highly appropriate to conduct similar studies in other South Asian and Western countries (Asghar et al. 2017a). Such studies could be useful to test factors like culture, values, life style and their impact of AT acceptance. It has great potential as comparing such results will help to generate a global framework of AT acceptance for the PWD (Alzheimer's Disease International 2014).

**RD7:** Big Data for Dementia Research

Big data is the *"extremely large data sets that may be analyzed computationally to reveal patterns, trends, and associations, especially relating to human behavior and interactions"* and is popularly used in many research domains including medical and telecare as well. Big data can be used for health monitoring of the PWD. Further research in big data used with ATs can contribute to our knowledge about disease management from diagnosis to prevention to personalized treatment (Andreu-Perez et al. 2015).

**RD8:** Cyber-Physical Systems and Cyber Security for Healthcare

Recent time has seen sharp rise in research related to cyber-physical systems (CPS) and cyber security. CPS is a *"mechanism that is controlled or monitored by computer-based algorithms, tightly integrated with the Internet and its users"* and cyber security consists of *"technologies, processes and measures that are designed to protect systems, networks and data from cyber-crimes"*. The CPS and cyber security has been successfully applied in many research areas including: manufacturing, entertainment, aerospace, transportation, energy and consumer appliances. However, the application of CPS and cyber security in the healthcare domain in general and dementia domain care in particular are still at the exploratory stage. The researchers should look into lessons learned from other disciplines for CPS and cyber security application into healthcare and dementia domains (AlTawy and Youssef 2016).

**RD9:** Wireless Body Area Networks and Connectivity

The wireless body area networks (WBAN) refers to a wireless network of wearable computing devices. The devices may be implanted inside the body or placed on the body in fixed positions. The WBAN monitor critical data and transfers it with high throughput and energy efficiency (Akbar et al. 2017). The WBAN could be used for connectivity and transferring dementia patient critical data (heart rate, diabetes readings, blood pressure, activity monitoring etc.) from one place to another safely and securely.

**RD10:** Robotics and Artificial Intelligence

There have been some recent research efforts for social assistance for the PWD through socially assisted robots and robots therapies for the PWD (Martin et al. 2006). As artificial intelligence (AI) refers to the learning and problem solving by the machine, the combination of robotics and AI should be applied in healthcare settings. This combination can make robots smarter; those can take actions according to the context, environment and needs of the PWD. Such smart robots which can use AI can act as friends, nurses, caregivers and companions of the PWD.

**RD11:** Industry 4.0 Approach for Dementia Centric Research

Industry 4.0 and its impact in the manufacturing sector are well studied however; there is lack of studies based on analyzing the usability of Industry 4.0 for digital enhancement, smart work environment, and healthcare sectors (Shamim et al. 2016). As Industry 4.0 refers to smart manufacturing, implementation of CPS for production, it is well suited for the development of ATs tailored to the needs of the PWD. The customized production process of Industry 4.0 is well suited for specialized ATs and worth investigating in this domain.

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# APPENDIX A

## Semi-Structured Interview Template

Participant's ID ______ - __________ - __

Visit Code 10 .0

Date of Interview ____________
DD MM YY

Initials of Interviewer _____ (minimum of 2 letters)

**To be completed at time of data entry:**

Date of data entry ____________
DD MM YY

City of the Interview _____

1. Overall, what is your experience using assistive technology (AT)? (Probes: What are some of the reasons you used assistive technology? What are some of the reasons you continued using assistive technology until now?)

   Enter response here

2. Now let's talk about the AT under your use in detail:
   a. What types of AT you are using?

      Enter response here

   b. What did you like most about the AT you are using?

      Enter response here

   c. What did you like least about the AT you are using?

      Enter response here

3. How much did you like the appearance of the AT? *(Probes: size, texture etc.)Do you require any change?*

   Enter response here

4. How effective are you current AT? How it increases your achievements? Whether it fulfills your needs?

   Enter response here

5. *Can you perform some of the maintenance needs of your AT by yourself?*

| |
|---|
| Enter response here |

6. Does it provide you with mobility support, environmental control or independence? How?

| |
|---|
| Enter response here |

7. Does it improve your self-esteem, confidence and cognitive abilities? If No, How it can?

| |
|---|
| Enter response here |

8. Does it provide opportunities of communication, social networking and sharing your ideas? If No, How is can??

| |
|---|
| Enter response here |

9. *Is it adaptable to your personality, cultural and religious beliefs?* If No, *How it can be?*

| |
|---|
| Enter response here |

10. Do you think the current AT appropriate for your future needs? If No, How it can be?

| |
|---|
| Enter response here |

11. Do you require any external support for using current AT? If the answer is Yes, What type of external support you require?

| |
|---|
| Enter response here |

12. Do you believe that the current AT you are using are affordable?

| |
|---|
| Enter response here |

13. Do you think you have appropriate knowledge and training to use current AT? If No, What type of knowledge and training you require?

| |
|---|
| Enter response here |

14. Does your current AT helps you in tourism and travel? If No, what type of help you require from AT for tourism and travel?

| |
|---|
| Enter response here |

15. Do you have any other recommendations for improving the quality of current AT?

| |
|---|
| Enter response here |

**<u>Comments</u>: INTERVIEWER,** use this space to summarize how the semi-structured interview went, including the mood or effect of the participant during the interview.

| |
|---|
| Enter response here |

# APPENDIX B

## Assistive Technology Usability Evaluation Questionnaire

**Dear respondent,**

- As part of my PhD research work at Bournemouth University, I am conducting a survey on my thesis topic "Impact of Assistive Technologies in Supporting People with Dementia". The objective of this survey is to investigate the usability of assistive technology from people with dementia based on their experiences and to explore their future needs.
- The information you provide is strictly confidential and will solely be used for research purpose only. The identities of participants will not be publicized. Results of the study will be made to general public, universities and students for further research. I will be appreciating if you could complete the following questionnaire.
- You are consenting on taking part, by completing this questionnaire. If you have any question about the research, please contact IkramAsghar or Prof Hongnian Yu.

  Prof Hongnian Yu: 01202 961150 (UK), Email: yuh@bournemouth.ac.uk

  IkramAsghar: 03335800415 (PAK), Email: iasghar@bournemouth.ac.uk

  For any complaints please contact Prof Mark Bently.

  Prof Mark Bently: 01202 962203 (UK), Email: mbentley@bournemouth.ac.uk

  Thank you very much for your cooperation. IkramAsghar (PhD Researcher), Bournemouth University, United Kingdom.

---

**Before you begin, please indicate who is completing this survey.**

I am an assistive technology user myself ☐

I am a family member of an assistive technology user and filling on his behalf ☐

I am a care giver of assistive technology user and filling on his behalf ☐

Other: Please specify ____________

SECTION I

The items in this section concern your Demographic Profile. Please choose the correct option from the given options.

**1. What is your Gender?**

Male ☐ Female ☐

**2. What is your age?**

1 – 20 years ☐ 21 – 40 years ☐ 41 – 55 years ☐ 55-70 years ☐ 70-85 years ☐ 85 or more ☐

**3. Where do you live?**

Lahore ☐ Islamabad ☐ Rawalpindi ☐ Faisalabad ☐ Abbottabad ☐ Peshawar ☐

Mianwali ☐ Other: Please specify ☐

**4. Where do you normally get assistive technology support?** (You can choose multiple options)

Own House ☐ Care Home ☐ Hospital ☐ Community Center ☐ Other: Please specify ☐

**5. Do you have any difficulty with the following function?** (You can choose multiple options)

Seeing ☐ Remembering ☐ Learning ☐ Lifting ☐ Hearing ☐

Interacting with Other ☐ Speaking ☐ Walking ☐ Thinking ☐ Listening ☐

Other: Please specify ☐

**6. What Type of Assistive Technology you use?** (You can choose multiple options)

Smart Walker ☐ Tablet or iPad ☐ Reminder of Prompter ☐ Assistive Mobile Phone ☐

GPS Technology ☐ Assistive Robot ☐ Monitoring Technology ☐ Software Technology ☐

Event Organizer ☐ Google Calendar ☐ Leisure Technology ☐ Wrist Watch with Sensors ☐

Web Based Technology ☐ Other: Please specify Assistive Software ☐

**7. What is your current living situation?**

Living alone ☐ Living with family members ☐ Living with roommates ☐

Living in a group home ☐ Living in a nursing facility ☐ Living in an institution ☐

**8. What funding mechanism you use while purchasing assistive technologies?** (You can choose multiple options)

Insurance ☐ Personal ☐ Donation ☐

Agency ☐ Government ☐ Other: Please specify ☐

SECTION II

The questions in these section concern different factors related to assistive technologies usage. Using the scales below, please indicate the extent to which you agree with each statement by circling your choice in the right columns.

| **Strongly Disagree** | **Disagree** | **Neutral** | **Agree** | **Strongly Agree** |
|---|---|---|---|---|
| **1** | **2** | **3** | **4** | **5** |

| No | Questions | Scale | | | | |
|---|---|---|---|---|---|---|
| 1 | The use of Assistive Technology has improved my achievements. | 1 | 2 | 3 | 4 | 5 |
| 2 | The Assistive Technology meets my needs. | 1 | 2 | 3 | 4 | 5 |
| 3 | The interface of the Assistive Technology is effective. | 1 | 2 | 3 | 4 | 5 |
| 4 | The Assistive Technology helps me to become more independent. | 1 | 2 | 3 | 4 | 5 |
| 5 | Operation and maintenance manuals are included with the Assistive Technology. | 1 | 2 | 3 | 4 | 5 |
| 6 | The operation and maintenance instruction book spells out all maintenance routines to be followed. | 1 | 2 | 3 | 4 | 5 |
| 7 | The operation and maintenance instructions are effective. | 1 | 2 | 3 | 4 | 5 |
| 8 | The Assistive Technology functions as claimed by the manufacturer. | 1 | 2 | 3 | 4 | 5 |
| 9 | The Assistive Technology provides mobility support for me. | 1 | 2 | 3 | 4 | 5 |
| 10 | The Assistive Technology provides environmental control for me. | 1 | 2 | 3 | 4 | 5 |
| 11 | The Assistive Technology provides sensorial support for me. | 1 | 2 | 3 | 4 | 5 |
| 12 | The Assistive Technology helps me carrying out daily activities independently without external physical support. | 1 | 2 | 3 | 4 | 5 |
| 13 | The Assistive Technology helps me to improve my self-esteem. | 1 | 2 | 3 | 4 | 5 |
| 14 | The Assistive Technology helps to improve my cognitive abilities. | 1 | 2 | 3 | 4 | 5 |
| 15 | By using the Assistive Technology the complexity of tasks decreases for me. | 1 | 2 | 3 | 4 | 5 |
| 16 | By using the Assistive Technology I feel safer and secure in carrying out routine activities. | 1 | 2 | 3 | 4 | 5 |
| 17 | The Assistive Technology helps me for more communication opportunities. | 1 | 2 | 3 | 4 | 5 |
| 18 | The Assistive Technology helps me to have interaction with other people. | 1 | 2 | 3 | 4 | 5 |
| 19 | The Assistive Technology enables me to develop social networks. | 1 | 2 | 3 | 4 | 5 |
| 20 | The Assistive Technology helps me to get formal support through interaction with others. | 1 | 2 | 3 | 4 | 5 |
| 21 | The Assistive Technology is adaptable to my life style. | 1 | 2 | 3 | 4 | 5 |
| 22 | The Assistive Technology is adaptable to my personality. | 1 | 2 | 3 | 4 | 5 |
| 23 | The Assistive Technology is compatible with my cultural beliefs. | 1 | 2 | 3 | 4 | 5 |
| 24 | The Assistive Technology influences my dietary style. | 1 | 2 | 3 | 4 | 5 |
| 25 | The Assistive Technology is appropriate for future use. | 1 | 2 | 3 | 4 | 5 |
| 26 | The Assistive Technology is likely to become obsolete in the near future due to compatibility problems with new devices. | 1 | 2 | 3 | 4 | 5 |
| 27 | It is reasonable to expect from me to carry out some of the repairs. | 1 | 2 | 3 | 4 | 5 |
| 28 | I can independently go through all start-up and diagnostic routines. | 1 | 2 | 3 | 4 | 5 |
| 29 | The supplier assembles and/or installs the Assistive Technology. | 1 | 2 | 3 | 4 | 5 |
| 30 | A technician or engineer is required for initial assembly or installation. | 1 | 2 | 3 | 4 | 5 |
| 31 | Special tools are required for assembly, installation or start-up. | 1 | 2 | 3 | 4 | 5 |
| 32 | Other kinds of devices/furniture are required to complete the system (e.g., special tables, wall mountings etc.). | 1 | 2 | 3 | 4 | 5 |

| No | Questions | Scale | | | | |
|---|---|---|---|---|---|---|
| 33 | The price and maintenance of the Assistive Technology is appropriate. | 1 | 2 | 3 | 4 | 5 |
| 34 | There are warranties with the Assistive Technology. | 1 | 2 | 3 | 4 | 5 |
| 35 | The Assistive Technology is dependable. | 1 | 2 | 3 | 4 | 5 |
| 36 | I can easily handle Assistive Technology maintenance. | 1 | 2 | 3 | 4 | 5 |
| 37 | I can sustain my attention while using Assistive Technology. | 1 | 2 | 3 | 4 | 5 |
| 38 | I was able to learn to use the Assistive Technology during the orientation. | 1 | 2 | 3 | 4 | 5 |
| 39 | I have sufficient technology literacy to use the Assistive Technology. | 1 | 2 | 3 | 4 | 5 |
| 40 | The angle and visual distance of Assistive Technology is appropriate for me. | 1 | 2 | 3 | 4 | 5 |
| 41 | The Assistive Technology is useful for tourism activities. | 1 | 2 | 3 | 4 | 5 |
| 42 | The Assistive Technology helps me while travelling. | 1 | 2 | 3 | 4 | 5 |
| 43 | The Assistive Technology is useful for selecting tourist attractions. | 1 | 2 | 3 | 4 | 5 |
| 44 | The Assistive Technology enables me to manage leisure activities. | 1 | 2 | 3 | 4 | 5 |
| 45 | Overall based on my experience I am satisfied with the performance of current Assistive Technology. | 1 | 2 | 3 | 4 | 5 |
| 46 | Based on my experience with Assistive Technology I am likely to keep on using it in future. | 1 | 2 | 3 | 4 | 5 |
| 47 | Based on my experience with Assistive Technology, I would recommend it to a friend. | 1 | 2 | 3 | 4 | 5 |

SECTION III

The question in this section concerns your future requirements from AT. Please choose the correct option from the given options.

**What Type of Assistive Technology would you recommend academia and industry to put more efforts in future based on your personal requirements?** (You can choose multiple options)

Smart Walker ☐ Tablet or iPad ☐ Reminder of Prompter ☐ Assistive Mobile Phone ☐
GPS Technology ☐ Assistive Robot ☐ Monitoring Technology ☐ Software Technology ☐
Event Organizer ☐ Google Calendar ☐ Leisure Technology ☐ Wrist Watch with Sensors ☐
Web Based Technology ☐ Other: Please specify Assistive Software ☐

**Do you have any suggestions of message regarding improvements in existing assistive technologies functionalities?**

## Thank You

# APPENDIX C

## Interview Participation Consent Form

**Title of Project:** *Impact of Assistive Technologies in Supporting People with Dementia*

**Name and contact details of Principal Investigator**

*IkramAsghar*

*Christchurch House, Talbot Campus, Fern Barrow, Poole, BH12 5BB, United Kingdom*

*iasghar@bournemouth.ac.uk*

**Please tick box if you agree with the statement**

1- I confirm that I have read and understand the information sheet for the above study and given the opportunity to ask questions. ☐

2- I understand that my participation is voluntary and that I am free to withdraw at any time (without giving reason and without there being any negative consequences) up to the point where the data are processed and become anonymous, so my identity cannot be determined. ☐

3- I agree to take part in this study. ☐

4- I understand that data collected about me during this study will be anonymised before it is submitted for publication. I understand that my name will not be linked with the research materials, and I will not be identified or identifiable in the outputs that result from the research. ☐

5- I agree to allow the dataset collected to be used for future research projects. ☐

6- I agree to be contacted about possible participation in future research projects. ☐

____________________

Name of Participant

____________________

Date

____________________

Signature

# APPENDIX D

## Case Study Participation Consent Form

**Title of Project:** *Impact of Assistive Technologies in Supporting People with Dementia*

**Name and contact details of Principal Investigator**

*IkramAsghar*

*Christchurch House, Talbot Campus, Fern Barrow, Poole, BH12 5BB, United Kingdom*

*iasghar@bournemouth.ac.uk*

**Please tick box if you agree with the statement**

1- I confirm that I have read and understand the information sheet for the above study and given the opportunity to ask questions. ☐

2- I understand that my participation is voluntary and that I am free to withdraw at any time (without giving reason and without there being any negative consequences) up to the point where the data are processed and become anonymous, so my identity cannot be determined. ☐

3- I agree to take part in this study. ☐

4- I understand that data collected about me during this study will be anonymised before it is submitted for publication. I understand that my name will not be linked with the research materials, and I will not be identified or identifiable in the outputs that result from the research. ☐

5- I agree to allow the dataset collected to be used for future research projects. ☐

6- I agree to be contacted about possible participation in future research projects. ☐

____________________

Name of Participant

____________________

Date

____________________

Signature