Social Situation Monitor

The Role of New Technologies in Modernising Long-term Care Systems

A Scoping Review

Valentina Zigante
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Contact: Katarina Jaksic

E-mail: katarina.jaksic@ec.europa.eu

European Commission
B-1049 Brussels

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1. Introduction

Despite vast differences in their organisation and state of development, long-term care systems in the EU face a number of common challenges against the background of rising demand fuelled by population ageing. Notably, these include guaranteeing access to affordable and high quality long-term care (LTC) services to a rising number of people in need; ensuring the availability of an appropriately skilled workforce and supporting informal carers. Finally, all of the above needs to be done in a cost-effective and efficient way to meet the challenge of fiscal sustainability of public expenditure on LTC. Technological advances and digitisation is often seen as a solution to some of the issues in the sector as well as it is becoming a normal part of life in other areas. This note reviews the literature covering the role of new technologies (including robotics, artificial intelligence and innovative use of already existing technologies) in addressing the challenges set out above. The main focus is on assistive technologies which include a digital or Information and Communication Technology (ICT) component[1] (see Lorenz et al., 2017).

The focus of the note is motivated by the widely acknowledged potential of a range of technologies used in people's homes and in residential facilities, to support the sustainability of LTC provision in the future. Driven by demographic ageing, an increasing number of people have long-term conditions and suffer from frailty leading to increased need for support and care. There is hope that assistive technologies, together with self-care by users and carers, can help monitor, treat, delay deterioration and even prevent certain conditions. These technologies may therefore improve quality and length of life while also relieving pressure on increasingly stretched health and social care services (Greenhalgh et al., 2015). Greenhalgh et al. however argue that even though the arguments for developing these products are well rehearsed, they are not "unchallenged" (2015). Different literatures come at this issues from different theoretical assumptions and different understandings of the realities of using and providing long-term care. It is therefore useful to take a narrative approach while bringing insights from a broad set of sources.

The issues of technology development for LTC, often linked to health care, has received much attention and funding both from national governments and from the EU level. There is intense national and EU level activity directed at producing assistive technologies at scale and drive these into production and widespread use. The EU has provided a substantial amounts of funding to stimulate research initiatives, development and market exploitation of innovative technologies for ageing well, including the Active and Assisted Living Programme (AAL JP) and the European Innovation Partnership on Active and Healthy Ageing (EIP AHA) which have for example funded projects on access to information for care providers, sensors for security in the home (Gehem & Sánchez Díaz , 2013).

The note is focused on the contributions, challenges and characteristics of technology in relation to the four key challenges to the modernising of long-term care in Europe. These aspects are access to LTC, the LTC workforce, the quality of LTC, and finally the sustainability of LTC. These aspects provide basis for the research questions guiding the literature review:

- (How) can technology facilitate and support *access* to appropriate long-term care?
- (How) can technology support the long-term care *workforce* and informal carers, and improve working conditions in the sector?

[1] This means that environmental technologies such as grab rails, zimmer frames etc. are not the primary focus. Many of these technologies are however linked to a digital function – for example sensor in floor mats to prevent falls.

- (How) can technologies support the improvement of *quality* of long-term care services and what are the challenges?

- (How) can the use of technologies help support the *sustainability* of publicly funded LTC systems?

The note further reports emerging findings in relation to the international response to the Covid-19 pandemic, where technology has become a much-used tool to contain the spread of the virus. These approaches include remote/video consultations with health care providers, remote monitoring where possible etc. This note briefly surveys the emerging evidence on how technology is being used in LTC provision to meet the challenges of the pandemic.

The review is focused on the literature on technology use for older people in need of LTC and includes examples from both residential care homes as well as different types of community care, including home care. We take a broad approach to including all types of needs, such as disability, frailty, mental health problems and cognitive issues, which are eligible for LTC services in Member States of the European Union (EU). It is further important to acknowledge, as noted in most systematic and narrative literature reviews in the field, that it is difficult to determine the current "state of the art" in technology development and deployment due to the dynamic definitions and various understandings of what assistive technologies are (Meiland et al., 2017). The growing coverage of various technologies used in LTC in the literature is typically skewed towards examples in the field of health care, or domains of LTC that are more health focused for example nursing homes in the US and dementia care in general (see for example Marikyan *et al.*, 2019 in relation to smart home technology). These factors mean that it is useful to include grey literature, including discussion papers, project reports and evaluations to gather the most up to date evidence in relation to LTC technology. Finally, to ensure that current technologies and findings are reflected we focus the review on the last five years, since 2015. Some theoretical contributions published before this time have been included as these remain relevant.

This note is structured as follows: section two provides an overview of the broad character of the literature on technology in LTC, including the types of technology and usage areas, section three outlines the methods used and the scope and findings of the search in terms of number of papers returned from key searches. Section four reports the findings from the literature review in relation to each of the research questions and section five draws out themes across the literature as a whole.

2. What is technology in long-term care?

Technology used in LTC includes a wide range of products and processes that are used in the home as well as in residential care homes. Technology both includes software (i.e. computer programs, ICT) and hardware (devices, assistive equipment, robots) (see Mosca *et al.*, 2017). This note is mainly focused on what is generally known as information and communication technology (ICT), i.e. technology that has a network or digital component but can be a combination of software and hardware. The development of technological software and devices designed to meet the increasing needs of a growing aging population is known as gerontechnology (Satariano *et al.*, 2014). There are differences in how the vast array of different technologies designed to support older people in need of care and support are distinguished, labelled and grouped into typologies. A useful starting point is to group technological products according to who the main user, or beneficiary, is. Assistive technologies, directed at older people and their informal carers include telecare (for example, alarms, sensors, and reminders), various smart home features, some robotics, some mobility devices and more. Telehealth (remote monitoring for clinical biomarkers), electronic records, electronic monitoring (of users and carers), online training for professional carers is primarily designed to help professional carers deliver health and

social care services, often in the home. Another approach, following Lorenz et al (2018), is to group technology based on its function, for example: treatment, safety and security, training, care delivery, social interaction. It is also important to note, as in Cook et al., that technologies can "serve multiple purposes, such as improving the independence and wellbeing of the care recipient while at the same time supporting and reducing the caregiver's workload" (Cook *et al.*, 2018). Table 1 outlines the technology types identified[2] and describes their usage and main characteristics and whether they are known under any other term/name.

Table 1: Typology of Technology Use in LTC Systems

Innovation/type of technology	Description
Information and Communication Technology (ICT)	Many of the technologies below have an ICT component or can be seen as examples of ICT. ICT in itself can be used for social interaction and networking when using various online platforms and forums. Includes Individual mobile devices (e.g., smart phones and tablets) (c)
Touchscreen technology (TT)	TT includes tablets and provides access to a range of applications which can be used for reminiscence therapy and engage with the user's current and past interests. It is an accessible medium which, once set up, requires little input from care staff or informal carers. (d)
Assistive technology (AT) [3]	Devices and equipment that compensate for sensory, physical/mobility, and cognitive impairments. Includes voice recognition software, text telephones, accessible keyboards, speech recognition software Supportive technologies: aids older people to perform daily activities that they would not be able to do without the functional support of the technology. Empowering technologies: train and empower older people to improve their functional capabilities, thus improving some of their capabilities that are required to maintain independent living. (b, c)
Telehealth/telecare	Health or disease management applications deliver services from a provider to a citizen, from one health professional to another, or between citizens and family members. In this framework of long-term care needs, home telehealth refers to a range of support, typically including not just clinical (medical) monitoring and intervention, but also a broader range of homecare support that more traditionally falls within the scope of social/homecare services. Mhealth (mobile health) is a subcategory. (c)

[2] Different types of technology are referred to in different ways depending on time of publication as well as the country the relevant research covers. In the below sections I have followed the usage of terms in each of the papers.

[3] These previous studies show that different authors from different countries have carried out research on ALTS but under variant names or terms. These variant names include: (i) assisted living; (ii) assistive living; (iii) assistive technology; and (iv) adaptive technology. (Oderanti and Li, 2016)

Ambient assisted living (AAL)	Assisted living technologies based on ambient intelligence. Ambient intelligence is a new paradigm in information technology aimed at empowering people's capabilities by the means of digital environments that are sensitive, adaptive, and responsive to human needs. This vision of daily environments will enable innovative human–machine interactions characterized by pervasive, unobtrusive, and anticipatory communications. AAL can be used for preventing, treating, and improving wellness and health conditions of older people and assist with activities of daily living. Includes medication management tools and medication reminders, mobile emergency response systems, fall detection systems, and video surveillance systems. Connect and communicate with their peers, as well as with their family and friends.
"smart home" technology	Includes different ICTs integrated in older people's homes to help them to perform activities of daily living independently. They include remote-controlled home automation systems, which have various sensors for doors and gates, microwaves or normal stoves, security devices, lighting, and an on/off switch for various appliances and home entertainment. The ICT components are programmed to react and communicate with each other through a local network, and with the surroundings via the Internet, ordinary fixed telephones or mobile phones. The technology can be used to monitor, warn and carry out functions according to selected criteria. (c)
Virtual reality	Applications and games usually used in headset which provides immersive experiences aimed at supporting cognitive function, reducing loneliness and improving quality of life.
Robotic technology	Personal care robots are designed to improve the quality of life of humans, on a non-medical basis. Care robots are machines that operate partly or fully autonomously with the aim of supporting potential users, older people and relatives as well as professional caregivers, in providing physical, cognitive or emotional support (a)
Electronic (medical) records (EMR)	Digital versions of paper charts. Electronic (medical) records contain notes and information collected and enable providers to track data over time, identify patients for preventive care and screenings and monitor patients. Also known as health information technology (HIT)
Electronic monitoring (patients/users)	Telemonitoring or remote patient monitoring is the remote exchange of physiological data between a patient at home and healthcare professionals at a hospital to assist in diagnosis and monitoring. Several technologies remotely manage and monitor a range of health conditions, and collect/send vital signs to a monitoring station for interpretation. (c)
Electronic monitoring (organisations)	Integrated computer–telephone technology to record service user visits. Tracking of the real-time location of homecare workers

Online training	Technologically supported training interventions frequently use computer and the internet, which both enable recipients to participate in distance education programmes and can facilitate learning at their own speed in their own time. (e)
Recruitment algorithms	Essentially a way of using technology, through data analysis, to carry out values based recruitment. Identifying candidates likely to enjoy becoming and remain being care workers.
Mhealth	Mobile phones and other wireless technology mainly used in medical care. These can also be used in LTC settings.
Mobility devices	Generally refers to environmental technologies such as wheelchairs, stair-lifts etc., but can also include a digital component such as technologically enhanced automobiles (GPS, self-parking). Can be understood as a sub-category to assistive technologies

Notes: a) Oderanti and Li, (2016) b) Vichitvanichphong et al., (2014) (c) Carretero (2015) (d) Goh et al. (2017), (e) Lorenz et al. (2017)

3. Methods

This note reports on a scoping review mapping the literature on technology in LTC. The steps set out by Arksey and O'Malley (2005) guided the review: 1) identifying the research question, 2) identifying relevant studies, 3) study selection, 4) charting the data, 5) collating, summarizing and reporting the results. The sixth step proposed by Arksey and O'Malley is an "optional" consultation exercise, to ensure that the findings are reflective of the literature. Given the small scope of this project we will not be able to complete the final step (Arksey and O'Malley, 2005). We conducted a rapid scoping review of peer-reviewed publications as well as reports and discussion papers in the grey literature from 2015 onwards. Initial scoping searches were carried out in Googlescholar, followed by more specific searches in key databases (e.g. CINHAL, Medline, PsychINFO, SocINDEX)[4]. Papers and references were managed in the Mendeley software. We undertook a thematic analysis of the selected papers, focused on gathering evidence of how the papers addressed the research questions.

We first searched for previous (systematic) literature reviews which covered questions that related to our four research questions. We included both qualitative and quantitative evidence speaking to the research questions and we extracted best practice examples. We include evidence from all countries, also beyond the EU, given that a great deal of evidence and examples are located in, for example, the US and Japan. We excluded feasibility studies (following Lorenz et al. 2017). Papers published since 2015, in English, were included. As mentioned above, the main focus is on technologies which have a digital or network component (ICT). These include assistive technologies (i.e. devices and equipment that compensate for sensory, physical/mobility, and cognitive impairments such as for example voice recognition software, reminders etc.), smart home technology and telecare/telehealth. Papers exclusively covering physical technology without a "smart" feature were excluded. Given the wide focus of the research questions the review had to be done selectively and focused on previous reviews as a way of quickly assessing the evidence in a relevant area.

[4] Details of search results and search terms are available on request.

4. Literature Review Findings

4.1 Access to long-term care services

This section reports evidence from the literature in relation to how technology can facilitate and support access to appropriate long-term care. Technological solutions in this field operate within, or in relation to, pre-existing structures, including institutional structures and territorial divisions in governance of health and LTC, which have a strong bearing on the level and ease of access to LTC services (including home care, community care, residential care, cash benefits and benefits in-kind[5]). The institutional structure and territorial division of LTC competences influences access due to the division of responsibilities between healthcare services and social services and issues around coordination between the two systems. Lack of horizontal coordination may have adverse effects for the recipient of LTC: e.g. waiting periods, administrative procedures, fragmentation of services, and a high risk of non-take up of services. Here technological solutions can play an important role in facilitating coordination, users' and family members' knowledge about services and the ease of accessing initial services when need has arisen. Further, many European countries are facing problems with LTC access and affordability due to the limited provision (including underfinancing) of home care and community-based services (Spasova *et al.*, 2018). Here technology is understood to have potential to support community-based services, often known as "ageing in place" in a cost-effective and easily managed way.

The evidence identified in the literature in relation to access to long-term care can be thought of in terms of functions along the LTC use pathway. Starting with *information* (which is also important throughout the care pathway) for users and carers to understand what is available and preparing for first interactions with care professionals, for example through gathering required documents and listing important questions. Next, the function of *facilitating easy access* to services can include various remote facilities, for example telecare. Finally, technology can function as an *ongoing support mechanism* which enables older people to remain in their home, i.e. ageing in place. These questions are crucial as many older people with LTC needs do not receive appropriate services, possibly due to lack of available services, but also due to lack of information, communication and facilitation of access to services which are indeed available. Table 2 summarises the themes identified in the literature.

Table 2 : Summary of findings - access

Theme	Examples of technologies	Expected benefits
Information and communication	Information platforms, online reviews, social media	Facilitating understanding of what is available and suitable. Better matching and targeting of services
Facilitate access to services	Telecare/telehealth Remote patient monitoring Hospital discharge/integration Community support	Reducing loneliness, fast access to services as part of hospital discharge or when a new need has arisen, or the person's health has deteriorated.
Ageing in place	"Smart" home technology, remote monitoring, telecare/telehealth	Enabling independence, reducing social isolation, preventing deterioration and hospitalisation

[5] When we discuss access to LTC services, it is useful to keep in mind that there is a difference between "legal access" all citizens have to service if they meet the eligibility conditions and the "effective access", that is the real access to services (prospective) LTC users have.

4.1.1 Information and communication about services and benefits

Making information about services readily accessible in a cost-effective way (for both local government, providers and users) is a challenge where technology can offer helpful solutions. This includes communicating information about benefits, including cash benefits available to support informal carers. Generally, the technological solution employed to make information available relies on websites and platforms that prospective users and their families can access through the internet, using computers, tablets or mobile phones. The information made available tends to be put forward either by (local) government, providers and provider associations, or charities and other interest organisations. Not to be neglected is the information made available by other users and families, often through various social media platforms such as Facebook and Twitter. Accessing and using this information relies on capability to use, and access to, both hardware and software technologies. In particular, access to and proficiency in using the internet is a key aspect.

The literature covers well, as expected, older peoples' abilities and usage patterns of the internet and various devices used to access the internet. Ang et al. (2019) argued that older people may not use the internet both because of non-health reasons (e.g., lack of digital literacy or internet access) or health related reasons. They went on to explore key correlates of health-related difficulty in internet use. Sub-group analysis identified that males, low education and higher needs (i.e. more instrumental activities of daily living limitations) were more likely to have health-related difficulties in using the internet. Importantly, Ang et al. found that social support networks functioned as mediators between poor internet use and quality of life – i.e. being able to use the internet was more important in relation to outcomes for people with less social support (Ang et al., 2019).

Studies have further questioned whether having access to and using the internet matters for take-up of services among older people. We did not find studies focusing specifically on LTC services, however, a health focused study found a positive correlation between internet use and use of various community based services, controlling for age, health status, mental health as well as ethnicity (Clarke et al., 2017). The study focused on health-related therapies accessed in the community, such as chiropractors but also included home care services such as meals-on-wheels and home help. The findings indicated that internet use predicted higher utilisation of "lifestyle" services such as osteopaths or acupuncturists and did not find any correlation with home care services (Clarke *et al*, 2017).

This question is also particularly important due to what has been identified as a pan-European "choice agenda" (Costa-Font and Zigante, 2016) which emphasises offering choice of services to prospective users and their families. This relies on a selection of providers being available to choose from and, crucially, that there is good information available about the services. A growing aspect is provider ratings online: Trigg (2014) concludes that online ratings can assist users to choose providers, however, they will need to be supported by carefully designed processes to maximize their usefulness. Similarly, Liu et al. (2016) argue that "social media platforms offer unique opportunities for patients and families to provide real-time feedback on their healthcare experiences." Their analysis however revealed that consumer-generated social media ratings reflected more subjective aspects of inpatient stays in hospitals. Unfortunately, evidence on nursing home care and other LTC services was found to be limited. Hefele et al (2018) found that Facebook ratings of nursing homes in the US state of Maryland were not significantly correlated with official quality marks or resident surveys. The authors caution that, given that it is likely that as older people use the internet more, the disconnect between social media ratings and official ratings can become a serious issue (Hefele *et al*, 2018). On the other hand, Li et al (2019) found moderate and significant correlations between social media ratings and inspection and survey ratings, also this in the US.

4.1.2 How can technological solutions support access to LTC services and benefits

At a time when a need for LTC services has become acute, easy and speedy access to appropriate services can be highly beneficial for users and their families. These situations most often arise when an older person is about to be discharged from hospital or following a more gradual deterioration at home, often when family members of relatives identify that the older person can no longer live safely at home without additional support, beyond any care provided by informal carers. The latter importantly includes timely setting up of services to prevent unnecessary deterioration. It can be useful to think about this theme as mostly about transitions and how technology has been shown (or not) to facilitate and support setting up a new care plan and enabling self-care, ensuring that hand-overs are done smoothly and without loss of information.

A key entry point into LTC systems is following a referral from primary care. Cartier et al (2020) explored the effects of a digital community resource referral platform in the US where new technology platforms have emerged with the purpose of facilitating referrals to community social services providers. Cartier et al. qualitatively analysed interview evidence regarding the usage and experiences of nine different platforms among health care organisations. It was found that community organisations were less keen on using the platforms, possibly due to lack or resources and incentives. Even though access to the platforms was generally free, the set-up and implementation costs can be significant, depending on the complexity of the system and training needed. Smaller organisations were found to struggle more with implementation and usage. Further, the clarity of communication in terms of benefits for the community organisations as well as naming champions improved adoption (2020).

As mentioned a key situation relevant to access is in relation to discharge from hospital. This falls under a broader debate on the integration of health and LTC services which is present in many EU member states. There is a lot of evidence around integration, however, the literature tends to approach the integration issue from the point of view of the health care sector rather than LTC. One example, Steele et al. (2018), studied six cases across Canada and New Zealand. The qualitative analysis found that, despite different models and contexts, the activities that were carried out through ICT systems where similar across the case sites. The most common activities included care coordination by inter-professional teams. The coordination was however limited by data access issues as well as physical system compatibility issues. The authors argued that even when the model of care could be seen as innovative, it was mainly used to facilitate the usual way of working which they saw as a constraint to achieving the benefits possible through the innovative models of care.

4.1.3 How can technological solutions enable and support ageing in place?

Community care services are underdeveloped in many EU member states, even though these are key facet in enabling access to LTC services for those in need. Community services is a key component in allowing older people to live well at home in line with the ageing in place paradigm. In addition to fulfilling the wishes of many older adults, aging in place may serve to reduce public expenditures for health services and formal long-term care. There is a growing interest in the literature whether technological innovations can enhance opportunities for aging in place (Satariano et al., 2014). This section surveys the literature on what kind of technologies are potentially helpful in supporting older people age in place.

One of the most researched technologies for ageing in place is telecare and telehealth. Telecare and telehealth are defined as interventions facilitating "the delivery of health and care from a distance, and the monitoring of [the health and well-being of] care recipients using technologies" (Carretero, 2015). Telecare/health facilitates direct contact and exchange of relevant information between professionals, care users and their families and informal carers (Loren*z et al*, 2017). A related technology type recently becoming more common in the literature is "smart home" technology. For example, Satariano et al. (2014) defines "smart technology" as technology that has some degree of artificial intelligence and usually have the following three key characteristics: technology, services and the ability to satisfy users' needs. The key features of a smart technology are the capability to gather information from the surrounding environment and react accordingly, which in the case of meeting LTC needs includes responding to arising needs through automated technology. It is argued that a "smart home" can support provision of cost effective home care for the ageing population and vulnerable users (Satariano *et al.*, 2014). Marikyan et al. (2019) identified the core functions of "smart home" technology as offering comfort, access to care, and to ensure users' safety. Smart homes can provide monitoring and disease management, for example the cognitive state of an older person can be monitored through smart home devices, which can alert users in case of any health inconsistency (Czaja, 2016). Through this care staff can monitor health remotely and detect life threatening changes early, as well as to provide medical care when necessary. Smart home applications can also support virtual medical visits which can replace tiring physical visits to clinics and hospitals (Czaja, 2016). The literature further argues that smart homes can improve socialisation and even help users overcome the feeling of isolation (Marikyan et al., 2019).

In terms of empirical findings of the efficacy of smart home technology, Liu et al. (2016) in a systematic literature review, found no evidence that smart homes and home health monitoring technologies help address disability prediction and health-related quality of life, or fall prevention. Liu's review is however somewhat dated. Turjamaa et al (2019) on the other hand found evidence that smart home solutions helped older people carry out everyday activities and improve physical safety and social communication. Older people reported that smart homes improved their sense of security, quality of daily life and activities and provided them with information about the care they could receive. Turjamaa et al. however agrees that there is a lack of research focused on the experience of older people using this kind of technology.

Communication with friends and family through mobile phone and internet applications falls under the classification of ICT (Carretero, 2015). Chen and Schulz (2016) explored the effect of ICT on social isolation. There was a dearth of rigorous research in the review (4 out of 25 studies were evaluated as good quality). Most studies focused on various dimensions of social isolation rather than the general concept. Key findings included that ICT had a positive, however short-term, impact on social support, social connectedness, and social isolation while the results for loneliness were inconclusive. Several studies reported inconclusive or insignificant results. The mechanisms between ICT and reduction in social isolation were "connecting to the outside world, gaining social support, engaging in activities of interests, and boosting self-confidence". Examples of ICT technologies included the use of communication programs (using landline phones, smartphones, iPads, emailing, and online chat rooms or forums) and high-technology apps (Wii, the TV gaming system, and Gerijoy, a virtual pet companion) which consistently reported a positive effect. The review suggested that elderly can benefit from ICT interventions and will use them frequently after proper training (Chen and Schulz, 2016).

4.1.4 Challenges to technology improving access to LTC

In spite of the potentials discussed above, the literature also conveys concerns and challenges, including how to determine to what extent and under what circumstances it is possible for older people to live safely and independently at home, and whether this is

possible regardless of age, income, or ability level (Satariano et al., 2014). It is clear that the efficacy of technology is key, however, the literature identifies several issues that are likely to adversely affect access to technologies among older people. Main factors include unaffordability, inappropriate products, lack of perceived and real ability to use technology and ill-fitted technology in terms of sensory and ergonomic issues as well as implementation and acceptability. (Czaja et al., 2006; Satariano et al., 2014). A further reason for issues around acceptability is worries about being stigmatised and labelled as a vulnerable person and that limited attention is often paid to aesthetics, which enforces the stigmatizing effect and introducing a "medical" looking device in a home environment (Niemeije*r et al*, 2014; Chung *et al*, 2016). Chen and Schulz (2016) further emphasise the role of training, both for users and caregivers, and the character of training (including setting, procedure, materials, timing, and instructor's style and attitude) as being important for achieving the benefits of assistive technologies.

The implementation, including acceptance, of technology is crucial if technology is to support older people in ageing in place. Peek et al. (2014) surveyed the literature focusing on factors influencing the acceptance of electronic technologies that support aging in place for older people. Peek et al. found that the literature is focused on the "pre-implementation" stage – where acceptance of a new technology was found to be influenced by six themes. These were concerns regarding the technology itself (e.g., cost, usability, privacy); expected benefits (e.g., perceived safety and usefulness); need for technology (e.g., perceived need and subjective health status); alternatives to technology (e.g., help by family or spouse), social influence (e.g., influence of family, friends and professional caregivers); and characteristics of older adults (e.g., desire to age in place). Research on the "post-implementation" stage was however scarce. In the available studies it was found that some of the factors important in the pre-implementation stage remained important while new factors also emerged (Peek *et al*, 2014). Similarly, Marikyan et al. (2019) found that despite the potential benefits, adoption rates of smart home technology remain low. Reported barriers include technological, financial, ethical and legal, knowledge and psychological resistance.

It has been found that various technologies, including smart home technologies, may negatively affect users' social life, and increase loneliness by replacing actual face-to-face communication (Marikyan et al., 2019). It has been argued that using technology may actually mean that users become more isolated if these replace real-life interactions with care staff, friends and family. Chen and Shulz (2016), in a key systematic review of this field of the literature, found one study reporting that a reduction in perceived loneliness was strongest at the short-term follow-up and that by 12 months, the effect was negative. They also suggested that the positive effects of ICT on loneliness and social connectedness were constrained if the user ended up spending a lot of time online.

Equity of access to LTC has been extensively discussed and similar arguments and considerations need to be applied to access to technology. Hall et al. (2019) argue that technological design and cost matter for ensuring equity of access to technologies. It has been shown that variations in design to suit individual circumstances matters for the acceptance of assistive technologies as well as for the proper functioning of the devises, but that personalised design is more expensive and not necessarily available to all users. Hall et al. further suggests that equity of access to technologies has not been prioritised, even though the current generation of LTC users are the least likely to be proficient and willing users of technology. The equity concern remains when we imagine coming generations of LTC users who will bring personal technology with them into their care setting and will require support in maintaining access to those technologies (Hall et al., 2019). The financial aspect was also discussed in Marikyan et al. (2019), in relation to smart home technology. The concern is that high-income earners will be the only ones benefiting from smart home technology and that the technology could create a gap between those who can and cannot afford it. However, "given the rapid advance of the technology and orientation of the technology producers on the mainstream market, smart

home technologies are expected to become more affordable over time" (Khedekar et al., 2017) and this may not be an issue in the future.

4.2 Quality of Long-term Care Services

Despite many efforts to improve the quality of long-term care, it remains a problematic issue in most EU countries. Quality care is vital to maintaining and improving the quality of life of frail elderly people in both residential and home care settings and preventing unnecessary deterioration and possible hospitalisations. (Local) governments try to influence quality in different ways and to varying degrees (Zigante and King, 2019), for example through regulation, financial incentives and information and knowledge sharing. Quality regulations vary substantially according to the type of care, the home care sector remains mostly unregulated, while residential care is governed by stricter requirements.

The literature shows two aspects of quality where technology may impact positively: firstly, it has been argued that technology can improve the quality of services provided, for example through reducing errors, ensuring timely visits, freeing up carers' time to spend more time socialising with the users, making services more personalised and increase users' independence. Technology can also support quality assurance efforts through monitoring of service provision. Issues such as timing and duration of visits, logging of medication, etc. can all be done electronically and be monitored for quality assurance purposes. We can also imagine remote surveillance protecting against abuse, but all of these tools must be set against the privacy of both users and care professionals.

Table 3 : Summary of findings - quality

Theme	Examples of technologies	Expected benefits
Structural and process quality	Remote monitoring, telecare/telehealth	More efficient and safer provision of care. Also more personalised through improved space (i.e. structure) and work processes that allow individualised plans.
Users' outcomes (outcome quality)	Information platforms, social media	Connectedness, reduced loneliness and mental health issues.
	Telecare/telehealth Remote patient monitoring, Hospital discharge/integration	Safety, hospital admissions, disease management, prevention
	"Smart" home technology	Independence and person-centred care
	ICT, social media	Social connectedness
Quality assurance and safeguarding	Electronic monitoring	Safer care, prevention

4.2.1 How can technology help improve the quality of LTC?

This section discusses the evidence in the literature on how technology has been found to impact on LTC quality. The functions of technology in relation to quality can usefully be related to Donabedian's structure, process and outcomes framework (Donabedian, 1982). This is a commonly referred to framework for understanding different aspects of quality: structure, process and outcome aspects of quality. The structure related aspects of quality consists of 'what you have' (factors which can be defined as the preconditions to achieve good quality in your operations), process quality is about 'what you do' (how the care is

provided), while outcome quality is the end result, or direct benefits to the care user. Technology can improve quality in terms of all three aspects and the discussion below is framed around the framework.

Structure and process quality

Process quality can be improved through the use of e-health records, remote management and electronic prescriptions. These technologies can optimise the data available and help to keep a register which both ensures accountability and can potentially lead to a reduction in medical errors. It has been hypothesised that health information technology (HIT) positively impacts on nursing home staff care processes and through that increases satisfaction and positively effects the quality of resident care. Ko et al (2018) however found no studies establishing a direct link in a survey of the literature. Studies concluded that the improvement in quality may in fact be confounded by the propensity to use more HIT in facilities with higher staff ratios. Qualitative studies reported that staff (both administrators and managers) believed that quality was positively impacted due to the capacity to monitor resident conditions, conduct oversight of care practices by frontline staff, and facilitate continuity of care. Similarly, it was reported that HIT improved the legibility of documentation and ease of access to needed information, which meant that better quality care could be delivered. Both nurses and care staff did not feel that HIT impacted on clinical decision-making. There were however concerns that HIT detracted from time that could be spent with residents which in fact was confirmed in observational studies (Ko *et al.*, 2018).

Kruse et al. (2017), in a systematic review, found that electronic health records (EHR) lead to significant improvement in the management of documentation in LTC providers. Improved quality outcomes were identified, however, only a few papers found impacts on user satisfaction and productivity. It was further argued that implementation of EHRs in LTC facilities caused improved management of clinical documentation that enabled better decision making. There were however negative effects in terms of workflow and productivity, but the studies did not show whether this was because of change management and the disruption that an information technology (IT) implementation can have on an organisation (Kruse *et al.*, 2017).

Finally, a key process indicator is the quality and efficiency of communications, between care staff, between care staff and user and family and between care staff and other health care providers. All of this can be facilitated through ICT. Leslie et al. (2020) found that communication was seen as pivotal to care quality overall. The characteristic of ICT policies that are important to support better quality is that they are focused on connecting people and to facilitate communication and relationships.

Outcome quality

There seems to be two main themes in the literature around technology's potential to improve the user's outcomes as a result of improved quality of LTC: firstly, promoting independence, person-centred care and quality of life, and secondly, promoting (medical) outcome improvement, including reducing hospital admissions, falls, and preventable deterioration of the users' condition. These themes can be distinguished in terms of their theoretical heritage, where the weight given to person-centeredness and independence in the literature can be traced to a sociological tradition of research where emphasis is placed on what matter to users. On the other hand, the outcomes focus is more common in the bio-medical literature on assisted living, generally focused on the technology itself and is oriented to demonstrating proof of concept – that is, that the technology 'works', ideally in a randomised controlled trial design (Greenhalgh *et al.*, 2015). These are discussed in turn below.

Meiland et al., in a literature review, found a wide range of positive outcomes related to independence and person-centred care from the use of technology solutions. For example,

that they complemented staff care, made users feel safe, and facilitated social interaction, improved wellbeing and independence. It was however emphasised that solutions must be personalised to fit the individual in order to complement person-centred care (Niemeije*r et al*, 2015; Meiland *et al*, 2017). Specifically, smart homes are argued to improve users' outcomes, such as socialisation, improved self-esteem and competence, as well as reducing social isolation (Marikyan et al., 2019). Similarly, a review by Daly Lynn et al. (2019) found a wide range of positive outcomes of the use of technological solutions, including feeling secure, enabling social interaction, enhancing well-being and overall promoting independence.

Assistive technologies have particular benefits for older people with dementia. Meiland et al. (2017) identified a set of evaluation studies which found that persons with dementia felt that electronic devices facilitated their independence and reduced family and carer stress and improved overall quality of life. Meiland et al. also point out that the technology does not necessarily need to be "purposely designed" for persons with dementia. Often mainstream technologies, such as electronic calendars, Web-based information systems, video-calling, and electronic activity support systems, can be adapted to meet needs, including memory support, information, socialising and keeping company, reducing psychological distress, and engaging in daytime activities (Meiland *et al.*, 2017). Touch screen technology can be a further useful tool both in dementia care users' own homes as well as in care homes. Goh et al. (2017) surveyed the literature and reported that touchscreen technology (TT), such as tablets, provide access to a range of 'apps' that help with memory and reminiscence as the apps can relate to a person's past or present interests. Empirical research is fairly limited, however, studies have found that people with dementia are able to use, enjoy, and benefit from using tablet devices, in particular in the early stages of the. Use of TT by people with dementia is associated with increased socialisation, enjoyment, quality of life, and reduced anxiety and depression, and can make a substantial contribution to helping people to live well with dementia (Go*h et al*, 2017).

Another type of technology often mentioned for their quality of life enhancing capabilities is robots. Robots employ many roles, beyond the commonly understood companion and lifting robots. Shishehgar et al. (2018) identify nine robot types which fulfil care needs of older people: companion, manipulator service, telepresence, rehabilitation, health monitoring, reminder, entertainment, domestic, and fall detection/prevention robots. Shishehgar et al. found evidence in relation to eight areas in LTC provision: social isolation, dependent living, physical or cognitive impairment, mobility problems, poor health monitoring, lack of recreation, memory problems and fall problems (2018). Johansson-Pajala et al, (2020) surveyed the usage areas for care robots such as Care-O-bot, Robot-Era robots, Zora, JustoCat and PARO. They found that the different types of care robots mainly assists in daily tasks, monitoring behaviours and health and provides companionship. Compared to no services at all, these activities represent an improvement, however the authors question whether they represent an improvement compared to LTC provided by a person (Johansson-Pajala et al, 2020). These questions are complex to evaluate and more research is needed.

Abdi et al. (2018) found evidence, even though they caution that good studies are scarce, in relation to five roles for socially assistive robots (SAR) in elderly care: affective therapy, cognitive training, social facilitation, companionship and physiological therapy. First, while SAR is capable of improving mood of subjects and hence wellbeing, it does not seem to be much better than a comparative soft toy or placebo robot in patient groups with dementia. Group settings were more effective than one-to-one interventions. Second, communication robots were significantly more effective at improving cognitive outcome measures than soft toys, particular among those without cognitive deficiencies. Computer programmes where, however, as effective as SAR interventions, and cheaper. Third, improved sociability was shown in several studies, across robot types and with and without dementia and generally better than a placebo (i.e. soft toy) and again a group setting worked better. Fourth, companion robots showed positive effects, in particular in reducing loneliness. This

is relevant as SARs could function as a pet in, for example, care homes where real pets may not be suitable due to allergies or risk of infection. Fifth, the findings were inconclusive in relation to physiological therapy, however, there were indications that SARs led to short term reductions in cardiovascular markers (i.e. lowered blood pressure similar to when in a calming situation). It is currently not known whether the short-term effects can be sustained in the long-term, in which case SAR may have a role as a non-pharmacological intervention for hypertension. Finally, Abdi et al. argue that the main value of SAR may lie in its multidomain functionality, even though there may be more cost-effective options for certain functions (2018).

Improved health outcomes can be achieved when technology performs operational functions, ensures care accessibility and availability, and improves users' safety (Czaja, 2016). Smart home technology can support monitoring and disease management, which can alert users and carers to any changes in health indicators collected. This can include cognitive state through monitoring of the user's behaviour (Czaja, 2016). The technology can detect changes at an early stage and even provide distant medical care when necessary (Marikyan et al., 2019). Remote care management, for example through the consultancy function of smart home applications, which can include virtual medical visits, can improve health outcomes through replacing physical visits to clinics and hospitals. Visits in person are often tiring and can expose the user to additional infection (Czaja, 2016 quoted in Marikyan et al., 2019). Further, electronic medical records (EMRs) in nursing homes proved to be a source of useful data to add to falls prevention modelling. EMRs increased the correct identification of residents with the highest risk of falls and through this enabled preventative action (Marier *et al.*, 2016).

4.2.2 Challenges to technology improving the quality of LTC

The literature suggests many channels and mechanisms through which technological solutions in LTC can improve quality and allow older people in need of care to lead more independent and comfortable lives. There are many encouraging findings, but also many challenges. Among those we note the issues around technology reducing human contact and indeed leading to increased loneliness for elderly living at home, issues related to practical usage and malfunctioning of technical solutions – which is also linked to the level of trust users can and will have in the device or software. Insufficient digital skills among older people and their caregivers is a major challenge, although as time passes this will become less of an issue as digital skills spread through the population. Data protection remains and is likely to become an increasingly challenging issue. There are further particular opportunities and challenges faced when implementing technological solutions in dementia care where the progression of the disease forms an unpredictable obstacle.

Firstly, as further elaborated above in section 4.1.4, there are concerns that reliance on technological solutions will result in increasing isolation for LTC users. Social exclusion may come about as the technology replaces human interaction by virtual communication, gradually excluding users from society. Specifically with regards to smart home technology, it has been reported that social life is negatively affected when the technology replaces actual face-to-face communication (Marikyan et al., 2019). The social isolation concerns also apply to robots as these may also lead to reduced human contact (Johansson-Pajala et al, 2020), but also applies to other technology types, for example remote monitoring, where in its absence an actual person would be "checking-in".

A key consideration emphasised in the literature is the uniqueness of individual care users' need and the progression of frailty and diseases, in particular dementia. There is, for example, so far little evidence around how to manage changing technology requirements as a person's dementia progresses. Additionally, some technologies would not be as suitable for those at a more advanced stage of dementia or for those living within a residential or nursing home (Meiland *et al.*, 2017). Similarly, Greenhalgh et al (2015) argue that the technological development as it stands tends to generate "superficially plausible

solutions" which fail to take into account how frailty and various medical conditions affect an older person's ability to understand and operate a technical device. Clinical experience has shown that older people's needs and capabilities are unique, "and every individual will have different goals and a different view of how technologies will best help them". Following on from these arguments, Daly Lynn et al. (2019), argue that a person-centred assessment of each individual's unique technology requirement is also recommended on an ongoing basis, as need is likely to change over time. Families and informal carers should be engaged in this process. A person may not need high levels of care when they first move into a care environment, but this time can be used to obtain consent for any future care needs, including the use of technology (Daly Lynn et al, 2019). Indeed, consent to the use of technology in care is an important factor to ensure dignity, protect privacy, enhance security of information and promote person-centred care. LTC facilities should have protocols in place to adequately inform and obtain consent for the use of such interventions from the resident or tenant. This is particularly important if an individual moves into accommodation with built-in technologies installed that will be automatically used (Meiland *et al.*, 2017).

The literature covers a range of ethical issues which may impact on the outcome quality experienced by users and caregivers. A key challenge, arguably even more so in relation to users with dementia, is the dilemmas between autonomy (which also brings a certain amount of risk) relative to reduced privacy, but increased safety (Meil*and et al*, 2017). This is particularly applicable to monitoring technologies as discussed in Hall et al. (2019), for example wearable or environmental sensors. These do provide increased safety but may make users feel "watched", vulnerable and less independent. There are further a number of ethical aspects around the monitoring of the workforce (discussed further below in section 4.3.1). This type of monitoring can support the ethical obligation to fulfil a duty of care towards users by providing added safety and improving quality of care through guarding against poor practice. On the other hand, the monitoring restricts the privacy of users and may make them feel uncomfortable. Hall et al. argue that it would be useful to clarify how, and what role, monitoring technologies can play in addressing concerns about abuse and neglect. They further emphasise that abuse and neglect are distinct issues (i.e. deliberate maliciousness versus ignorance, or lack of skill) and thus there may be different implementation connotations in relation to remote monitoring (2019). Also in relation to robots there are concerns around loss of privacy, loss of control, and questions about responsibility, if something goes wrong with the robot (Johansson-Pajala et al, 2020).

To summarise, technological solutions were considered both "an invasion of privacy (Niemeij*er et al*, 2015) and a way to prevent unnecessary intrusion on privacy" (see Daly Lynn et al, 2019). This is a key tension in the literature on quality of LTC in general and the question is particularly relevant in relation to technology. Daly Lynn et al. found that data security and its implications for privacy had to date (2019) not been covered much in the literature. Finally, in relation to residential care homes, there is a possible major conflict between the interests of the institution and the interest of the resident, where the institutions may favour technology which limits privacy and independence in order to reduce risk, even though this has a potential negative impact on the residents' quality of life (Daly Lynn et al, 2019).

If LTC technology is to have a positive impact on quality, a key requirement is that the technology works as intended and is available when needed. However, the literature finds a range of issues related to the practical implementation and availability of technological solutions. Daly Lynn et al. (2019) and others found that assistive technology provision is fragmented, it can be difficult to access, and there are gaps in the coverage of devices which are designed to support well-being and quality of life rather than physical care needs. Further, issues commonly reported were difficulties using systems, lack of acceptance by the user and the reliability of the technology. The review also indicated some challenges associated with the use of technology-based interventions, such as false alarms and alarm fatigue (Niemeijer *et al.*, 2014). Meiland et al. argue that not enough studies have dealt

with the usability issues and in particular the additional support needed by informal caregivers and professional carers. They also emphasise that the lack of high-quality scientific research into the effectiveness and cost-effectiveness of assistive technologies is an important issue (2017).

4.3 The long-term care workforce

Workforce challenges for the LTC sector includes the perception of the care profession as un-attractive due to negative reputation and is associated with poor working conditions and job precariousness as well as low pay in most roles. The poor working conditions include high levels of strain, high workloads, insufficient training, a lack of decent rest time, in some cases lack of support and autonomy, and high psychosocial risks. Conditions of employment vary substantially between the health and social sectors and between private and public facilities. There are examples of working conditions being better in the health care sector, where wages are regulated and higher. There are issues around both initial training and ongoing training and development. As discussed above, workforce issues are a key component in the quality challenge, and it is thus important to consider the quality of care services not only for beneficiaries, but also for the people who work and provide services.

Similarly, the burden on family caregivers, or informal carers, is increasing and many European governments have reformed their LTC systems towards more 'aging in place', which relies on support by informal carers (Ranci and Pavolini, 2015). It is unclear how informal caregivers will cope with the increased workload. It has been argued that, as well as professional carers, technology has the potential to support informal carers in providing care to users with increasingly demanding needs. Technology can support care workers as well as informal carers in a multitude of ways, including facilitating case management, communication and reduce paper work. Travel may be reduced through telecare options and remote communication with users in their homes. Technological advances not only have the potential to support informal and professional caregivers to care for older people in the home or long-term care settings, but also the potential to alter workforce needs and potentially mitigate the rising workforce demand. Governments as well as private business are heavily involved in this issue.

Table 4 : Summary of findings - workforce

Theme	Examples of technologies	Expected benefits
Training (I/F)	Learning technology	Retention, job satisfaction
Recruitment (F)	Algorithm, matching	Retention, job satisfaction
Work processes (I/F)	Formal carers: Robotics, patient monitoring, electronic records	Replacing/supporting care workers, job satisfaction
	Informal carers: Robotics, communication with care services, virtual consultation	Reduce caregiver burden
Workforce monitoring (F)	Video monitoring, electronic monitoring (including GPS)	Improving safety
Adoption and implementation (I/F)	Skills, attitudes, stakeholders/partnerships	Sustainable interventions
	Family decision making, knowledge and awareness	Reducing family and informal carer stress

Note: I: informal carers, F: formal carers

4.3.1 The formal care workforce and technology

Chapman et al. (2019), in a robust and extensive study based in the US, question what technologies may facilitate, replace, or enhance recruitment, training, and retention of the LTC workforce. They surveyed 62 companies meeting criteria for potential impact on the workforce. Categories included wearables, robots, sensors/alerts, health/social data collection and tracking, family/caregiver communication services, online care management, online worker training, and facility or home health staffing systems. Key findings included that there was little rigorous research on the impacts for care and services or which will have the greatest potential impact on the workforce providing direct care. There seemed to be evidence that worker retention improved when system allowed better client to worker matching, more control over shift scheduling, and more efficient staffing. In particular, regarding recruitment and retention, Chapman et al. further found use of technologies such as predictive analytics which were used to identify candidates best suited for care positions. They found that this was useful both at the initial recruitment stage as well as for long-term retention. For example, Arena identifies job applicants who are most likely to do well, and match them into the best fit roles, locations, and departments, and uses machine learning to improving staff retention rates and other operating metrics.

Another example of mathematical/statistical methods to support workforce was predictive modelling, which was used to enhance worker retention, user safety and behaviour change. Predictive modelling uses data from within the organisation to anticipate, for example, falls, deterioration of users' condition or challenges experienced by workers before they occur. Worker retention was also improved when technologies which supported shift scheduling, effective work location, and targeting of users to those most in need, were employed and carers found that their work was effective and they were able to provide good quality care with less wasted time. It is argued that predicting needs changes among users is key for efficient use of the workforce and can support general good staff practices. Chapman et al. further reports that it is key to keep staff engaged by providing more information to them, allow flexibility of scheduling, enable more choice of users, allow staff to work at the top of their skill level, and ensure that the best candidates are hired into positions and that staff who do well get rewarded (2019).

Raynor (2014) argues that online learning and training technology is an emerging field of great promise to the care workforce. Benefits include lowering costs and improving quality through improved training delivery. There is little time and money for training and providers report challenges around releasing workers for training for a full day for example. In this environment online delivery platforms can meet diverse geographic and linguistic needs. One approach includes learning a new skill online, freeing up classroom time to practice new skills.

Ko et al. (2018) reviewed studies on staff satisfaction and turnover following health information technology (HIT) adoption. The findings were mixed, some studies in fact found increased turn-over following adoption of HIT, and qualitative evidence revealed that the leavers stated "information overload". Other studies found negative attitudes towards the HIT, but no resignations. Impact on staff satisfaction was both positive and negative, which fits with the mixed retention evidence. Interviews also showed that even if staff struggled with HIT initially, very few chose to leave. The authors caution that they did not find evidence around staff's views of changing responsibility, personal growth, or achievement in contributing to workplace satisfaction (Ko et al., 2018).

The impact of technology on work processes seems to be a conflictual relationship. There is the evidence listed above, where great potential is experienced. On the other hand, Saborowski and Kollak (2015), carried out a qualitative exploration of formal care professionals' views on working with technology and how they "'care for or look after technology". Findings included that care staff experience difficulties using technology such as malfunctioning (e.g. false alarms), are unreliable and difficult to manage. On the other

hand when the technology worked well, care professionals were more than happy to use it and to explore all functions and possible benefits. The authors argue that it is crucial to research how care professionals integrate technology in their daily practice in order to understand how work processes can be improved and to support their role as users and facilitators of assistive technology. This is relevant, perhaps even more so, in relation to care robots (see Johansson-Pajala *et al.* 2020). Care robots have been proven to have a positive impact, not only on older adults, but also for those who work with them, including professional caregivers and informal carers. However, concerns among direct care providers include how useful the robots are, how to advice the user and how to manage learning to use the robots themselves. Concerns are more common among direct care providers than among care managers. There is also a perception that robotics and technology in general is not covered enough in nursing and care professional training and diplomas.

There have been suggestions that technology has the potential to replace care workers in carrying out certain tasks. This is however not likely to mitigate workforce shortages (Chapman et al., 2019). Robots which assist with lifting patients to help to take physical strain off the worker tend to be used alongside the care worker rather than replacing. Technology solutions that facilitate the workforce and improve care were more prominent in the research findings, including remote monitoring which collected data in order to inform home visit needs and identify which team members were needed in the home. Similarly, electronic documentation can assist with tasks such as medication and activity reminders when caregivers and family are away (Chapman *et al.*, 2019).

There is only one study quantitatively exploring whether technology can replace or reduce formal and informal care hours. Anderson and Wiener (2015) used US data to study of substitution and complementarity between technology and care hours (formal and informal). Previous studies offer mixed results and the Anderson and Wiener explain the difference with contextual factors, data, and analysis methodologies (in particular whether the studies control for differences in disability levels of recipients using these services). In their empirical investigation they did not find evidence that assistive technologies reduced paid care, while there was some evidence that informal care hours were reduced. One possibility is that both informal and formal caregivers also benefit from assistive technology use by care recipients. Even if assistive technologies did not reduce the hours of care, it may be that intensity has been reduced and strain on informal caregivers likewise, as this was not captured in the quantitative analysis.

A final aspect which may contribute to the caring profession being seen as unattractive are the abuse scandals which have taken place in several EU member states over the past decade. Monitoring, for example through video, is a way of protecting users from potential abuse or neglect and staff from inaccurate claims and indeed abuse from users. There is however a debate, mainly in the US where monitoring is legal in certain states, how the privacy of workers and indeed users can be protected. Monitoring is often perceived as a tool used against workers rather than something which is there to supportworkers (Hall et al., 2017).

4.3.2 Informal caregivers and technology

Technology can support informal caregivers in a multitude of ways, and we may in fact argue that many technologies support the caregiver more than the user. Examples include using mainstream technologies, such as baby-monitors to ensure people with dementia are calm and secure without disturbing them in their sleep (Lorenz et al 2017). More specifically designed products, including 'Ambient assisted living' (AAL) technologies, could relieve some of the informal caregivers' task pressure and provide them with peace of mind. On the contrary, informal caregivers might also feel threatened by these technologies, as they could take over some of their tasks and make them feel less needed although Jaschinski and Ben Allouch did not find direct evidence of this. They however

found that informal carers often did not see a need for support and struggled to trust a technology with the care of their loved ones (2019).A majority of studies have found that assistive technologies reduce caregiver burden. Even though they, of course, do not completely take away the responsibility and stress of caring for an older adult, assistive technologies can reduce stress, workload and burden associated with caregiving activities. There were, on the other hand, some concerns that family members having more access to users' lives would create additional burden on the family members as they would find it harder to take "time off" (Madara Marasinghe, 2016).

It is also worth discussing the role of informal carers at the point of referral into usage of assistive technologies. Cook et al. (2018), found that key facets included knowledge and awareness (informal carers lacking prior knowledge of technologies), responsibility (falling on the caregiver given that much technology is there to support the caregiver and in cases where the user is unable to consent), usefulness, usability and functionality. Koumakis et al. (2019) found that the greatest benefit for caregivers was a reduction in stress and anxiety through the support in keeping the user safe.

4.3.3 Challenges to LTC workforce improvements through technology

It is clear that the introduction of new and innovative technological solutions to LTC provision, even though they can offer improvements in time, places additional, at least temporary, demands on care workers. There are two sides to this question – what additional skills are needed and how can the implementation of new technologies be made in such a way that the transition is less painful and new skills can be acquired easily. There is a growing literature on implementing and sustaining (complex) interventions in the provision of LTC. These offer a range of insights into how best to support staff training, skills and how to routinize new practice. For example, (Colón-Emeric *et al*, 2016) offer detailed insight into implementation into care homes in the US. Much of these lessons are applicable to the implementation of technological solutions, and some are referenced below, although it is beyond the scope of this note to explore them in full. Instead the focus is on skills, attitudes and organisational characteristics which facilitate the implementation of technological interventions.

The literature emphasises that service organisations need to ensure that users (both professionals and/or care recipients) have sufficient skill levels to operate a new technology before introduction as inadequate user training has been reported as a key barrier to technology implementation in several studies (surveyed by Aaen, 2019). Staff training might also need to go beyond functional instruction to a deeper understanding of anticipated benefits and the underlying rationale for using monitoring technologies (Hall *et al.*, 2017). This involves willingness to extensively reorganise, including new workflows, responsibilities, and roles for carers and users. Equally important is to consider informal procedures and tacit knowledge (Aaen, 2019), as well as "invisible work practices", that is, undocumented work required to maintain and support technological interventions (*Procter et al*, 2018). The skills and environment issue can also be facilitated through involvement of all stakeholders in discussions and decision-making in order to arrive at a shared understanding of the range of potential benefits and challenges from the use of technologies (Hall et al., 2017). Similarly, Ko et al. (2018), argue that staff training, skills, perceived value of HIT, and integration into organisation workflows are key factors for successful implementation of technology. Ko et al. further found that effective implementation, good training resources, adequately trained IT staff and setting up a system support plan predicts greater satisfaction with HIT in nursing homes.

Regarding the implementation process, it was found that nursing homes did not often employ a systematic process and lacked the necessary infrastructure such as wireless connectivity. This is important, as without initial investment in implementation and training

of their workforce, care providers are unlikely to realise potential gains from technology. Ko et al. (2018) argue that policy makers need to create incentives for preparation, infrastructure, and training when implementing technology.

4.4 Sustainability of publicly-funded long-term care systems

Technological solutions have been hailed as an answer to the challenge of ensuring continued sustainability of LTC systems in EU member states. The financial sustainability of LTC systems is an important challenge for several reasons. If the system is financially unsustainable, it can endanger the adequacy of LTC provision, leading to underfinancing and spill-over effects for other social protection spending, mainly the health services such as through unnecessary or prolonged hospital stays. Financial sustainability is affected both by fragmentation of care (i.e. lack of coordination between health and social entities) and the lack of clear financial strategies of the territorial entities responsible for LTC and secondly, by excessive use of residential and nursing home care. It is in particular in relation to avoiding unnecessary institutionalisation and enabling users to remain safely at home that technology can play a significant role. Sustained success requires consideration of the interests of diverse stakeholders and a well thought through and sustainable business case setting out how to integrate ICT services into routine health and LTC provision (Oderanti and Li, 2016).

This section reports under what circumstances technological solutions have been found to be cost-effective, or where relevant, reduce costs, and what potential there is for savings in the future. Cost savings seem to be driven by either efficiency improvements, where technology facilitates care tasks and allows care workers to work efficiently or indeed technological solutions substituting for care workers time or tasks, and prevention of expensive deterioration of users' health. This section ends with a brief discussion of the literature on business models and government activities, which can support innovation and the diffusion, and adoption of technological solutions and is a necessary condition for sustainable use of technologies in LTC.

Table 5 : Summary of findings - sustainability

Theme	Examples of technologies/approaches	Expected benefits
Cost-effectiveness of technologies (productivity improvements)	Home based technologies including telehealth, assistive technologies	Users remaining at home longer, work processes more efficient (e.g. administration and travel)
Workforce sustainability	Supporting digital skills	Less transaction costs related to recruitment
Digital inclusion of target user groups	Supporting skills and access to IT	Effective usage of technological products.
Policy supporting investment into promising technologies	Funding models, national strategic plans, promoting usage (cross-brand compatibility)	Sustaining technological interventions and innovations over time

4.4.1 Are LTC technologies cost-effective and are savings possible?

The literature reports many arguments in favour of why different technological solutions should be cost-effective and ultimately generate savings compared to the status quo. The empirical evidence however remains scarce. Partly this is due to lack of robust research, for example, most studies that assess the use of technology in LTC are based on pilot

programs rather than fully developed RCTs (Mosca et al., 2017), lack of economic evaluations estimating benefits as well as costs and inability to cover the wide variety of technologies, usage patterns and needs (including co-morbidities) present among LTC users. Studies do not in general take into account costs and benefits for informal carers, which according to Anderson and Weiner (2015) is important as it is estimated that reducing the need for informal carers could increase the overall labour supply in the economy.

Cost-effectiveness/cost-benefit evidence

Not many studies have attempted to weigh costs against benefits when evaluating technology interventions in LTC. Among the few studies that are seen as robust RCTs, the Whole System Demonstrator (WSD) programme in the UK is often referenced. This was the largest-scale trial of telehealth and telecare to be carried out in the UK. Henderson et al. found that the telecare and telehealth intervention was not cost-effective compared to 'ordinary care' (Henderso*n et al*, 2014). Vannieuwenborg *et al.*, (2016) using cost-benefit analysis, reported qualitative outcomes improvements following the introduction of a Smart Care Platforms (SCP) which supported integration for all actors involved in home care. The outcomes included peace of mind, quality of care, strengthened involvement in care provisioning, and more transparent care communication. For providers the introduction of SCP also lead to a reduction in expenditure on two administrative process steps: care rescheduling and billing for care. Previous literature reported that there is a lack of impact on quality of life of the user and an increase in cost. In a broad literature review, Khosravi and Ghapanchi (2015) reported that even though they observed a significant positive effect in terms of outcomes of technologies (including ICT, robotics, telemedicine, sensor technology, medication management applications, and video games), more studies are needed regarding the outcome and effectiveness of these technologies. McFarland et al. (2019) reviewed the literature on telehealth and no statistically significant differences with standard home care for a range of outcomes (including quality of life, wellbeing, physical functioning) at follow-up times up to 12 months. It seems that telehealth may offer reassurance to users living at home; however, a lack of high-quality studies and heterogeneity between interventions makes overall conclusions difficult (McFarland *et al.*, 2019).

Woolham et al. (2019) found, in relation to telecare, that it may be the way in which the technology is used, rather than telecare itself that explains lack of positive outcomes. I.e. 'sub-optimal' outcomes from telecare may be linked to how telecare is adopted, adapted and used; and that this is influenced by staff training, telecare availability and a failure to regard telecare as a complex intervention. The findings may help us understand why evidence tends to find that telecare does not deliver better outcomes while local government and providers either agree or disagree. Woolham et al suggests that enhanced training opportunities for carers is key, recognising that introducing telecare is not a simple 'plug and play' solution but needs to be understood as a complex intervention and be implemented as such (Woolham *et al*, 2019).

Meiland et al (2017) reported that no studies were found which tested the cost-effectiveness of assistive technologies or health technology interventions for dementia users. This was echoed by Koumakis et al., who emphasised the scarcity of economic evidence regarding non-pharmacological interventions for people with dementia. They did find various benefits of assistive technologies for persons with dementia, but cautioned the reliability of the evidence given that the majority of studies where uncontrolled and based on small sample sizes (2019).

The findings overall indicated that more robust research is needed, the cost effectiveness is currently unknown and personalisation of technology for users is important (Daly Lynn et al, 2019). Even if *cost*-effectiveness has not been established, it is a good start to consider whether technological interventions are effective in producing the benefits

envisaged. A much sought-after way to reach this goal is to increase efficiency by reducing expensive institutional stays and substituting these with low-cost home care (Mosca et al., 2017).

There has been much hope around the possibility that technologies can improve workforce efficiencies. Chapman et al. (2019) found that various technologies improved time efficiencies through different methods, such as tracking where staff spent their time and replacing certain in-person interventions with technology-based interventions (e.g., reminders, social activity, remote monitoring). The technology could provide a clearer picture of which clients need which services, and when, which then allowed tasks to be delegated properly. Some technologies also allow certain tasks to be automated, which could ensure that caregivers maximize their time as well. Care companies commented that they did not necessarily believe that their products would contribute to overall visit reduction, but that they would instead ensure that visits were more productive by illuminating which patients were most in need of what types of care (Chapman et al., 2019).

Finally, some attempts have been made at estimating system wide costs and benefits of the introduction of technologies. For example, Rahman *et al.*, (2019), based on the Australian case, formulated a framework for calculating cost-benefit analysis of LTC technologies at a population level. They argue that even though some cost-benefit analyses on single technologies are available in the literature, there is a gap when it comes to considering the entire population or considering a set of chronic diseases and comorbidity (Rahm*an et al*, 2019). Their modelling is not based on primary data and does not offer real world results, but the framework may be useful as a guide for analysis in other countries.

4.5 LTC Technology and the response to teh Covid-19 pandemic

This report was written during the Covid-19 pandemic in 2020. Even though it was an ongoing and fast-moving situation, it soon became clear that technology had and has a huge potential to support the efforts to contain the spread of the Covid-19 virus. It has also become clear that LTC systems and in particular residential care homes have been hit very hard by the virus, with a large proportion of Covid-19 related deaths taking place in care homes in many European countries. There is emerging evidence exploring best practice examples, policies and approaches taken by various countries to use technology to support the long-term care system.

The by far most covered area is how to combat loneliness and social isolation among older people in society and in residential care homes. Social distancing and shielding advice for older people or with certain underlying health conditions mean that many people who live at home are not able to leave their home and not able to have, other than essential, visitors. Similarly, in residential care, many countries have limited visits to only those on compassionate grounds. This isolation is known to have severe negative effects on both mental and physical health. The literature reports several technology based solutions to alleviating loneliness and isolation[6] but also gaps in the availability and capability to use technology (e.g. Brooke and Jackson, 2020). Comas-Herrera *et al.*, (2020) surveyed international examples of interventions to manage Covid-19 outbreaks in nursing and residential care settings. They find many examples of the use of technology to facilitate virtual contact with families in order to alleviate loneliness and social isolation. There is however also evidence that not all care homes have access to the internet and devices for

[6] Noone et al. (2020) reviewed the previous literature on video call interventions to alleviate loneliness and social isolation with the purpose of informing the current debate. They found that there is currently uncertain evidence on the effectiveness of video call interventions to reduce loneliness in older adults. However, these results are valid under normal circumstances and may well not hold when people are living under lockdown circumstances. Benefits are potentially significantly larger.

residents to use. For example, in Australia there are trials of video-chat with families, in Austria, a number of initiatives by public authorities and private non-profit organisations have supported the acquisition of digital devices or online communication for residential care homes. On the other hand, in Italy, the majority of nursing homes already have the required digital systems to carry out video calls or similar alternatives. Similarly, in the US, Xie *et al.* (2020), argue that hybrid solutions, mixing online and offline strategies, are invaluable in ensuring the inclusion of vulnerable populations, such as older people, and that most of the solutions are already available but need further reach and funding.

The social isolation of informal carers has also been acknowledged in Lorenz-Dant et al. (2020), who report that the majority of countries surveyed have put in place virtual interventions to support informal carers. Many countries have offered structured interventions, such as psychological support, physical exercises or virtual training. Shortfalls have also been identified: informal carers may not necessarily have access to internet or do not have the relevant technical knowledge to operate the technological devices and it is difficult to get help and instruction under lockdown. Not everyone feels comfortable in online support groups due to privacy concerns. Lorenz-Dant (2020) recommends increased funding for remote support interventions (including for individuals to get necessary devices) and robust evaluations which would mean that these kind of virtual services could support informal carers not just during the pandemic, but also in the long run to be less socially isolated, to participate in meaningful and effective activities and to improve their well-being.

Given the emerging evidence of the catastrophic effect of hospital discharge into care homes, bringing the virus into the vulnerable population, care coordination and integration is a very important aspect of the Covid-19 response. There is no evidence of a role for technology in the discharge area, however it appears that telehealth is being developed in many countries. Comas-Herrera *et al.*, (2020) found that in England, steps have been taken towards improved telehealth facilities between residential care homes and secondary care. Care homes can now use NHS Mail and MS Teams to communicate with healthcare providers. People living in care homes may be offered telemedicine consultations and regular care home rounds (by GPs or others) are encouraged to be delivered virtually whenever possible. In China, Zhou *et al.*, (2020) found that counselling, supervision, training, as well as psychoeducation was carried out through online platforms (e.g., hotline, WeChat, and Tencent QQ). Early reports also showed how people in isolation actively sought online support to address mental health needs, which demonstrated both a population interest and acceptance of this medium. Steinman et al, (2020) offered findings on how to implement extended use of technologies such as video calling to older users who have little experience. Simple things have been found to matter, e.g. practicing ahead of time, ensure that users are wearing their hearing aids (where relevant), get help from a family member, friend, paid caregiver, or staff member in advance to familiarise the user with video-call technology.

Finally, workforce is likely to be an even more pressing issue due to staff needed to self-isolate and taking time off to look after others as well as limitations in flexibility due to users isolating. There is not much evidence around whether and how technology is used to support the workforce, however, for example, in England, free online training has been made available towards the required care qualification to speed up recruitment processes (Comas-Herrera *et al.*, 2020).

5. Conclusions

LTC systems in EU member states face common including guaranteeing access to affordable and high quality LTC services; ensuring the availability of an appropriately skilled workforce and supporting informal carers while ensuring future fiscal sustainability of public expenditure on LTC. Technology in LTC is widely acknowledged as a potential solution to support the sustainability of LTC provision in the future. There is hope that assistive

technologies, together with self-care by users and carers, can help monitor, treat, delay deterioration and even prevent certain conditions and relieve pressure on increasingly stretched health and social care services. The arguments in favour of this are "well-rehearsed" but not "unchallenged" (Greenhalgh et al. 2015) and this note makes a contribution to the literature by surveying the literature and taking a narrative approach while bringing insights from a broad set of sources.

In terms of *access*, the literature has shown that technology has a role to play throughout the pathway into care. First, in accessing information about services, technology can offer cheap and effective ways of making information available through online platforms, including information from other users and their families shared on social media. Older people who do not use the internet may struggle to access this information and there are concerns around whether the information is up to date and accurate. Second, at the point of needing care, which often takes place upon discharge from hospital or through a primary care referral, technology has been shown to support integration efforts, in particular through facilitating usual processes but lacking in innovativeness. Third, key for access to services is the potential of technologies to enable "ageing in place". Telecare, smart home technologies and remote monitoring can help older people carry out everyday activities and improve physical safety and social communication. Older people reported that smart homes improved their sense of security, quality of daily life and activities and provided them with information about the care they could receive. Evidence also speak in favour of a positive effect of ICT on social isolation, however, possibly only in the short-run though. The literature suggested that elderly can benefit from ICT interventions and will use them frequently after proper training.

(Process) *quality* of LTC can be improved through the use of e-health records, remote management and electronic prescriptions. These technologies can optimise the data available and help to keep a register, which both ensures accountability and can potentially lead to a reduction in medical errors, although the evidence is weak. The concerns that HIT detracted from time that could be spent with residents was confirmed in observational studies. Electronic health records (EHR) lead to significant improvement in the management of documentation in LTC providers. Improved quality outcomes were identified, however, only a few papers found impacts on user satisfaction and productivity. A wide range of positive outcomes of the use of technological solutions has been identified: including feeling secure, enabling social interaction, enhancing well-being and overall promoting independence. Specifically, smart homes are argued to improve users' outcomes, such as socialisation, improved self-esteem and competence, as well as reducing social isolation. In particular personalised solutions can complement person-centred care. Persons with dementia felt that electronic devices (including touch screen technology) facilitated their independence and reduced family and carer stress and improved overall quality of life. Robots have been found to provide support with social isolation, independent living, physical or cognitive impairment, mobility problems, poor health monitoring, lack of recreation, memory problems and fall problems, with positive outcomes. In particular, robots' multidomain functionality is a benefit, even though there may be more cost-effective options for certain functions. Some preventative effects in residential care homes have been identified from using electronic medical records in relation to risk of falling.

The literature reports that technology may facilitate, and enhance recruitment, training, and retention of the LTC *workforce*. Evidence suggests that worker retention improved when systems allowed better client-to-worker matching, more control over shift scheduling, and more efficient staffing. In particular, regarding recruitment and retention, predictive analytics which were used to identify candidates best suited for care positions were successful. Worker retention was also improved when technologies which supported targeting of carers to those users most in need, were employed and carers found that their work was effective and they were able to provide good quality care with less wasted time. Health information technology, including electronic records, had a mixed impact on

workforce. Implementation was met with resistance and staff satisfaction was mixed, however there was no evidence of increased turn-over. Care staff experienced difficulties in how to 'care for' or look after technology, including malfunctioning (e.g. false alarms), unreliable and difficult to manage devices and programmes. On the other hand when the technology (including care robots) worked well, care professionals were more than happy to use if and to explore all functions and possible benefits. There is to date no evidence showing that technology can replace care workers, however, certain tasks can be supported, but not likely to mitigate workforce shortages. Finally, workforce monitoring has been debated as a way of avoiding abuse or neglect scandals/suspicions. There are however many issues around this, including the privacy of users and how care workers feel about being monitored. Technology can support informal caregivers in a multitude of ways, and we may in fact argue that many technologies support the caregiver more than the user and a majority of studies have found that assistive technologies reduce caregiver burden and one study suggests technology can reduce informal care intensity.

The empirical evidence on the cost-effectiveness and hence opportunity for efficiency improvements, cost-savings and overall *sustainability* remains scarce. Partly this is due to lack of robust research, including a lack of economic evaluations estimating benefits as well as costs and inability to cover the wide variety of technologies, usage patterns and needs (including co-morbidities) present among LTC users. The studies that are present have not found evidence in favour of cost-effectiveness but some specific cost savings such as for example administrative procedures. The evidence on improved outcomes is more abundant. It has further been argued that the lack of positive outcomes of, for example, telecare can be explained through how it is being used, and how it was implemented (i.e. adopted, adapted and used) and that this is influenced by staff training, telecare availability and a failure to regard telecare as a complex intervention. There is in particular a lack of studies on the cost-effectiveness of assistive technologies for dementia users. Finally, workforce efficiencies were identified, including time efficiencies through different methods, such as tracking where staff spent their time and replacing certain in-person interventions with technology-based interventions (e.g., reminders, social activity, remote monitoring).

Finally, in relation to the response to the Covid-19 pandemic, the by far most covered area in the literature is how to combat loneliness and social isolation among older people in society and in residential care homes. There are significant gaps in the availability and capability to use technology, however, international evidence suggests that governments and local charities have invested in training and support, including financial support for acquiring devises for communicating remotely with family and friends. Progress in the area of telehealth has been made, for example, in terms of carrying out rounds in nursing homes remotely if possible.

The literature reports a range of issues constraining the potential of LTC technologies in alleviating the challenges of access, quality, workforce and sustainability. These are fairly similar for the different areas and are here summarised as overall considerations. Firstly, it is clear that the efficacy of technology is key, however, the literature identifies several issues that are likely to adversely affect the benefits of technologies among older people. Main factors include unaffordability, inappropriate products, lack of perceived and real ability to use technology and ill-fitted technology in terms of sensory and ergonomic issues as well as implementation and acceptability. Older people also report feeling stigmatised and vulnerable and resistant to having a "medical" looking device in a home environment. This is particularly relevant for monitoring technologies, for example wearable or environmental sensors, as even though these do provide increased safety, they may make users feel "watched", vulnerable and less independent. There are also concerns around increased loneliness and social isolation by replacing actual face-to-face communication with remote or digital presence. Similarly, it is unclear how technologies can be made truly person-centred and be updated/changed as frailty progresses. This is particularly the case for users with dementia. It is argued that a person-centred assessment of each individual's

unique technology requirement is also recommended on an ongoing basis, as need is likely to change over time. Families and informal carers should be engaged in this process.

Ethical issues, for instance around the monitoring of the workforce, data protection, privacy and conflicts between the interests of an institution and the interest of the resident, where the institutions may favour technology which limits privacy and independence in order to reduce risk, even though this has a potential negative impact on the residents' quality of life. In the same vein, it is normatively important to ensure equity of access not only to LTC overall, but to technology in itself. Equity of access to technology depends on technological design and cost and this is important to explore further going forward given that coming generations of LTC users will bring personal technology with them into their care setting and will require support in maintaining access to those technologies. The concern is further that high-income earners will be the only ones benefiting from smart home technology and that the technology could create a gap between those who can and cannot afford it.

This broad review of the literature has identified a number of themes that carry across the four research areas. Firstly, the literature overall is very optimistic of the potential for technology to be a strong positive force in LTC. For example, "Technological innovation […] can contribute to promoting function and participation in opportunities in ways never before imaginable; consequently, the uses for assistive technology in health and social care are multiplying" (Durocher *et al.*, 2019). Technologies are likely to become cheaper and more accessible over time, and the older population will, if nothing else through the cohort effect, become more and more proficient at using technologies. Yet, the literature offers highly mixed evidence on whether technologies produce the anticipated benefits and the current evidence does not support cost-effectiveness of technological interventions in LTC. Granted, there is a lack of robust economic evaluations, but the ones that are there are not positive. Woolham et al. (2019) argue that this may be due to issues around implementation, and given the commonly reported challenges, including workforce resistance and users' unwillingness to adopt[7] technologies this may well explain a significant proportion of the negative findings.

Secondly, a lot of the issues the literature brings out in terms of why LTC technology is not successful in achieving the gains expected (in terms of access, workforce, quality and sustainability) is due to issues inherent to the innovation process (i.e. designing and bringing a new/new use of old product to market) and implementation issues. It seems that complex funding/commissioning structures are an obstacle to investment into development of technological solutions, and the particular set of stakeholders and users is a challenge in terms of diffusion/adoption of innovations. User co-production/design is often mentioned as a solution as currently, often products are created without a user-centred design, which considers the needs and characteristics of the user (Chapman et al., 2019). Mosca et al argue that, in the LTC sector, to facilitate the diffusion of technology, there is a particular need to address infrastructural readiness, investment costs, and resistance to change by LTC workers (2017). Mori et al identified the following barriers to implementing technological innovation in LTC: organisational inertia, barriers related to privacy and security, the lack of coherence with the regulatory system, and the issue of data management accountability (2012). Aaen (2019) argue that "sustainable implementation" and routinisation of technologies should be understood as a complex organisational challenge that requires ongoing attention and support, also beyond initial adoption (Aaen, 2019). Given the above and the significant upfront costs (including training and support for staff and users) is important to consider the design, implementation and sustained support to ensure that the product or service reaches its full potential. Throughout this review is has become evident that a major challenge to technological

[7] These differences are somewhat reflected in the studies' scopes and analytical levels, with "acceptance" (or adoption) mainly being applied on the user level, "implementation" and "rollout" on the organizational level, and "uptake" on the market level.

progress in the LTC sector lies in implementation, diffusion and adoption of technological innovations. There is also a role for policy makers to play, for example, in terms of providing sufficient technical infrastructure (i.e., high-speed connections to the internet all over the country) to support the large-scale implementation of, for example, telecare solutions. It is important to see technologies as emerging "digital infrastructures" instead of as isolated technical functions. For policy makers, this means that the role of governments and agencies should be to facilitate, not plan and design" (Aaen, 2019).

Minor characteristics worth noting include that the role of technologies in dementia care is particularly optimistically supported in the literature. The literature suggests that people with dementia are enthusiastic about using assistive technology to remain independent and that more applications of existing technology, using, for example, mobile phones and apps, will be put to use to benefit persons with dementia (Meiland et al, 2017). However, particular challenges apply to dementia care, such as how to personalise technologies to account for needs, abilities and progression of the disease. Further, the literature is very US focused. This may be due to the fact that the LTC sector is closer, in particular nursing homes, to health care than in most European countries and the health literature in general is much more comprehensive. The literature is further denoted by many pilot studies, protocols with short follow-up times and descriptive evaluations. It appears that rolling out a technology on a large scale is challenging, and even more so in ensuring that it is evaluated in a robust way, in particular in capturing costs and benefits.

Finally, there is a need for a clear taxonomy describing technologies in LTC. A facet constraining the ability to do research is the lack of clarity around categories and labelling of technologies as well as the expected outcomes (Graybill *et al.*, 2014). More research is consistently called for in almost every study covered in this note and there seems to be a particular dearth of robust research around cost-effectiveness as well as appropriate design and implementation keeping the user in focus.

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