BMJ Health & Care Informatics

# Literature review: technological interventions and their impact on quality of life for people living with dementia

David Sanders [1], Philip Scott [2]

**To cite:** Sanders D, Scott P. Literature review: technological interventions and their impact on quality of life for people living with dementia. *BMJ Health Care Inform* 2020;**27**:e100064. doi:10.1136/bmjhci-2019-100064

Received 01 June 2019
Revised 11 October 2019
Accepted 17 December 2019



[1]School of Computing, University of Portsmouth, Portsmouth, UK
[2]Centre for Healthcare Modelling and Informatics, University of Portsmouth Faculty of Technology, Portsmouth, UK

**Correspondence to**
Dr Philip Scott;
philip.scott@port.ac.uk

## ABSTRACT

**Objectives** Rapid technology-driven innovation in the healthcare sector has led to an increasing ability to effectively respond to health challenges. However, the cognitive challenges faced by a person with dementia exacerbate the difficulty of designing enduring technological dementia care solutions. Despite this, and in the absence of a cure, facilitating well-being and improved quality of life becomes pivotal for those living with dementia and their caregivers. This review aimed to identify and consolidate the provision of technological solutions for dementia care, and how these are perceived to impact the quality of life of a person with dementia.

**Methods** Articles and journals were identified using keywords including those relating to quality of life, assistive technologies and technology adoption and acceptance. Greater priority was given to resources published after 2010 due to the speed of technological advancement, and peer-reviewed articles were preferred.

**Results** 91 resources were identified, with 38 contributing to the final review. In addition to multiple quality of life measurement tools, the literature identified a large variety of solutions that fell into three categories: those used 'by', 'with' or 'on' a person with dementia.

**Conclusions** This review concludes that the 'one size fits all' approach to many solutions reflects the lack of supporting evidence, negatively impacting trust in their usefulness among caregivers and their subsequent adoption rates. This could be attributed to limited involvement of people with dementia in studies of effectiveness and adoption. Additional research is recommended to further consolidate research on quality of life and to understand the individuality and progression of dementia and its influence on dementia care solutions.

## INTRODUCTION

Dementia care is arguably one of the most challenging domains in an already highly complex healthcare environment. Despite the rapid progression of technological advancements in healthcare, the cognitive decline experienced by a person with dementia places new demands on the ability to provide effective and enduring dementia care solutions.

The ageing population has led to an increasing number of people with dementia, with over 850 000 believed to be living with the condition in the UK, at a cost of over £26 billion.[1] Although such figures can help appreciate the scale and widespread impact of dementia, they are unable to represent the personal impact on the individuals living with the condition and those around them.

As generations age and technology becomes more widely familiar, people are more likely to place trust in technology for their healthcare. The potential is already starting to become recognised, with the widespread adoption of electronic health records and its ability to reduce costs and increase efficiency.[2 3] Despite this, Greenhalgh *et al*[4] highlighted the unrealistically rapid implementation of healthcare technology expected by policymakers, often due to the need for establishing such services in busy and financially stretch organisations, while Nair and Dreyfus[3] identified the disparity between healthcare technology investment and its limited subsequent adoption by service providers.

The WHO, who have endorsed the 'Global action plan on the public health response to dementia 2017–2025', highlight the importance of technology to improve dementia care.[5] In the absence of a cure, facilitating well-being and improving quality of life of someone with dementia becomes arguably even more important. 'Beyond the Pill' care (ie, non-pharmacological care interventions) is pivotal in achieving this, with techniques such as reminiscence therapy proven to improve mood and cognition.[6]

With 60% of people with dementia living at home[1] and 700 000 informal caregivers in the UK,[7] there is a need for 'beyond the pill' solutions to reduce the burden on caregivers. This need is unlikely to decrease, with the number of people living with dementia

expected to rise from 850 000 to over 2 million people by 2050.[7] Despite this, 63.5% of caregivers believe they are not given enough support from the healthcare service.[7] However, with caregivers reporting higher levels of emotional strain when not using any beyond-the-pill solutions, compared with those who used both in home (eg, meals on wheels) and out of home (eg, transportation),[8] the importance of 'beyond the pill care' cannot be overstated.

This review will explore and consolidate the provision of technological solutions available for people with dementia. Additionally, it will consider how the domains deemed important to quality of life are impacted by the technological solutions discussed. This will be structured around the following research questions:

1. How is quality of life for people with dementia defined and measured?
2. What technologically based solutions are currently available to assist people with dementia with their quality of life, and how do these contribute to the domains deemed important to quality of life?

## METHODS

### Search and selection strategy

The following tools were chosen for the identification of literature, as they were deemed most relevant to the topic: University of Portsmouth Discovery service, Sage Journals, British Journal of Healthcare Computing and PubMed. It was decided the Discovery Service would be the primary source of literature due to the higher probability of accessing full text, as it is the direct library service with access to all university journal subscriptions. This search primarily took place between October and December 2017 and was expanded between November 2018 and March 2019. The following keywords were used as a search basis:

- Technology in dementia.
- Assistive technology in dementia.
- Technology limitations in dementia.
- Dementia Technology acceptance/adoption.
- Quality of life in dementia.
- Dementia self-image.
- Dementia therapeutic methods.

Therapeutic methods were included in keywords due to their relevancy in 'Beyond the Pill' care and quality of life.

To ensure as much relevant literature as possible was covered, there were also searches conducted with the phrase 'mild cognitive impairment' in place of 'dementia'. As some searches were returning tens of thousands of results, database filters were used to refine results, including:

- Date published.
- Language of literature.
- Source (journal type and publication type).
- Full text only.

Initially, abstracts, contents and conclusions were reviewed to determine the suitability to this report, before a more in-depth analysis was undertaken. Literature that was subsequently used was stored in Mendeley reference management software for easy retrieval and reference purposes.

### Quality appraisal

There were several considerations made in the decision process for determining appropriate literature; this was to ensure the validity and relevance to the topic. Publication type was used as a gauge of validity, with a preference for peer-reviewed articles. However, books and other online resources were considered to ensure a holistic view of the topic was gained.

Due to the exponential growth in technological advancement, the date of material was an important factor in the decision process. For this reason, there was a greater emphasis on material published after 2005. However, peer-reviewed literature from before this year was considered, to build a better understanding of the progression of technology in dementia. In addition to this, research on the provision of technological solutions was primarily focused on material published after 2013, to build on a similar review conducted by Cook *et al*.[9] This approach ensured that the literature review was focused on the most recent advancements.

Further consideration was given to the clarity of text, and the substantiation of points made, to ensure the accuracy and relevance to the topic.

## RESULTS

Figure 1 shows a Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow chart[10] of results following the search. Table 1 shows a matrix of relevancy for the selected literature against the keywords detailed in the Search and Selection Strategy section. Table 2 shows a breakdown of selected literature by year. Table 3 illustrates the provision of technological solutions and their relation to the domains defined in Dementia Quality of Life Instrument (DQoL). Solutions used 'on' a person with dementia, despite often causing feelings of resentment,[11] are assumed to improve self-esteem due to their ability to allow an individual to live independently.

## DISCUSSION

### Determining the quality of life for a person living with dementia

Determining quality of life is a difficult task due to the subjectivity and individuality involved. This challenge is exacerbated as a person's opinion of their own quality of life adapts along with cognitive diseases such as dementia,[12] with changing priorities through the progression of the disease.[13] For example, a person might value intellectual capacity highly during the early stages of

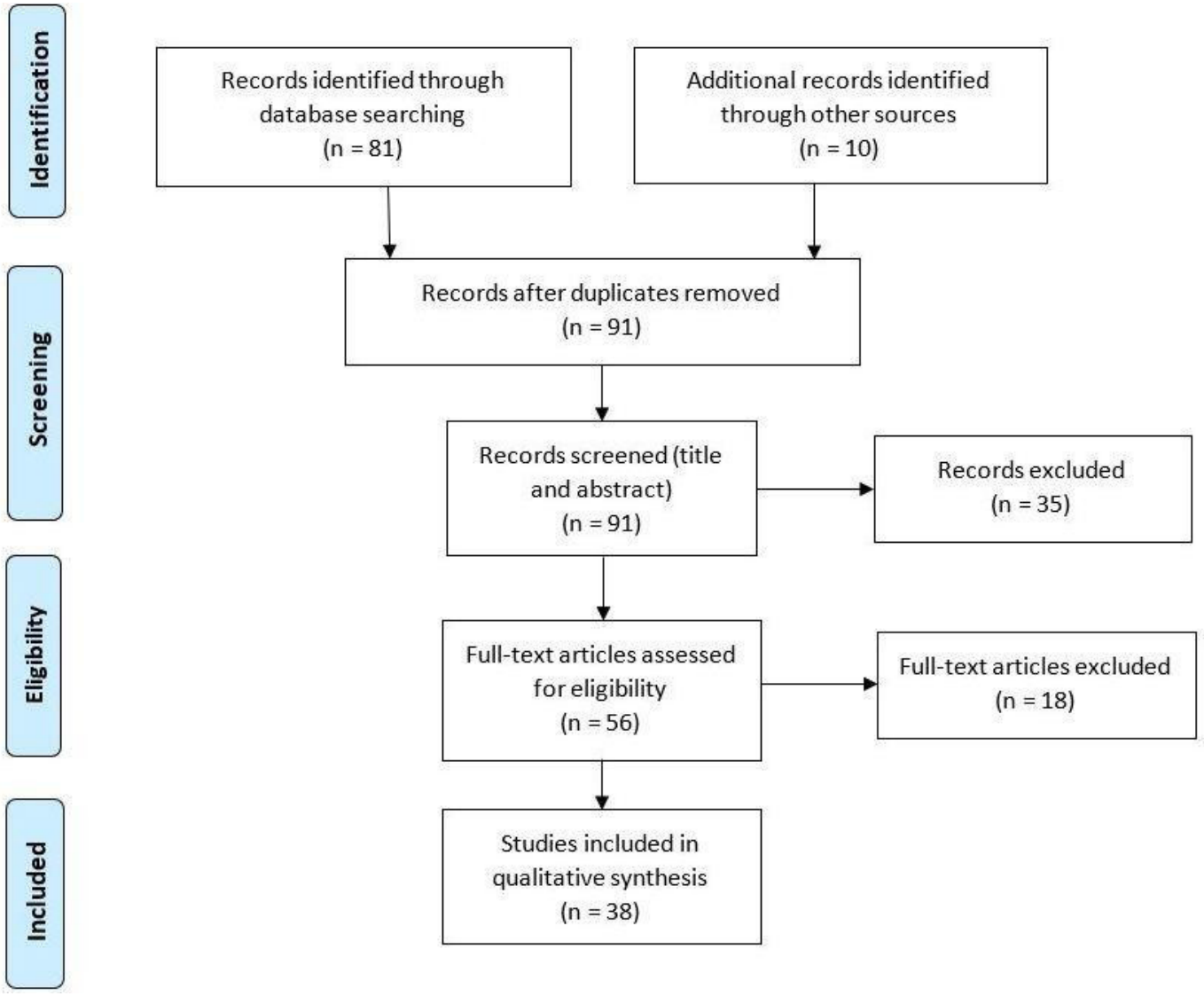


**Figure 1** Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow chart of literature search result.[10]

dementia, whereas safety and comfort may take precedence as the condition progresses.

Despite the publication of many instruments designed to measure quality of life in dementia, each with differing approaches, Lawton's model, defined in 1994, appears to have had the most influential impact on subsequent instruments.[14] It argues the importance of subjective and objective factors as well as defining four overarching contributing areas to quality of life: psychological well-being, behavioural competence, objective environment and perceived quality of life.[15] Researchers have interpreted Lawton's model differently, with some considering them as predictors of quality of life, and others believing they are the defining features of quality of life.[14]

In 1995, the WHO defined quality of life as 'the individual's perception of their position in life in the context of the culture and value system in which they live, and in relationship to their goals.[16] However, this definition does not consider the restricted ability of someone with declining cognitive ability to make judgements and communicate their subjective state. This gap was identified by Logsdon *et al*,[13] who designed the Quality of Life in Alzheimer's Disease (QoL-AD) model to enable individuals with progressive cognitive impairment to rate their own quality of life, while providing a comparison to a caregiver's opinion. This model was originally tested on a sample size of 177 patient/caregiver dyads and offers a series of 13 factors that fit under the four domains set out by Lawton. Patients and caregivers are able to rate each of the 13 factors to determine a quality of life rating.[13] This model has the benefit of being administered within 10 min and assessing the reliability against a caregiver's score, yet lacks the ability for patients and caregivers to define their own weighting of the different factors, and thus what is most important to them.

One model that does take individual perception and weighting into consideration, influenced by Lawton's model, is the DQoL. In contrast to QoL-AD, which is

**Table 1** Literature relevancy matrix

| | Technology in dementia | Technology limitations and acceptance in dementia | Quality of life | Therapeutic methods | Additional comments |
|---|---|---|---|---|---|
| Astell *et al*[33] | X | | | | |
| Boyd *et al*[23] | X | | | | |
| Brod *et al*[24] | | | X | | |
| Clarkson *et al*[1] | X | X | | | |
| Cook *et al*[9] | X | | X | | |
| Czarnuch *et al*[8] | X | X | | | |
| Day Clock[26] | X | | | | |
| Dua *et al*[19] | | | | | Used in the introduction for providing information around the WHO's action plan |
| Fleming and Sum[17] | X | | | | |
| Gibson *et al*[36] | X | | | | |
| Gibson *et al*[22] | X | | | | |
| Glaser and Salzberg[2] | | | | | Used in the introduction for providing information on the wider use of technology in healthcare |
| Greenhalgh *et al*[4] | | | | | Used in the introduction for providing information on the wider expectation of technology in healthcare |
| Hopkins[28] | X | | | | |
| Huldtgren *et al*[30] | X | | | X | |
| Impact on Carers[7] | | | | | Used in the introduction to provide statistics on the impact of dementia |
| iSupport[20] | X | | | | |
| Jamieson *et al*[25] | X | | | | |
| Kasl-Godley and Gatz[35] | | | X | X | |
| Kim *et al*[31] | X | | X | X | |
| Lawton[15] | | | X | | |
| Lawton *et al*[18] | | | X | X | |
| Leroi *et al*[37] | X | | | | |
| Liu *et al*[38] | X | X | | | |
| Logsdon *et al*[13] | | | X | X | |
| MagiPlug[29] | X | | | | |
| Marshall[21] | | | X | X | |

Continued

**Table 1** Continued

| | Technology in dementia | Technology limitations and acceptance in dementia | Quality of life | Therapeutic methods | Additional comments |
|---|---|---|---|---|---|
| Moher *et al* [10] | | | | | Used for the PRISMA framework for search results |
| Murphy *et al*[32] | X | | | | |
| Nair and Dreyfus[3] | | | | | Used in the introduction for providing information on the wider limitations of technology in healthcare |
| Pivotell[27] | X | | | | |
| Ready and Ott[14] | | | X | | |
| Revell *et al*[12] | | | X | | |
| Robinson *et al*[11] | X | X | | | |
| WHO[16] | | | X | | |
| Woods *et al*[6] | | | X | X | |
| WHO[5] | X | X | | | |
| Zheng *et al*[34] | X | | | | |

PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

**Table 2** Selected literature results by year of publication

| Year of publication | Quantity of references used |
|---|---|
| 2018 | 1 |
| 2017 | 8 |
| 2016 | 4 |
| 2015 | 3 |
| 2014 | 3 |
| 2013 | 4 |
| 2012 | 1 |
| 2011 | 1 |
| 2009 | 2 |
| 2007 | 1 |
| 2005 | 2 |
| 2003 | 1 |
| 2002 | 2 |
| 2001 | 1 |
| 2000 | 1 |
| 1999 | 1 |
| 1997 | 1 |
| 1996 | 1 |
| 1994 | 1 |
| Undated | 7 |

used by both people with dementia and their caregivers, DQoL is exclusively for people with dementia and allows an individual to rate factors under five domains: positive affect, negative affect, feelings of belonging, self-esteem and feelings of aesthetics.[17] The term 'affect' refers to an individual's subjective opinion on how emotions impact their mood both positively (eg, pleasure, interest) and negatively (eg, sadness, anger).[18] The DQoL model was tested on a sample of 99 patients with mild to moderate dementia and was found to be more accessible than the QoL-AD scale, with only 4% unable to complete the screening stage, as opposed to 12.4% for the QoL-AD model.[14] The increased availability, domain simplicity and aggregated importance ratings are likely to better represent the subjective factors that contribute to quality of life.

The DQoL model (table 4) has been selected for this review as a reference point for technologies discussed. Therefore, technological interventions will be compared against the five domains of DQoL deemed important to quality of life.

## The implementation and challenges of technological solutions for people with dementia

In 2017, the WHO recognised a neglect in public policy for the provision of dementia care solutions.[19] One specific strategic area of the WHO global action plan[5] is focused around improving care for people with dementia, with a focus on enhancing information systems for dementia and fostering innovation.[19] This action

**Table 3** Matrix of solution effectiveness in relation to the DQoL model

| DQoL domains<br>Solution | Solution category | Self-esteem[24] | Positive affect[24] | Negative affect[24] | Feeling of belonging[24] | Sense aesthetics[24] |
|---|---|---|---|---|---|---|
| Large simple clocks/calendars[17 26 36] | Used 'By' people with dementia[22] | X | | | | |
| Motion sensor lighting[22] | | X | | | | |
| Smart pill dispensers[17 27 28] | | X | | | | |
| Reminder displays/Dictaphones[22] | | X | | | | |
| Boil Alert[22] | | X | | | | |
| MagiPlug[29] | | X | | | | |
| Smoke alarms[36 37] | | X | | | | |
| Modified telephones[36] | | X | | X | | |
| Talking Mats[32] | Used 'With' people with dementia[22] | X | X | | X | |
| Games and entertainment applications[23 30 32–34] | | | X | | | X |
| Multimedia reminiscence applications/devices[22 23 30 32–34] | | | X | | | X |
| 3D modelled familiar environments[30] | | | X | | | X |
| Old-fashioned radio/TV[30] | | | X | | | X |
| Telecare services (alarms and sensors)[22 36 37] | Used 'On' people with dementia[22] | X | | | | |
| GPS tracking devices[11 22 36 38] | | X | | | | |
| Fall detectors[22 36] | | X | | | | |
| Water/gas monitoring and control[22 36] | | X | | | | |
| Geofencing alarms[22 36] | | X | | | | |

DQoL, Dementia Quality of Life Instrument; GPS, Global Positioning System.

plan represents a positive movement to encourage the creation and support of solutions that improve the quality of life for both patients and caregivers. In response to the global action plan, the WHO developed iSupport, an online training programme for caregivers of people with dementia.[20] iSupport helps caregivers understand the impact of dementia and helps them recognise and improve the quality of care provided for both the person with dementia and themselves.

Beyond support for caregiver learning, such as iSupport, assistive technology appears to play a pivotal role in improving an individual's quality of life. In the context of dementia, Marshall[21] defined assistive technology as 'any item, piece of equipment, product or system… that

**Table 4** DQoL domains and mean ratings (adapted from Brod *et al* [24])

| Domain (description) | Rating of importance (on a scale of 1–5) |
|---|---|
| *Self-esteem*: Thoughts and feelings about themselves (frequency feels confident, satisfied with self, accomplished something, makes own decisions) | 3.66 |
| *Positive affect/humour*: Frequently felt happy, cheerful, content, hopeful, found something that made them laugh, jokes and laughs with others | 3.55 |
| *Negative affect*: Frequently felt afraid, lonely, frustrated, embarrassed, angry, worried, depressed, nervous, sad, irritated, anxious | 3.86 |
| *Feelings of belonging*: Frequently felt useful, felt people liked you, felt lovable | 3.66 |
| *Sense of aesthetics*: Extent to which obtained pleasure from sensory awareness, appreciation of beauty (extent of enjoyment listening to music, listening to sounds of nature, watching animals or birds, looking at colourful things, watching clouds or sky) | 3.99 |

DQoL, Dementia Quality of Life Instrument.

is used to increase, maintain or improve functional capabilities'. However, this definition does not consider the potential impact on some of the qualitative measures that improve quality of life, such as those defined in DQoL. Consequently, this review suggests a more suitable definition, in the context of this literature review, would be 'A technological solution that intends to improve the quality of life for people with dementia or their caregivers, either through maintaining or improving functional capabilities, facilitating improved self-esteem or sense of belonging, or increasing the ability to gain pleasure through activities or environments'.

Gibson *et al*[22] conducted a comprehensive study on the available assistive technology solutions for people with dementia in the UK and proposed a useful segregation of solutions. All solutions observed were able to be placed into one of three categories: 'by', 'with' or 'on'. 'By' solutions are those that can be used independently by the person with dementia, and generally support the completion of everyday activities (eg, signage or alarms). 'With' solutions are collaborative and encourage the interaction between the caregiver and individual with dementia (eg, reminiscence aids). 'On' solutions are designed to intervene in a person's life without active participation, and generally aim to lessen the risks to the person with dementia (eg, fall detectors or smoke alarms). It is, however, noted that some solutions may apply to more than one category, such as a game which can be used 'by' someone, but also as a tool to encourage communication 'with' a caregiver. Figure 2 illustrates the categories and some example subcategories that fit under assistive technology.

### Solutions used 'By' people with dementia

As one of the most prevalent symptoms of dementia is forgetfulness,[5] it inherently becomes more challenging for people with dementia to learn something new and unfamiliar. Therefore, it could be argued that creating solutions that are designed to be used 'by' someone with dementia independently, is one of the more complex problems faced in dementia-related care. Despite the challenging nature, enabling people to perform simple everyday activities is significant, as it lessens the burden on caregivers, and can help improve an individual's self-esteem,[23] noted as one of the key domains in DQoL.[24] This is supported in a study[25] which concluded that technology can support increased confidence and retention of independence for people with progressive neurodegenerative diseases such as dementia.

Due to the challenges of designing solutions to be used by someone with dementia, many examples are simple in design and function, with an aim of improving

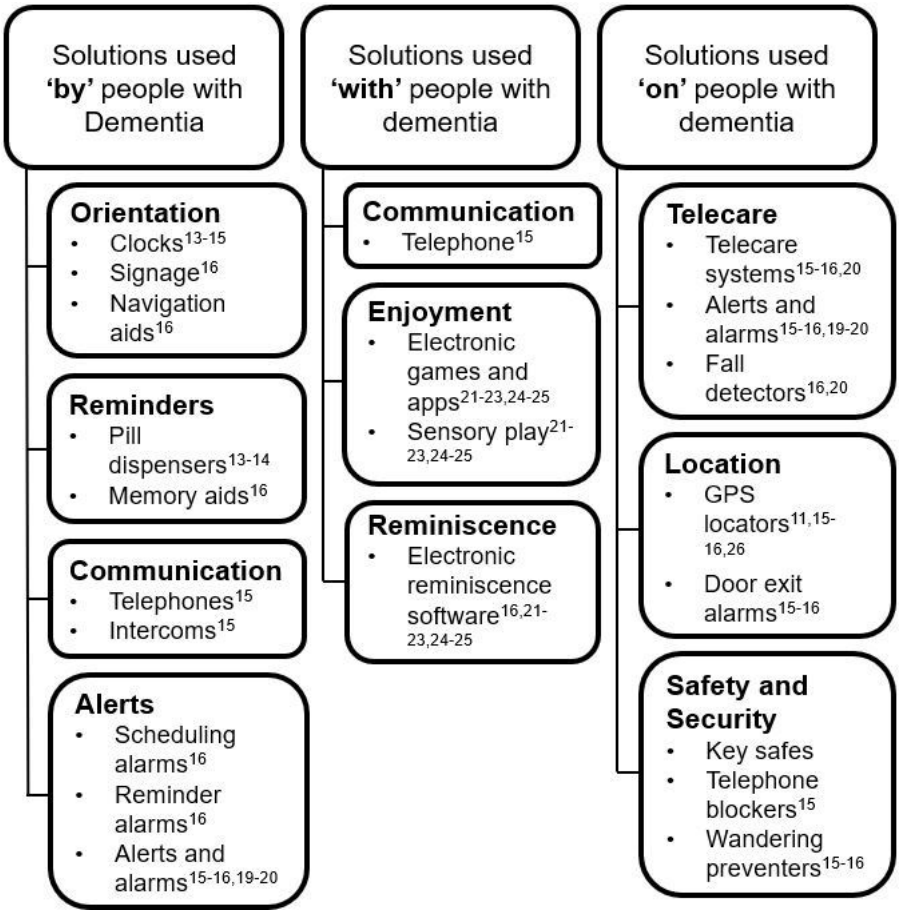


**Figure 2** Categories and subcategories of assistive technology (AT) (adapted from Gibson *et al* [36]). GPS, Global Positioning System.

intuitiveness and ease of use. Solutions such as large clock faces are examples where no user interaction is required, however Gibson *et al*[22] found the date format on many (dd/mm/yyyy) to be unsuitable for people with dementia. Other available examples have further simplified this by only displaying the day of the week, and a general time of day (ie, morning, afternoon, evening, night), such as that provided by Day Clock.[26] Similarly, Gilliard and Hagen, as cited by Fleming & Sum,[17] created a simple 'Day and Night Calendar' that was successfully adopted by 84% of participants, with caregivers stating simple and familiar formats were impactful. Other technologies for time and place orientation, such as motion sensor lighting, are also available to mitigate some of the risks associated with dementia.

One issue experienced by many people living with dementia and their caregivers is poor medicine adherence. Pill dispensers can help alleviate this problem, acting as alerts or reminders, in addition to preventing overdoses through the separation and locking of doses. Such devices are becoming increasingly sophisticated, with examples such as 'Pivotell'[27] able to alert a caregiver if a dose is missed. Fleming and Sum[17] emphasised the high acceptance rate for pill dispensers in the Gilliard and Hagen study, with over 80% of participants finding them useful. Despite this, Hopkins[28] found that complex designs and difficulties learning to use such devices often proved restricting. Other alert-based solutions, such as 'Boil Alert' to prevent cooking accidents, and 'MagiPlug'[29] to prevent overfilling baths or sinks, are available to enable people with dementia to safely live more independently.

Generally, 'by' solutions that require minimal interaction from users seem to promote greater acceptance. This is supported by Cook *et al*[9] who also highlight more successful outcomes through lower interaction requirements. Familiarity is also likely to play an important part, recognisable objects and familiar voices are more likely to be accepted and are easier to use intuitively.

### Solutions used 'With' people with dementia

In a study conducted by Gibson *et al*,[22] it was found that the fewest available solutions fit into the 'with' category (enabling social interactions and communication with others). This could be attributed to healthy people often having trouble interacting with people with dementia, partly down to a lack of understanding.[24] In addition, other potential symptoms of dementia, including difficulties with speech, reasoning and decision-making, could make it difficult for people with dementia to engage in meaningful interactions, often detrimental to their self-confidence and quality of life.[30] Despite this, positive social interaction can have a substantial impact, with Kim *et al*[31] stating that positive social experiences are proven to slow down symptoms of the disease. Enabling these dialogues and experiences also has the potential to positively influence feelings of worth and belonging and can help individuals with dementia to experience activities or environments that they can appreciate and enjoy with others—all of which being vital factors in the DQoL model.

One example of a 'with' solution is Talking Mats, a communication tool seeking to help people with communication difficulties interact by using symbols to represent feelings and emotions. This was found to improve communication with people with dementia at all stages of the disease.[32] However, this study was conducted using the physical product, and although a mobile application is available, there is no literature on its effectiveness in the context of dementia.

Games and applications for the enjoyment of people with dementia are becoming more common with increased accessibility and affordability of touchscreen devices.[33] Although not primarily communication-based activities, they can be used with a caregiver to promote discussions and enjoyment. Touchscreen games appear to be well received, with over 90% of participants in the Astell *et al*'s[33] study stating they experienced enjoyment when playing a familiar card game that had been digitised. This result was slightly higher than the 85% who enjoyed playing a generic, non-familiar game on a touchscreen device. This finding was echoed by Zheng *et al*,[34] who also identified positive impacts on an individual's cognition and balance as a result of game-based interventions, however highlighted a current lack of evidence supporting their use.

With negative social experiences or social isolation impacting self-confidence,[30] it is imperative that positive experiences are encouraged and facilitated to improve quality of life. One method of achieving this is through reminiscence, proven to improve mood, cognition and behaviour,[6] while also increasing interpersonal communication.[35] Reminiscence therapy is the use of familiarity to promote discussion, with objects, activities or events of individual significance being used to facilitate this. Huldtgren *et al*[30] point to many examples of technological solutions for reminiscence, including:

- The use of photo, video and music to support one-to-one reminiscence sessions, with positive reported outcomes.
- 3D modelling of environments (eg, Gardens) for people with dementia to enjoy environments they can no longer access, well received among those in mild to moderate stages of dementia.
- An old-fashioned radio, and television that played music and news from 1930 to 1980, proving popular although some participants had difficulties with a standard remote control.

### Solutions used 'On' people with dementia

Accounting for most of available care solutions in the UK, and responsible for monitoring activity and location of individuals and giving caregivers access to people with dementia in emergencies, are 'on' solutions.[22] These solutions typically require no interaction or knowledge from the person with dementia and are often put in

place for safety reasons and to reduce the physical and emotional burdens of care.[36] Solutions in this category fall into either telecare, location monitoring, or safety and security.

Telecare refers to the remote monitoring of people often in their own homes and aims to promote greater independence.[22] According to Gibson and colleagues, most telecare services included alarms and sensors connected to a telephone line or internet connection to a caregiver. Other advancements, such as those in accelerometers, also allowed for devices such as fall detectors, which can be easily included due to the modularity of telecare services. The use of such services, although endorsed by the Department of Health and having shown to prolong independent living, lacks evidence to support its cost-effectiveness in the context of dementia.[37]

Location monitoring is perhaps one of the most controversial areas of dementia care and is often used to counteract some symptoms of dementia, such as wandering. These solutions generally use Global Positioning System (GPS) technology so that caregivers can monitor the geographic location of the person with dementia.[38] Liu and colleagues discovered a high acceptance rate of GPS-based devices among caregivers, with peace of mind and greater independence being the significant benefits. However, in a study conducted by Robinson *et al*,[11] it was found that people with dementia occasionally resent the idea due to a perceived loss of confidence in their abilities.

Devices for safety and security generally aim to monitor or restrict a specific activity that could potentially become a risk. Examples include key safes for easy access to a house in an emergency, technology to automatically disable water flows or gas supply, geofencing to mitigate the risk of wandering and telephone blockers that can divert or cancel calls not on a predefined list.[22]

## CONCLUSION

Measuring the quality of life for a person living with dementia presents a unique and complex challenge, this is due to the subjectivity of determining quality of life and the cognitive impairment experienced by someone with dementia. To handle this complexity, models have been suggested that aim to be more accessible and often objective in order to determine the quality of life. One example is DQoL, an instrument that allows an individual to rate factors under five domains: positive affect, negative affect, feelings of belonging, self-esteem and feelings of aesthetics.[24]

The use of technology in dementia care has become increasingly popular, coinciding with the exponential growth in technological innovation. Care solutions can be broadly placed into three categories: solutions used 'by', 'on' or 'with' a person with dementia.[22] Solutions used 'by' or 'on' a person with dementia were determined to have a greater impact on an individual's self-esteem, one domain of the DQoL model. This is due to their ability to enable someone to maintain independence despite their condition. Solutions used 'with' a person with dementia are more likely to have a profound impact on quality of life, due to their ability to increase a person's self of belonging and their ability to engage meaningful conversation. The growing provision of dementia care solutions is likely to increase individuals' trust and familiarity with them, in addition to reducing the dependence on institutional care. Such growth could continue to empower users of solutions; however, care should be taken to avoid the appearance and feelings of dependence for people with dementia. In addition, with the increased uptake of internet of things, devices such as fall detectors and carer alarms, the design and implementation of technological solutions should consider issues pertaining to system security and data privacy, in addition to the challenges of adoption.

Although research is extensive, it often does not directly involve people with dementia, especially those in the severe stages of the condition. This is evident in the quality of life studies and those testing the effectiveness of assistive technologies, with many instead consulting the caregivers of people with dementia. This could be seen to undermine the credibility of such research and explain the high level of disparity in the understanding of key factors, such as measuring quality of life or determining the acceptance of technology. These limitations would warrant further research and consolidation of the available techniques and, despite the ethical barriers, would benefit greatly from the involvement of people with dementia. Such research would benefit from longitudinal data analysis due to the progressive nature of the condition. In addition, this analysis should consider changing quality of life priorities and therefore determine the applicability, relevancy and ability for an individual to use a solution over a period of time.

Dementia care requires highly targeted and individual approaches due to the subjectivity of determining quality of life, and expansiveness of the condition combined with other health problems that a person might face. This challenge appears to negatively impact caregiver trust in available solutions, which may be seen to take a 'one size fits all' approach. However, multiple objective factors have appeared useful in determining subjective concepts such as quality of life and technology acceptance. The home environment of an individual and the care support they have available to them can act as useful indicators of general quality of life and technology acceptance.

To further tackle the complex challenges that face people with dementia, their caregivers and those creating solutions to support them, the following further research has been identified:

- Research to further understand the progression of dementia and its effects on care needs and factors deemed important to quality of life.
- Greater emphasis on the inclusion of people with dementia in studies on technology acceptance.

- Research to understand the benefits of customisable solutions (ie, those with the ability to alter the level of functionality available to an individual based on their cognitive abilities).

**Funding** The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

**Competing interests** None declared.

**Patient consent for publication** Not required.

**Provenance and peer review** Not commissioned; externally peer reviewed.

**Data availability statement** No data are available.



**ORCID iDs**
David Sanders http://orcid.org/0000-0003-4467-7577
Philip Scott http://orcid.org/0000-0002-6289-4260

## REFERENCES

1 Clarkson P, Davies L, Jasper R, *et al*. A systematic review of the economic evidence for home support interventions in dementia. *Value in Health* 2017;20:1198–209.
2 Glaser J, Salzberg C. *The strategic application of information technology in health care organizations*. San Francisco: Jossey-Bass, 2011.
3 Nair A, Dreyfus D. Technology alignment in the presence of regulatory changes: the case of meaningful use of information technology in healthcare. *Int J Med Inform* 2018;110:42–51.
4 Greenhalgh T, Wherton J, Papoutsi C, *et al*. Beyond adoption: a new framework for theorizing and evaluating Nonadoption, abandonment, and challenges to the scale-up, spread, and sustainability of health and care technologies. *J Med Internet Res* 2017;19:e367.
5 World Health Organization [Internet]. Who.int, 2017. Available: http://www.who.int/mediacentre/factsheets/fs362/en/ [Accessed 9 Apr 2019].
6 Woods B, Spector AE, Jones CA, *et al*. Reminiscence therapy for dementia. *Cochrane Database Syst Rev* 2005;151.
7 Impact on carers [Internet]. Dementia Statistics Hub. Available: https://www.dementiastatistics.org/statistics/impact-on-carers [Accessed 19 Apr 2018].
8 Czarnuch S, Ricciardelli R, Mihailidis A. Predicting the role of assistive technologies in the lives of people with dementia using objective care recipient factors. *BMC Geriatr* 2016;16.
9 Cook G, Bailey C, Moyle W. The impact of ICT-based telecare technology on quality of life of people with dementia: review of the literature. 2013 6th International Conference on human system interactions (Hsi) 2013.
10 Moher D, Liberati A, Tetzlaff J, *et al*. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS Med* 2009;6:e1000097.
11 Robinson L, Brittain K, Lindsay S, *et al*. Keeping in touch everyday (KITE) project: developing assistive technologies with people with dementia and their carers to promote independence. *International Psychogeriatrics* 2009;21:494.
12 Revell AJ, G. L C, S. L W, *et al*. Quality of Life in Alzheimer's Disease (QoL-AD) Scale: Factor Solutions in Non-Demented Elders. The Pennsylvania State University, [Online]. 2002;2-4. Available: https://sharepoint.washington.edu/uwsom/sls/Documents/2000/QOL_AD_2002.pdf
13 Logsdon RG, Gibbons LE, McCurry SM, *et al*. Assessing quality of life in older adults with cognitive impairment. *Psychosom Med* 2002;64:510–9.
14 Ready RE, Ott BR. *Health Qual Life Outcomes* 2003;1:11.
15 Lawton MP. Quality of life in Alzheimer disease. *Alzheimer Dis Assoc Disord* 1994;8:138–50.
16 WHO | WHOQOL. Measuring Quality of Life [Internet]. Who.int. Available: http://www.who.int/healthinfo/survey/whoqol-qualityoflife/en/ [Accessed 12 Mar 2018].
17 Fleming R, Sum S. Empirical studies on the effectiveness of assistive technology in the care of people with dementia: a systematic review. *J Assist Technol* 2014;8:14–34.
18 Lawton MP, Van Haitsma K, Klapper J. Observed affect in nursing home residents with Alzheimer's disease. *J Gerontol Series B* 1996;51B:P3–14.
19 Dua T, Seeher KM, Sivananthan S, *et al*. World health organization's global action plan on the public health response to dementia 2017-2025. *Alzheimer's & Dementia* 2017;13:P1450–1.
20 iSupport | Home [Internet]. Isupportfordementia.org. Available: https://www.isupportfordementia.org/en [Accessed 3 Dec 2017].
21 Marshall M. *State of the art in dementia care*. London: Centre for Policy on Ageing, 1997.
22 Gibson G, Newton L, Pritchard G, *et al*. The provision of assistive technology products and services for people with dementia in the United Kingdom. *Dementia* 2016;15:681–701.
23 Boyd HC, Evans NM, Orpwood RD, *et al*. Using simple technology to prompt multistep tasks in the home for people with dementia: an exploratory study comparing prompting formats. *Dementia* 2017;16:424–42.
24 Brod M, Stewart AL, Sands L, *et al*. Conceptualization and measurement of quality of life in dementia: the dementia quality of life instrument (DQoL). *Gerontologist* 1999;39:25–36.
25 Jamieson M, Cullen B, McGee-Lennon M, *et al*. The efficacy of cognitive prosthetic technology for people with memory impairments: a systematic review and meta-analysis. *Neuropsychol Rehabil* 2014;24:419–44.
26 Day Clock & Ward Orientation Clock – Helping People Live With Dementia [Internet]. Day-clock.com. Available: https://www.day-clock.com/ [Accessed 3 Dec 2017].
27 Pivotell [Internet]. Pivotell.co.uk. Available: https://www.pivotell.co.uk/ [Accessed 16 Mar 2019].
28 Hopkins P. The use of technology to help patients with self-medication. *Nursing Times* 2005;101:24–5.
29 Magiplug [Internet]. Magiplug. Available: http://www.magiplug.com/ [Accessed 16 Mar 2019].
30 Huldtgren A, Mertl F, Vormann A, *et al*. Reminiscence of people with dementia mediated by multimedia artifacts. *Interact Comput* 2017;29:679–96.
31 Kim C, Wu B, Tanaka E, *et al*. Association between a change in social interaction and dementia among elderly people. *Int J Gerontol* 2016;10:76–80.
32 Murphy J, Gray C, Cox S. Talking mats: the effectiveness of a low technology communication framework to help people with dementia express their views. *Journal of Assistive Technologies* 2007;1:30–4.
33 Astell AJ, Joddrell P, Groenewoud H, *et al*. Does familiarity affect the enjoyment of touchscreen games for people with dementia? *Int J Med Inform* 2016;91:e1–8.
34 Zheng J, Chen X, Yu P. Game-based interventions and their impact on dementia: a narrative review. *Australasian Psychiatry* 2017;25:562–5.
35 Kasl-Godley J, Gatz M. Psychosocial interventions for individuals with dementia. *Clin Psychol Rev* 2000;20:755–82.
36 Gibson G, Dickinson C, Brittain K, *et al*. The everyday use of assistive technology by people with dementia and their family carers: a qualitative study. *BMC Geriatr* 2015;15.
37 Leroi I, Woolham J, Gathercole R, *et al*. Does telecare prolong community living in dementia? A study protocol for a pragmatic, randomised controlled trial. *Trials* 2013;14:349.
38 Liu L, Miguel Cruz A, Ruptash T, *et al*. Acceptance of global positioning system (GPs) technology among dementia clients and family caregivers. *J Technol Hum Serv* 2017;35:99–119.