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How are attitudes and behaviours to the ageing process changing in light of new media and new technology? How might these continue to evolve by 2025 and 2040?

Future of an ageing population: evidence review

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How are attitudes and behaviours to the ageing process changing in light of new media and new technology? How might these continue to evolve by 2025 and 2040?

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Executive summary

Well-publicised demographic changes regarding the increasing proportion of older people in society (not just in the UK but across the globe) indicate that by 2050, it is projected that a fifth of the worldwide population will be aged over 60 years, and in some countries the proportion of older people will be even higher. Digital technologies – in particular computers and the internet – are also increasingly available and offer sophisticated functions and services that are widely expected to have a role to play in responding to the challenges posed by the ageing population. This brief review examines current usage of digital technologies by older people and the ways in which this is changing their experiences of ageing. It considers some of the attitudes and behaviours underpinning policies and practices regarding this relationship. The expected evolution of technology over the next 10 years (until 2025), and the nature of projected developments as we approach 2040, are also considered. Finally some of the key research challenges are considered. The main points are summarised below.

Older people's use of new technologies

The most significant digital technology in terms of actual/potential transformation of the lives of older people is the internet. Yet, despite the myriad benefits that can be gained from the information, communication and connectivity that it makes available, many older people have been relatively slow to adopt the internet compared to younger generations, leading to a so-called 'grey digital divide'. Nevertheless this divide is narrowing and growing numbers of older people are using a wide range of digital technologies. There is some evidence of differences between older and younger people's patterns of usage, but there is also evidence of significant heterogeneity between older people in terms of both usage and attitude.

Changes in their experiences of ageing

Older people, even those who are not users themselves, recognise that technology can have benefits for their independence and well-being. They can mitigate the impact of declining capabilities, and facilitate communication, for example easing the pain of separation from loved ones caused by geographical distance through the use of, e.g. Skype and email. However choice, control, issues of privacy, and fear of reduced social interaction are key concerns for older people, particularly in relation to the use of assistive living technologies.

Changing attitudes and behaviours towards ageing and older people

New technologies have promoted extensive debate and discussion by academics and others regarding older people in the context of their use/non-use of digital technologies. A number of myths have developed and become prevalent regarding older people and their relationship with digital technologies. These appear to be influencing corporate and government behaviours towards older people – sometimes in unhelpful ways.

Emerging technologies and future technology developments that may have particular impact for older people

The McKinsey Global Institute (Manyika *et al*., 2013) identifies the following technologies as likely to have significant economic and social impact by 2025: mobile internet, the automation of knowledge work, the 'Internet of Things', cloud technology, advanced robotics, autonomous and near-autonomous vehicles, next-generation genomics, energy storage, 3D printing, advanced

materials, advances in gas exploration and recovery, and renewable energy. These technologies offer potentially significant benefits for citizens of all ages. Specifically for older people, many of these are likely to have an impact in terms of prolonging life expectancy and maintaining physical capability and independence into older age. For example autonomous or near-autonomous vehicles offer the possibility of safe personal transportation into considerably older age.

Key research challenges to be addressed if the potential benefits are to be realised

- Exploration of the impact of pervasive computing – for example use of wearable computers, embedded intelligence in the home environment and in external spaces.

- Understanding the impact of increasing complexity and the tension between integration of services planned by governments and the proliferation of systems and devices in the commercial market.

- Identification and development of social processes to engage older people in the design and development of future technologies that meet their specific needs and capabilities, and associated implementation strategies.

1. Introduction

Well-publicised demographic changes regarding the increasing proportion of older people in society (not just in the UK but across the globe), and growing recognition of their economic and social significance, mean that attention is being focused on the implications and associated policy and practice issues. At the same time, the scope and number of new technologies is increasing rapidly. It is recognised that these changes, together with other social and demographic changes, mean that the experience of ageing for the current generation of older people is different from that of previous generations – which may be in both positive and negative ways. It is also recognised that recent and emerging technological developments have the potential to mitigate or prevent some of the negative personal, social and economic consequences of ageing and an ageing population.

By 2050, it is projected that around one fifth of the worldwide population will be aged over 60 years (United Nations, 2012), and in some countries the proportion of older people will be even higher. Digital technologies – in particular computers and the internet – are widely expected to have a role to play in responding to these challenges. There is increasing interest in the exploitation of digital technologies specifically to deliver care and health monitoring services for older people (Wangberg *et al*., 2007). Digital technologies also provide access to an ever-increasing range of information, goods, services, entertainment/leisure, and educational and social networking opportunities that can help older people to maintain their independence and social connectedness and to improve their quality of life. If older people are 'digitally engaged' (i.e. have access, interest and the ability to use digital technologies) there are opportunities to reduce the so-called 'burden of care' associated with an ageing population, and to achieve wider benefits from their ability to participate socially and economically (Bradshaw, 2011). Furthermore, because government as well as commercial services are increasingly being delivered online, it is recognised that older people who are not digitally engaged will not only fail to enjoy the advantages, but may be at risk of real economic and social disadvantages (Olphert and Damodaran, 2013).

The aim of this Evidence Review is to explore how attitudes and behaviours to the ageing process are changing in light of new media and new technology, and how these might continue to evolve by 2025 and 2040. It focuses on addressing the following questions:

- How are older people themselves using new technologies and new media?
- How have these changed their own experiences of ageing?
- How have new technologies changed attitudes and behaviours towards ageing and older people?
- What emerging technologies and future technology developments may have particular impact for older people at a personal, social and economic level?
- What are the key research challenges to be addressed if individuals and society are to derive most benefit from developments in technology?

This review is informed by research evidence and systematic reviews of the literature relating to older people and digital technologies undertaken by the authors as part of research projects funded by the UK Research Council's New Dynamics of Ageing Research Programme (2008–2013)[1] and the EU's Ambient Assisted Living Programme (2010–2012).[2] This 'state of the art' knowledge has been further informed by the authors' research collaborations with leaders in the field of human–computer interaction, including the Human Centred Computing research group at the University of Dundee and the Digital World Research Centre at the University of Surrey, participation at national and international conferences such as the British Society for Gerontology Conferences 2010 and 2012, the International Society for Gerontechnology Conference 2010, and the International Association for Gerontology and Geriatrics conferences 2013. A supplemental review of the literature was undertaken for the purposes of updating this evidence base, drawing on articles published since 2012, and additional academic advice was sought to address in particular the question of potential future technology developments.[3]

[1] Sustaining IT use by older people to promote autonomy and independence. ESRC Grant Ref. RES-353-25-0008. See http://sus-it.lboro.ac.uk

[2] HOST – Smart technologies for seniors in social housing. EU Grant Ref. AAL-2010-3-041. See: www.host-aal.eu/

[3] Thanks are due to Professor Bryan Manning, University of Westminster.

2. Review findings

2.1 Older people's attitudes and behaviours

2.1.1 How are older people themselves using new technologies and new media?

Digital technology has replaced analogue technology in many familiar consumer products and household appliances (e.g. mobile phones, digital cameras, digital radio and digital television) and has enabled the development of new devices such as e-book readers and satellite navigation systems (Ofcom, 2010).

Data from a survey of 323 older people (aged 50+ years) (Damodaran *et al*., 2014) show that older people are using a wide range of digital technologies. The most common digital devices used by participants included mobile phones (95%), CD/DVD players (91%), desktop computers (88%), digital cameras (78%), laptop computers (74%), and satellite navigation (43%). Less commonly used devices included MP3 players (31%), games consoles (29%), e-book readers (18%), digital camcorders (37%) and tablet computers (23%). The majority of participants used a wide range of digital devices, with 60% of respondents reporting using between four and seven digital devices on a regular basis. Approximately 20% used one to three digital devices and approximately 20% used seven to twelve digital devices.

Evidence suggests (e.g. Damodaran *et al*., 2014) that many older consumers welcome the additional features, functionality and benefits that digital versions of familiar products and devices offer, especially when these help to overcome the physical challenges that can accompany ageing such as decline of eyesight/hearing, memory problems, reduced dexterity or mobility. Many also offer opportunities for saving money or effort. For example e-book readers have become very popular with older readers (Bowker Market Research, 2012) because they are light to hold, help readers to remember their place, can provide dictionary definitions or translations, the font and lighting can be adjusted to improve readability, and they provide easy access to a supply of reading material which can save on the cost of buying books and/or travel to shops and libraries.

However the most significant digital technology in terms of actual/potential transformation of older peoples' lives is the internet. Indeed it has been argued that access to the internet has such fundamental implications for individuals that it should now be regarded as a basic human right (United Nations General Assembly, 2011). Yet, despite the myriad benefits that can be gained from the information, communication and connectivity that it makes available, many older people have been relatively slow to adopt the internet compared to younger generations, leading to the 'grey digital divide' (Millward, 2003).

The digital divide is a term that came into usage with the Clinton/Gore administration in the USA in the 1990s, recognising the implications for social inequalities that can follow from lack of access to new (digital) technologies. Norris (2001) identifies three different categories of digital divide – global, demographic and democratic. Global digital divides occur between less economically developed countries (LEDC) and more economically developed countries (MEDC); demographic divides on the other hand occur within nations, both LEDC and MEDC, due to disparities in the population from factors such as income, education and health. Norris further proposes, however, that even when there are high levels of uptake and usage of the internet, this not does always lead to improvements in democracy and empowerment of

individuals, resulting in a ‘democratic divide’ between those who can use and exploit the technology to achieve these ends and those who can/do not (Norris, 2001).

Age is widely recognised to be one dimension of a demographic digital divide, which tends to follow lines of social inequality. In other words, those who are not using the internet tend to be from lower socio-economic status groups, have lower levels of education and also have a disability or are in poor health. Older people are more likely to have lower incomes and levels of education and to have one or more disabilities or health conditions and therefore it is not surprising that they are also less likely to be digitally engaged. In the UK, figures from the Office for National Statistics (ONS) (2014a) showed that 13% of UK adults (6.4 million) have never used the internet. Of this group, older people represent the vast majority, with 5.6 million people over the age of 55 in this category (Office for National Statistics, 2014a). This ‘grey digital divide’ is evident not just in the UK but across the globe and in both developed and developing countries, for example in Canada (Haight *et al*., 2014) and in China (China Internet Network Information Center, 2014).

This finding has led to a number of misconceptions about the relationship between older people and technology (explored in more detail in Section 2.2). In particular it has led to the belief that older people are not interested in or do not have the ability to use new technologies. Yet many studies show that chronological age in itself is not a barrier to the adoption of the internet. For example, a large-scale survey by Pew Internet in the USA (Smith, 2014) shows that there are two distinct groups of older Americans: “The first group (which leans toward younger, more highly educated or more affluent seniors) has relatively substantial technology assets and also has a positive view towards the benefits of online platforms. The other (which tends to be older, and less affluent, often with significant challenges with health or disability) is largely disconnected from the world of digital tools and services, both physically and psychologically).”

Yet older people are a vastly heterogeneous group; in addition to the basic physiological, psychological and socio-economic differences that distinguish human beings from each other, they may develop, in different degrees and different combinations, changes in health and capability. Furthermore their individual experiences over the course of their lifetime will have shaped their attitudes and motivations in different ways. This suggests that older people may be even more diverse in terms of their characteristics, needs and preferences in relation to technology usage than younger people. Digital exclusion is likely to be exacerbated by a combination of multiple factors in the same way as an individual’s level of social and financial deprivation.

Specific barriers to internet adoption by older people have been extensively researched and are well established. These include lack of skills/capability and confidence (Chen and Persson, 2002; Selwyn *et al*., 2003; Tak and Hong, 2005; Freese *et al*., 2006; Juznic *et al*., 2006; Schleife, 2006; Carpenter and Buday, 2007; Turner *et al*., 2007; Quinn, 2010; Heart and Kalderon, 2013; Heinz *et al*., 2013), social support (Paul and Stegbauer, 2005; Carpenter and Buday, 2007; Hill *et al*., 2008; Heart and Kalderon, 2013; Lee and Coughlin, 2014), cost/affordability/income (White and Weatherall, 2000; Chen and Persson, 2002; Saunders, 2004; Carpenter and Buday, 2007; Morris *et al*., 2007; Hill *et al*., 2008; Pan and Jordan-Marsh, 2010; Lee and Coughlin, 2014), inadequate training and the lack of ongoing support (Digital Inclusion Panel, 2004), concerns about security (Olphert *et al*., 2005; Xie *et al*., 2012), and lack of perceived need/motivation (Melenhorst *et al*., 2006; Morris *et al*., 2007). Some of these barriers can be addressed through interventions such as the appropriate provision of education, training, support, and the promotion of user-centred, inclusive approaches to the design of technology to make hardware and software easier to use and more accessible for those with

physical and/or cognitive limitations. Issues of cost and affordability require different interventions relating to the provision of low-cost, subsidised or free internet services for those least able to afford them, and the availability of affordable equipment. There is some evidence that cost of accessing the internet is becoming a less important barrier than in the past; this may be because equipment such as tablets and mobile phones which can be used for internet access are less expensive than desktop or laptop computers, and/or because many older people tend to be the recipients of 'handed down' technologies from family members. Perhaps the more challenging issue to address is lack of perceived need and motivation from some older people. Currently, initiatives from the UK Government such as 'Digital by Default' are seen as providing 'push' to encourage non-users to use digital channels to engage with government services. However studies such as Damodaran *et al*. (2014) identify a number of strategies that can encourage older people to explore and learn digital skills in the pursuit of activities that are enjoyable, meaningful and worthwhile, creating 'pull' for sustained digital participation rather than 'push' for short-term digital connection.

It has been suggested that the 'grey digital divide' is a relatively short-term phenomenon, and that the gap will eventually close, as people who are established computer users move into retirement, or as a consequence of the many initiatives and programmes designed specifically to encourage and teach older people to use computers and the internet, or perhaps as a consequence of improvements in ease of use and accessibility of the technology. Certainly there are growing numbers of older users; in the UK for example only 9% of people over 65 years used the internet on a daily basis in 2006, compared to 42% in 2014 (Office for National Statistics, 2014b). However older users can face a range of particular difficulties and challenges relating to their physical and cognitive abilities as well as to their social and economic circumstances, which may make it difficult or even impossible for them to continue sustained usage. Data from various surveys (Young *et al*., 2012; Olphert and Damodaran, 2013) indicate that between 3% and 39% of users may give up using their computers at some point and for some period of time, and suggest that older and disabled people are more likely to give up than other categories of user.[4] Thus, while it is encouraging to see growing numbers of older people becoming regular internet users, it may not be a permanent feature of their old age.

Surveys show that in addition to differences in the levels of internet usage between age groups, there are differences in the way in which different age groups use the internet (Ofcom, 2010; Dutton and Blank, 2013; Office for National Statistics, 2014a,b). As can be seen in Table 1, older people are generally somewhat less likely to use the internet for a range of activities than younger people, although there are some notable differences. Younger people are much more likely than older people to use the internet for social networking (although data suggest this is an application that is growing in popularity with older users). On the other hand, older people are more likely to use the internet for booking an appointment with a doctor/health practitioner.

Mobile phones have become everyday items for the vast majority of the population and older people are no exception, although studies and surveys show that patterns of usage may be different between generations. For example the use of mobile phones ('smartphones') to access the internet has grown rapidly in recent years, with around 62% of UK adults now said to be using this type of mobile phone in some surveys (Ofcom, 2014), whereas among older people

[4] Some reasons for the wide divergence in the statistics are discussed in Olphert and Damodaran (2013) but primarily relate to differences in the length of time used as an indicator of disuse, which ranges from 1 month since last use to 1 year. The study with both the largest sample size (25,169,820) and longest interval since last use (1 year) shows that while around 3% of the population as a whole may give up using their computers, this rises to almost 10% of older and disabled users.

(65+ years) the adoption of smartphones is currently estimated in the same survey to be around 20%. As with the adoption of the internet, the gap between older and younger users is closing, with one study suggesting that older people intend to purchase a smartphone when they next change their phone. This pattern of adoption suggests that older people are perhaps less likely to change their phones/upgrade as frequently as younger people. This may reflect values of economic prudence and against 'change for change's sake', and/or a reluctance to move away from familiar and less complex versions of their phones. While some market reports suggest that 80% of adults "reach for their smartphones within 15 minutes of waking", other studies (Hardill and Olphert, 2012) show that some older people regard their mobile phones more as devices to be used in case of emergency and rarely use them at all.

Table 1: Internet activities by age group (%)

Types of activity						
Age	**Reading or downloading online news, newspapers or magazines**	**Social networking e.g. Facebook or Twitter**	**Using services related to travel or travel accommodation**	**Internet banking**	**Selling goods or services over the internet**	**Making an appointment with a doctor or other health practitioner**
16–24	*65*	*91*	*38*	*56*	*24*	*8*
25–34	*73*	*80*	*53*	*71*	*36*	*8*
35–44	*69*	*68*	*52*	*66*	*35*	*11*
45–54	*60*	*54*	*54*	*62*	*26*	*13*
55–64	*48*	*37*	*44*	*47*	*15*	*15*
65+	*24*	*13*	*22*	*23*	*8*	*5*
Base: Adults (aged 16+ years) in Great Britain						

Source: Office for National Statistics (2014b)

2.1.2 How have these changed their own experiences of ageing?

Notwithstanding differences in frequency and patterns of usage, older users greatly value the benefits and independence that the internet provides. In addition to improved independence, reported benefits include enhanced personal health and well-being, self-efficacy, social interaction, economic and life chances, and civic engagement and participation (Damodaran *et al*., 2014). Conversely, when asked how they would feel if they were *not* able to use the internet, participants in one survey used strongly emotive words such as 'distraught', 'devastated', 'powerless', 'deprived' and 'lost' (Damodaran *et al*., 2014). Even when older people are not internet users, most are aware of the benefits for other people and express positive views towards it. Negative attitudes relate primarily to concerns about fraud, online security, pornography and concerns about 'computer addiction' (Damodaran *et al*., 2014).

For many older people, it could be said that the internet represents a form of assistive technology, helping them to lead their lives more independently and effectively (although paradoxically older people are often unaware of assistive technologies and in-built accessibility features that could help them with use of information and communications technology (ICT) in the face of capability changes). However the attitudes held towards assisted living technologies (ALTs) more widely by older people are perhaps more complex (Damodaran and Olphert, 2010). This is an aspect of technology development that highlights some sharp differences

between the hopes and aspirations of society, and those who care for older people, and the wishes and aspirations of older people themselves. While governments, healthcare providers and families/carers can see tremendous potential benefits for the way in which older people can be supported and helped to live independently, older people themselves have less positive views. As with the internet, many older people who do not use assistive technologies see them as being of tremendous potential benefit to other older people, but they are less willing to contemplate them as options for themselves. Choice, control, issues of privacy, and fear of reduced social interaction are key concerns for older people in relation to ALTs (Damodaran and Olphert, 2010).

The longer-term adoption patterns and social and economic impact of such technology developments are, however, still very much the subject of debate, and evidence points in opposite directions. While some studies suggest that existing telecare and telehealth applications do provide benefits for users and that older adults will welcome new forms of technology that could help them maintain their independence and quality of life (Heinz *et al*., 2013), others suggest that older people in poor health are currently least likely to adopt new technologies, and many older adults do not share the perception that ICT can significantly improve their quality of life (Heart and Kalderon, 2013). Furthermore, recent reviews of studies of the cost-effectiveness of telemedicine and telecare interventions concluded that there was no evidence that these are cost-effective compared to conventional health care (Chaudhry *et al*., 2006; Mistry, 2006; Barlow *et al*., 2007).

2.2 How have new technologies changed attitudes and behaviours towards ageing and older people?

2.2.1 Context

New technologies have promoted extensive debate and discussion by academics and others regarding older people in the context of their use/non-use of digital technologies.

The impact of new media and technology on attitudes and behaviours to the ageing process is reflected in popular culture on websites and on television. For example the impact of new media such as the website whenparentstext.com (n.d.), which has the caption “small keypad, old hands”, memes such as “my mother’s keyboard” (A Zillion Dollar Comics, 2013) passed around on Facebook, and even scenarios of Grandpa Simpson, painting him as ineffectual and lonely on the long-running television show the Simpsons, all reveal the prevailing beliefs and assumptions about ageing and the use of technology. Older people’s use of Facebook has even been highlighted on a Tumblr microblog entitled *Old People Writing on a Restaurant’s Facebook Page* (Tumblr, 2013) where Facebook posts written by older people are singled out. The first entry on this page has 4,670 notes (i.e. interactions with the post). The speed and reach of such posts poking fun and revealing underlying individual attitudes are far greater than individuals (rather than organisations) previously enjoyed and allows for a much more rapid and comprehensive spread of ideas and attitudes, including those relating to older people. The rise of new media is a double-edged sword for older people (and individuals in general); on the one hand giving older people an individual voice, on the other hand leaving them open to unwanted attention. Such attitudes create a feedback loop of sorts by creating and reinforcing beliefs that older people tend not to be able to use technology.

From the perspective of older people, factors affecting technology use are also apparent. In an American interview study of an ethnically diverse, low-income group of 91 older adults, there were a number of factors to taking up internet training, with ageing anxiety, computer anxiety,

education and gender factors in particular predicting intention to take computer training (Jung *et al*., 2010). Psychological barriers were seen as stronger predictors of use than previous computer experience in this group (Jung *et al*., 2010). Another qualitative study from Israel found that older people felt they had the capacity to learn technology for those that desired such learning (Blit-Cohen and Litwin, 2004). Additionally, the need for training and encouragement were highlighted (Blit-Cohen and Litwin, 2004). The studies point to a need to not treat older people as a homogeneous group of 'internet refuseniks', but to take into account life factors and motivation.

A number of myths have developed regarding older people that manifest themselves in attitudes which have become prevalent in our society – and influence corporate and government behaviours and policies relating to older people. There is a paucity of analysis of myths specific to older people in technology in the academic literature. One exception to this is the paper by Wandke *et al*. (2012) in the journal Gerontology, which addresses the question of the origins of such myths in the following way:

"These myths are based less on a systematic review of the scientific literature (usually myths are not explicitly discussed there) than on our experiences over the past 8 years of research in this field and on discussions with computer scientists, designers and older people. Quite explicitly, many myths can be found in mass media and advertisements and are often embodied in electronic devices specifically designed for older people."

We have taken a similar approach to identifying three common myths about older people and digital engagement. It is important to state that the myths are implicit in our digital society, and are manifested thematically, i.e. they are exhibited in behaviour. For example 'Techy tea parties', the annual 'Spring online campaigns' and 'IT taster sessions' reflect the belief that older people need encouragement and persuasion to go online.

The authors have based their identification of myths on (i) their years of combined experience working with older people, with Government departments, industry professionals, academics and social and healthcare practitioners and on (ii) their observations of manifestations of these myths in popular culture.

The three myths documented are implicit in society and are reflected thematically in papers and presentations in conferences, articles in the press, in Government policy statements, and in digital inclusion campaigns. Further, the authors' research (including the NDA Sus-IT project) on use of information and communication technologies by older people provides empirical evidence of the reality of older people's digital engagement. The findings contrast sharply with the myths identified. The three myths are described below.

2.2.2 Myth 1: Once people go online, they stay online

Evidencing the existence of the myth: There have been numerous digital inclusion initiatives over the past decade including IT and Biscuits, UK Online, Spring Online (Digital Unite, 2015) and, most recently, 'techy tea parties' (Age UK, 2014). These are all focused on getting people online and 'selling' the benefits of being online – but are not aimed at helping to sustain digital engagement over the long term and in the face of age-related capability decline.

Reality: Between 3% and 10% of internet users stop using the internet for a variety of reasons. Research evidence shows that, for significant numbers of people, a range of issues arise in later life as ageing is associated with sensory, physical and cognitive changes such as impaired

sight and hearing and reduced mobility (Olphert and Damodaran, 2013). Such changes pose problems for some older individuals in learning and using ICT (Ramondt *et al*., 2013). For example, deterioration in visual function affects the capacity of older ICT users to see what is on the screen while the effects of cognitive impairment on short-term memory among some older ICT users have been identified as barriers to continued use. Chronic pain can also be a significant barrier to sustained use of ICT (Young *et al*., 2012).

2.2.3 Myth 2: Older people are not interested in going online

Evidencing the existence of the myth: The significant effort and emphasis given in Government circles and by major charities and other agencies to attempt to persuade older people to go online through a variety of programmes reflects the belief that older people are not interested in the internet. This myth is prevalent in wider society as well, for example, the US television show '$#*! My Dad Says' screened an entire episode about the father not wanting Wi-Fi in his house! (Internet Movie Database, 2015).

Reality: There is a widespread belief that in these groups there are many older non-internet users who are hardened 'refuseniks' who actively resist use of technologies and for whom it is necessary to develop new strategies to engage their interest in using technology. Yet there is also a critical distinction between lacking perceived relevance of the internet and being a hardened refusenik. Indeed, the main reason older people go online is the perceived usefulness of doing so (Wandke *et al*., 2012). Further, the usability barriers faced by older adults can be interpreted mistakenly as disinterest rather than an access issue, when it is problems with perceived usability rather than perceived usefulness that are cited by older people as the main barrier to use (Wandke *et al*., 2012). Related to this myth is the idea that as people who have grown up in the digital age get older, they will continue to be digitally engaged (Wandke *et al*., 2012). This fails to take into account decline in age-related capability, motor skills and cognition, and the effect that learning new interaction paradigms has on older users (Wandke *et al*., 2012). This evidence is seen with the current cohort of older people who have difficulty understanding multi-layered interfaces, having grown up in a previous interaction paradigm (Lim, 2010).

2.2.4 Myth 3: The digital skills older people require are the same as those needed in the workplace (i.e. 'one size fits all' both in terms of the type of skills and the mode of delivery)

Evidencing the existence of the myth: There is extensive investment (for example by Go-ON, BBC, UK Online, etc.) in categorising 'basic skills' and providing training material online – as though the requirements were homogeneous and could be met through standardised delivery.

Reality: The digital skills required by older people no longer employed in the workplace, who have their own agenda and their own objectives for use of ICT, are in fact very different to those generally required and acquired in the workplace. For example, older people often use video-communication tools such as Skype for communicating with younger grandchildren, but prefer to use email with grandchildren over the age of 10 (Sayago *et al*., 2011). These are very specific skills sought and used for a very specific subset of interactions – and are sometimes characterised as 'micro-learning'.

The exception to this individual agenda is that there are certain skills which relate to safeguarding security and privacy, and dealing with technological change such as automatic upgrades. Sayago *et al*.'s (2011) study demonstrated that older people were aware of the need for security and privacy. Older people are highly vulnerable to fraud and varied scams unless they develop such skills themselves or have access to readily available advice and help.

2.3 What emerging technologies and future developments may have particular impact for older people at a personal, social and economic level?

2.3.1 Future developments in technology

Predicting future developments in technology is difficult. Moore's Law (Moore, 1965) predicts that technological developments will proceed at an ever-increasing pace. Technology change can be both evolutionary and revolutionary; much of the change in technology we expect to see over the period in question will be evolutionary change, in terms of continuous development/improvement of existing devices and applications. Accordingly the developments described above are likely to continue to evolve and become more sophisticated, potentially increasing their usability, utility and acceptability to individuals, and thereby increasing their potential adoption and benefits. Periodically, however, there are 'disruptive' developments that will have a more dramatic effect on society or parts of it. Few foresaw the huge and pervasive impact of the internet on individuals and society as a whole when the 'world wide web' first appeared as a mechanism for communication between scientists in the 1980s, yet identifying the currently emerging technologies that will go on to have this scale of impact is difficult to do at the early stages of the development and adoption.

In 2013 the McKinsey Global Institute issued a report identifying twelve 'disruptive' technologies that they believe will have significant economic and social impact by 2025 (Manyika *et al*., 2013). These are: mobile internet, the automation of knowledge work, the 'Internet of Things', cloud technology, advanced robotics, autonomous and near-autonomous vehicles, next-generation genomics, energy storage, 3D printing, advanced materials, advances in gas exploration and recovery and renewable energy. Many of these technologies in isolation could deliver significant benefits not only for citizens of all ages, but with specific implications for older people. For example autonomous or near-autonomous vehicles may have an impact in prolonging and enhancing ability to travel; some older people have to stop driving as a result of physical impairments and others simply lose confidence – safe personal transportation could overcome these barriers and enable people to travel away from the home, whether for social or business reasons. Advances in materials and in 3D printing may offer new possibilities for joint replacements and even organ replacements. However the greatest changes and most beneficial outcomes are likely to arise from developments which are enabled by combinations of these technologies. Two key areas of potential benefit for older people are in health and independent living, and in social inclusion and participation.

2.3.2 Implications for health and independent living

Advances in genomics, materials and robotic surgery technology are likely to have a major impact in terms of prolonging life expectancy and maintaining physical capability in older age. Advances in mobile internet, the Internet of Things and cloud technology will make ICT both more pervasive and more 'invisible', i.e. less need for physical interaction with devices by the 'end user' (older person). This is already leading to new developments that are expected to improve the management of chronic conditions, extend the range of conditions which are managed at home, and allow management while outside the home (Lewin *et al*., 2010).

Among the types of services that stand to benefit from mobile internet technology, health care is one of the most promising. In just one application – management of chronic disease – this technology could potentially cut more than $2 trillion a year in the projected cost of care by 2025. Today, treating chronic diseases accounts for about 60% of global healthcare spending,

and it could be more than $15 trillion globally by 2025. Patients with conditions such as heart disease and diabetes could be monitored through ingestible or attached sensors, which can transmit readings and alert the patient, nurses and physicians when vital signs indicate an impending problem, thus avoiding crises and the costs of emergency room visits or hospitalisation (Manyika *et al*., 2013).

The greatest benefits in health care could come from improved efficiency in treating patients with chronic conditions. Using sensors that read the vital signs of patients at home, nurses and doctors can be alerted to emerging problems, such as a dangerous drop in the glucose levels of a diabetic patient. Advising patients about how to address problems at home or treating them in outpatient settings lowers the frequency of costly emergency visits and unnecessary hospitalisation (Lewin *et al*., 2010). We expect to see a shift over the next few years from alarm-based telecare systems to systems that use more-nearly continuous lifestyle monitoring. We also expect to see the development of augmented reality services for those with cognitive disabilities and telecare services for older people when they are outside the home – through SMS reminder systems, navigation services, and services to locate dementia sufferers who wander and become lost.

The longer-term adoption patterns and social and economic impacts of such technology developments are, however, still very much the subject of debate, and evidence points in opposite directions. While some studies suggest that existing telecare and telehealth applications do provide benefits for users and that older adults will welcome new forms of technology that could help them maintain their independence and quality of life (Heinz *et al*., 2013), others suggest that older people in poor health are currently least likely to adopt new technologies, and many older adults do not share the perception that ICT can significantly improve their quality of life (Heart and Kalderon, 2013). Furthermore, a recent systematic review of studies of the cost-effectiveness of telemedicine and telecare interventions concluded that there was no evidence that these are cost-effective compared to conventional health care (Mistry, 2006).

Developments in robotics are widely predicted to lead to an increased use of robots/robotics for personal care and assistance. Japan, which has the largest and fastest growing older population, is leading in the research, development and deployment of advanced robotics. Robot assistants are being developed that will be capable of undertaking a range of ‘caring’ tasks, e.g. assisting with moving to and from a bed, wheelchair, seat or toilet, stair climbing, etc., drug and medication delivery, bathing and washing, help with eating (Yamazaki *et al*., 2012), and other devices will provide ‘exoskeleton’ support for limbs to aid movement and mobility (Lo and Xie, 2011). It is possible that when devices are found by users to mitigate the effects of growing frailty by prolonging some degree of independence and autonomy, that the attitudes towards robot assistants will become more favourable and their acceptance more widespread. Such devices have clear potential benefits for older people with physical and/or cognitive impairments that affect their ability to care for themselves. Tangible evidence of the impact of their use in achieving a reduction in the negative experiences and consequences of increasing vulnerability and progressive dependence on others can be expected to change the attitudes towards ageing of other people and of themselves.

However, other devices are being developed with the aim of providing social support and companionship. Paro, a robot which looks like a baby seal and which responds to human contact, is already in therapeutic use in Japanese hospitals and care homes and has been found to have positive effects on well-being (Mordoch *et al*., 2013). The market for personal care robots, which currently stands at $155 million in Japan, is predicted to grow to $3.7 billion

by 2035 (Kondo, 2014). Pressure on costs and resources for health and social care provision for older people in the UK is likely to mean that we will see growing numbers of robotic devices being deployed in the medium to longer term, but there are cultural differences between the UK and Japan which make it difficult to predict whether robots will be as widely accepted here. The evidence from Damodaran and Olphert (2010) mentioned above suggests that choice, control and personalisation will be important considerations for 'end users', alongside concerns about the potential for reduced social/face to face contact with people. There are also major ethical and safety issues to be addressed and debated (Sharkey and Sharkey, 2012), although a new International Standard (ISO 13482) (International Organization for Standardization, 2014) has recently been released to address safety standards for personal care robots, which is said to pave the way for greater consumer trust and confidence.

2.3.3 Implications for social inclusion and participation

As the 'grey digital divide' closes, and as digital technologies become more pervasive, it is predicted that most people will be online most of the time (Manyika *et al*., 2013). Online applications and services will continue to develop and to replace traditional delivery channels, both for Government and for commercial organisations. As well as telecare and telehealth services to ensure physical well-being, we expect to see take-up of a range of digital participation services which will connect, engage, stimulate and entertain older and disabled people in their homes. Already digital participation services offer older and disabled people access to a wide range of internet services which allow them to save money and to participate more fully in society.

A variety of means of interaction, including augmented reality services, will facilitate virtual participation in a wide range of activities. These could be family and social events, learning opportunities, work, or leisure activities such as the pursuit of hobbies or virtual tourism. Assuming the services and means of interaction are easy to use, accessible (including cost), and accompanied by appropriate learning and sustained support, older people – especially those with mobility limitations or who are geographically or socially isolated – could benefit by feeling more connected, more empowered and more independent through easy access to information and services.

Teleworking services are important to the future well-being of older and disabled people who wish to live independently at home, allowing older and disabled people to continue to contribute their skills to the economy and to society. They also enable greater job flexibility for potential informal carers who might otherwise struggle to combine a part-time job with responsibilities as a carer (Lewin *et al*., 2010).

3. Key research gaps and challenges

Emerging gaps in the understanding of the adoption of technology by older people include the lack of knowledge regarding the impact of pervasive computing – for example use of embedded intelligence in highly varied applications ranging from wearable computers, through embedded intelligence in the home environment to use in external spaces. The nature of the impact of pervasive computing for older people has the potential to polarise – if interaction becomes more flexible or more natural, then it may make interaction easier. On the other hand, the embedded nature of it may make it more complicated to use and accommodate, i.e. how do you control something when there is no physical artefact to interact with? For people with mild to moderate cognitive impairment, how will they understand a world controlled by 'invisible hands'?

Another gap that is already becoming apparent relates to the impact of increasing complexity and the tension between integration of services planned by governments and the proliferation of systems and devices in the commercial market. The proposed coming together of the delivery of health and adult social care will pose many dilemmas demanding relevant research to inform solutions and strategies.

Accepting and being able to accommodate technology change is likely to be an important component of older peoples' lives in the future – irrespective of the specific development involved. We can already see that a desire to 'keep up' has played a role in motivating older people to explore using new technologies. There are numerous lessons to be learned about how to encourage and support ongoing learning and exploration in safe, familiar venues with trusted people in the community. Such settings can provide the context for mechanisms and opportunities to encourage exploration and learning about new technologies, and support both for trouble-shooting and with transition/upgrading to new versions of familiar technologies.

There are already significant gaps at all levels in knowledge, awareness and preparedness needed to include a widespread lack of awareness of the individual and societal issues. It is the case that there is a substantial and growing body of knowledge (e.g. from the New Dynamics of Ageing Research Programme (Economic and Social Research Council, 2013)) about older people and their relationship with technology but this is not widely known and there are many prevalent myths (discussed in Section 2.2) which serve to impede progress.

There are very many research topics and issues that need to be addressed with the proliferation of pervasive technologies. Pressing requirements include the following.

- Explorations of the impact of pervasive computing – for example use of wearable computers, embedded intelligence in the home environment and in external spaces.
- Investigations of how people deal with changes to domestic technologies (i.e. smart TVs, smart appliances, thermostats, etc.) and how their use can be supported long term.
- Understanding the impact of increasing complexity and the tension between integration of services planned by governments and the proliferation of systems and devices in the commercial market. (This poses a particular complication in setting up telecare/telehealth devices in the home.)
- Identification and development of social processes to engage older people in the design and development of future technologies and their implementation strategies.

- Investigation of the digital disengagement process in which multiple and interacting factors (physical, psychological, social and technological) are involved. Each of these aspects merits further research to gain knowledge and understanding of the triggers, onset and progression of contributory factors to disengagement and in particular the way in which the factors act cumulatively or in combination to reduce and potentially bring to an end the digital engagement of individuals.

4. Conclusions and recommendations

4.1 Conclusions

This brief review of how new media and new technology are changing attitudes to and behaviours in the ageing process makes clear the vast scale of change occurring with developments in technology. However, the formulation and planning for systematic and strategic organisational, cultural and societal change lag far behind the scale and pace of technological change. Yet the challenge of accommodating and adapting to the changes that offer us solutions and benefits requires profound change in how we address our relationship with technologies – and take into account the many ethical dilemmas it will raise.

One major requirement will be to achieve greater digital inclusion throughout the population. There are many opportunities to progress this – given the political will. For example, Government procurement policy has the potential to be a powerful driver of digital inclusion and participation. By requiring most, if not all, ICT products, systems and services paid for by Government to include design features that are appropriate for older people and which have been shown to be valued and helpful to them, change would be swift among technology providers, and among ICT developers and designers – with widespread benefits for all. Such policies would include the requirement to recognise the diversity of older people, their needs, capabilities and the social and economic opportunities that would be enabled by appropriate ICT design and the provision of community-based ICT support. The latter will allow integration of offline and online support in existing venues and include outreach services to the housebound – promoting integration of health and social care. Such policies will need to emphasise the need for sustained long-term provision – and at a consistent level across the country.

Digital connection and internet access for older people have huge ramifications for their financial security. On the one hand it offers opportunities for making savings and for remaining economically active and on the other it presents a minefield of potential dangers associated with fraud and a wide variety of scams, identity theft, and so on. With the advent of ‘digital by default’, appropriate help and support with ICT in the community will become crucial to enabling self-help and promoting the autonomy and independence of many people.

4.2 Recommendations

The route to a sustained digitally engaged and empowered older population can only come about through appropriate design of technology and by making the right support and learning opportunities for ICT use universally available – locally in the home and in the community. Much of the knowhow required to address the existing shortcomings in ICT design and support provision already exists in the research outputs and outcomes of major publicly funded research programmes in the UK such as the New Dynamics of Ageing Research Programme. Exploiting this expertise appropriately has the potential to deliver an inclusive connected progressive society. Realisation of this potential requires political awareness and skill, the ability to harness lessons learned and viable collaborative approaches developed in the field in times of economic difficulty and unprecedented demographic shift. The ultimate reward available to any nation following this path is the achievement of the widespread active participation of the older population in the digital world and the many benefits that will follow for a digital society and economy.

The new research knowledge now available (for example through the New Dynamics of Ageing Research Programme) of the multi-faceted nature of digital engagement of older people highlights the need for joined-up policy and strategy of Government, business and relevant agencies in the third sector to address in co-design and with full engagement of older people to address effectively the real challenges of digital inclusion. Specific recommendations are as follows.

Nationwide networking and collaboration

- Coordinated policies, strategies and practices – informed by grass-roots engagement and participation – to promote and support digital participation that extends across central government and local government, the third sector and the business sector.
- An integrated framework of evidence-based strategies for promoting sustained digital participation.
- Recognition of the diversity in the older population in policies, strategies and design.
- Widespread opportunities for development of digital capabilities of all – including older and disabled people – through enjoyable and rewarding pursuits enabled by use of ICT and the internet.
- Community-based ICT learning and support provision.
- Engagement of older people in the design and development of ICT and in deliberating policy and strategy options for deploying ICTs to improve their quality of life.

Cross-silo collaboration

To reduce the negative impact of many professional groups – including technology developers – who are working in 'silos', it will be important to bring together engineers to work with specialists from other disciplines and to ensure they work with older and disabled people within an appropriate ethical framework. Technology providers and developers could have a far more extensive role than is currently the case to work to explicitly enhance the user experience and to reduce the barriers and frustrations experienced by older ICT users. Using their skill and expertise in a co-design context with older people and other end users would enable appropriate changes to be made in the design of software and hardware in order to better match the characteristics of older users' requirements and preferences, (including their impairments). Further, collaboration in an ongoing manner could better the management of the negative consequences of upgrades. This collaborative working would also help to dispel some of the myths held by developers about older ICT users. Collectively such collaboration enables significantly enhanced quality of user experience and satisfaction in using ICT.

Public demonstrators of smart houses/pervasive computing

To enable the general public to experience pervasive computing in a guided non-threatening setting, demonstrators incorporating varied 'scenarios of use' offer a powerful way of promoting awareness of the potential of developments now in the research and development laboratories.

Engaging users in the specification and design of future technologies

Use of prototyping, development of use scenarios and evaluation of planned developments – before new systems and products are introduced in the commercial market – enables potential flaws and problems to be identified at a stage in the development cycle where changes can be made.

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