Assistive Technology for Dementia People

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There has been a significant increase in the number of people diagnosed with dementia (PLWD). With diminishing public health and social care resources, there is substantial need for assistive technology-based devices that support independent living. The term assistive technology (AT) is used to describe electronic devices that can be used to support PLWD's lifestyles. These devices can improve the living standards of PLWD, encourage independence, and may decrease hospital admission rates. Furthermore, assistive technology can reduce the stress of caring for PLWD. AT devices that support remote assistance of PLWD can play a vital role in mitigating loneliness and stress caused by pandemics, reducing the need for home visits and hospitalization, thus reducing the costs associated with caregiver services. Reducing the risks of virus transmission within care homes are also a major consideration.

Keywords: sensors ; dementia ; caregiver ; assistive technology ; Covid-19

1. Telecare

Telecare devices can be installed in homes to enable remote execution of a variety of tasks by application of several technologies. Telecare services such as "electronic assistive technologies" and "environmental controls" are used to render a full framework of "smart housing" [1][2]. Studies indicate that telecare technologies that require minimal interaction from PLWD are more successful, because of their impact upon quality of life [1]. These devices also facilitate remote surveillance of PLWD in their own homes and provide them with greater independence in their daily activities [3]. Most of these telecare devices use several sensors, including alarm systems, to provide real-time information to the caregivers remotely. These telecare systems also include fall detectors. Such telecare services provide valued independence. In the case of dementia, however, proof of cost-effectiveness is lacking, as current research lacks adequate user, cost–benefit, and health economic testing with PLWD in particular [4].

Another important category of telecare devices are those that enable clinical processes to be conducted remotely [1]. Such devices use advanced technologies for data processing (such as voice recognition and visual image processing). Other factors, such as artificial intelligence (AI), mobile systems, and remote sensors to diagnose and monitor the treatment of patients, have improved the utility of telecare devices. Hence, telecare systems can enhance services available to PLWD and take into consideration any restrictions on physical distance, as they operate remotely. Below, a description of different telecare devices has been provided, categorized according to their functionalities.

1.1. Reducing Hospitalization

Telecare services can help to significantly reduce length and number of hospital admissions. The average hospital duration of stay could be shortened by between 20% to 60% [5]. Telecare services can also support the independence of PLWD by providing some hospital facilities at home. Hospital care provides around-the-clock care during a period of hospitalization; however, assistance can be limited by available resources soon after discharge. Telecare services can also be considered as a form of interim treatment, such that once discharged from hospital, PLWD can continue to be provided with a level of treatment or monitoring using home technology.

Such services may reduce costs associated with treatment by providing economic treatment alternatives applicable to the home setting of PLWD and reducing transfers and handovers involved in patient admissions. This approach could greatly help to work within the social distancing constraints imposed by a pandemic such as COVID-19. In addition, it might also reduce the tremendous pressure on healthcare services during a pandemic [6]. This could be particularly beneficial for PLWD in whom poor outcomes result from acute hospital admissions due to increased risk of behavioural and psychological disturbances during such stays [6][7]. Studies suggest that acute admission to general hospitals should be avoided to reduce associated risks of delirium and to maintain a stable mental state [6]. Therefore, based on the pandemic scenario created by COVID-19, avoiding hospitalization is desirable especially for PLWD, who may also be at increased infection risk due to reduced protective immune response evident in older PLWD [8].

1.2. Virtual Visiting

Virtual home visits of PLWD dramatically reduce mortality (by approximately 25%) and long-term care admissions (by approximately 45%) [9]. Such assistance, however, has been withdrawn in Wales and England, because of the considerable personnel requirements associated with them. Therefore, due to cost and personnel constraints, home visits are not undertaken as much as desired. As an alternative approach, telecare devices offer an effective solution, which is particularly helpful to PLWD living alone. This approach can go some way to address user and professional satisfaction [7]. Studies from a community nursing research perspective have shown that up to 46% of home visits can be replaced with virtual visiting [9]. Furthermore, it can help reduce the need for physical contact in a pandemic situation imposed by a disease such as COVID-19.

Robots have also been developed to support the caregivers [2][10]. Social robots can remotely monitor the activities of PLWD using several sensor types and provide prompts through video conferencing [11][12][13]. These robots can support PLWD in daily activities such as food preparation, eating etc., along with providing opportunities for recreational activities and informal caregiving [14][15][16][17].

1.3. Reminder Systems

Telecare systems can serve several purposes, including as a reminder support system. Short-term memory loss, for example, is commonly observed as part of the normal aging process, but it can easily curtail independence for PLWD. The functionality of an alarm, communication system, diary, and platform for setting reminders can be combined with basic technologies [18]. When such technology is combined with the capabilities of mobile phones it can help caregivers easily keep in touch with PLWD. A recent research example suggests a remote reminiscence conversation and prompter system which works via a videophone device [19].

Reminder systems help people manage their medications, as lack of compliance with medication regimes is a common issue amongst PLWD. Automated pillboxes can be operated from a small workstation at the PLWD's home and provide prompts from remote call centres or carers as to when medication is due [2][5]. In a recent report, it was shown that such systems can decrease hospitalisation rates by 41% and improve drug enforcement from 34% to 94% [2][5]. Due to healthcare and social constraints imposed during the spread of COVID-19, caregivers can benefit from the applications, such as reminder systems, through remote implementations.

1.4. Video Monitoring

Information and communication technologies can provide real quality of life improvements for PLWD [20][21]. Video monitoring can serve the need of improving safety in real time by exploiting advances in communication technologies, networks, and developments in video and audio processing algorithms over normal telephone lines [18]. Although the primary use of such technology, commonly via touch tone telephone, is remote surveillance, it can also be used for video and audio communications with family members. As there is a need for computers or mobile devices at either end, usability can be difficult for PLWD. Video monitoring systems can be linked to social caregivers to assist with remote services during periods of restricted care. For instance, these systems can be used to trigger emergency services to respond to a fire alarm and inform the caregivers in real time, providing them with an opportunity to remotely monitor the situation and provide support. Given the current scenarios created by the COVID-19 pandemic, such video monitoring systems could also be of great help in remotely monitoring the daily activities of PLWD, along with maintaining the physical constraints imposed by it.

2. Location

Location monitoring normally uses Global Positioning System (GPS) technology to remotely check the physical locale of PLWD by caregivers [22]. Although many studies show that caregivers and PLWD alike find these systems helpful in providing a level of independence [23], there are some contradictory studies which show that with daily usage, PLWD have less confidence in them [24].

Outdoor activities are important for the health benefits of PLWD. Various technologies such as smartphones with a GPS tracking facility and maps support "safe walking" and help with navigation for PLWD, which is often challenging when they are outdoors [25][23][26][27]. Furthermore, there are virtual systems which provide such facilities for the indoor environment, e.g., exercising and navigating virtual home settings [28][29]. PLWD who have mobility issues can use virtual environments as an alternative to carer-supported exercises, which is potentially beneficial to both the carers and PLWD. This is particularly beneficial during pandemics such as COVID-19, which require physical restrictions as safety measures.

From our literature review, we found no randomised control trials which investigated the efficacies of location-based technologies for PLWD. However, there are a few trials with positive outcomes. A recent trial was conducted over three months, with 28 PLWD and their carers. In this study, 77% of carers recommended to others the benefits of GPS technology [30]. Around half of the PLWD found that having a GPS system indicated that they became more unaccompanied, whereas 45% reported that they were more often left free, and 25% reported to be more regularly left free. Furthermore, half of the carers reported a positive impact with reduced stress levels after the trial. Moreover, it was reported that the carers could provide more freedom to their loved ones (60%). Hence, it has been shown that the GPS technology has several beneficial effects on the PLWD and the carers using it. In their study, there were two dropouts, because of their dementia progression. The PLWD could not go out alone, and therefore there was no need of the GPS technology to track their locations. This was the same reason for the dropouts in a different such trial testing the efficacy of GPS technology on PLWD [31]. This shows the downside of GPS technology, that it cannot always reduce the risks among the PLWD to go outdoors alone and, hence, while introducing such technologies, more than just the potential of the person to find his or her way back home should be considered. For instance, GPS technology cannot minimise the risk of road accidents, in case the PLWD is vulnerable to such risks.

In other studies, it is shown that the GPS technology might also offer a false sense of protection. In other words, it provides an impression that the individual using it is inherently “safe”, while several other risk factors still remain at large [31]. Therefore, it is mentioned that early stages of dementia are the suitable periods during which such technology can be helpful for the PLWD; however, we believe that it can also be used in later stages of dementia to reduce the risk of wandering, because of its various functionalities. For instance, it can be used to improve safety for the PLWD to encourage the freedom of roaming in all stages of dementia [31][32]. In this study, some practical issues which should be noted while using GPS technology have also been presented. Many users did not actually carry the GPS device while going outdoors (33% of the time), for several reasons such as being familiar with the everyday routes and low battery of the device. Moreover, in this study, forgetfulness in carrying the device before going outdoors was not reported to be an issue, although it could be an issue for the PLWD living alone. It is shown in other studies that efficient usage of modern AT devices relies on the consistent usage in the everyday routines of the PLWD [33][34]. As a result, making it a habit to charge the device and carry it while going outdoors is crucial in accessing the advantages of GPS technology in fulfilling the needs of the PLWD and carers. Another trial was conducted to test the efficacy of location-based technology [35]. The study was conducted over a period of 3 years, consisting of 25 Finnish PLWD with their carers, and it was shown that ATs such as location-based devices and motion sensors were most helpful for the PLWD to stay home. This is because, during the study period, such technologies could help avoid potentially harmful events, for instance night wandering during winter. Because of the frequent changes of the requirements of the users, various types of the AT devices were used in the trials for an average period of 7.5 months. This study shows the frequent changes of the technological requirements of the PLWD. For instance, ATs such as GPS devices and motion sensors can be helpful only for a particular period of time, when the PLWD is still able to be mobile and maintain his/her safety while being outdoors unaccompanied.

In another study, conducted over a period of 2 years to test the efficacy of GPS technology among the PLWD, several important themes were reported based on qualitative interviews [36]. In this study, it is reported that the carers found the GPS technology to be very much advantageous in terms of improving not only the safety but also the freedom. Furthermore, in a different study concerning GPS technology and dementia, it was shown that in order to ensure the safety, the carers would have to consider restricting the mobilities for their loved ones had there been no such technology [31]. This freedom was highly valued by PLWD. In addition, it is reported in the study that the PLWD who used such technology did not have the feelings of being monitored or tracked. This might be because of the particular usages of the carers, because the carers reported using it only when necessary, instead of infringing on the privacies of the persons. This shows that for the device to be successful and beneficial for the users, the privacy of the PLWD plays an important deciding factor. Furthermore, it was reported that even if the participants faced some technical challenges, they found the GPS technology to be very much helpful. Another study was conducted on five pairs of spouses with mild to moderate stages of dementia, for a period of six weeks using GPS technology [32]. The participants were not only interviewed, but also observed during the study. It was reported that all the participants found the GPS devices to be very much helpful, particularly in supporting the freedom of PLWD. The participants had developed a good level of reliability and an increase in their confidence in using the GPS devices through repeated testing. This is an important aspect for efficient use of the devices, i.e., to be familiar with the usage of technology through practice. In general, the study reported positive feedback about the usages of the GPS technology. Even if some participants needed the support from the researchers towards understanding the technology, all of them could finally adopt the technology. Apparently, the study showed that the key role of GPS technology was for using it for safety of the PLWD while being outdoors, instead of using it as a precautionary measure for wandering. In this study, it was shown that the PLWD did not have privacy infringement issues of being monitored, whereas there are other studies have reported such issues [36][37]. This is also emphasized by professionals in the literature [38][39]. However, we think such concerns about privacy infringement may not be a deciding factor for the

usage of AT devices, as the PLWD may not always have the capacity to consent, given the benefits of AT devices towards safety and security of the users. In fact, it is reported that the participants wanted to be locatable and were becoming concerned when they were not seen [40]. This might be because in the study, the location information was shared only with the spouses.

Finally, another study was conducted on GPS technology, with 18 PLWD and carers, over a period of 2 months, showing the comparison between the usages of two different GPS watches. In that study, both the types of GPS watches were tested by the same participants; hence, they could report the comparative usability of both devices. The usability of the two devices varied based on the ratings of features of the devices. Hence, the crucial message from the research on GPS devices is that the efficacy and usability of the existing GPS devices differ from manufacturer to manufacturer [41].

To summarize, the findings from these studies were limited by the absence of a control group, and small sample sizes. Additionally, the indicators were of low quality and minor statistical significance. Hence, we consider the results of these studies to be only partial in examining the efficacies of location-based technology for PLWD. However, GPS technology may be very much helpful for the users and carers in maintaining dementia-related behaviours such as agitation and wandering.

Health Monitors

Used similar to wrist watches, these devices help monitor the movement, skin temperature, and pulses of the bearer. With continuous usage, a pattern is automatically generated for the individuals, and whenever there is any deviation it transmits an alarm to the carers through multi-link [42]. Such devices can be used by PLWD to remotely monitor their general wellbeing. They can be further used as fall detectors (e.g., Tunstall, Tele-alarm) and to transmit real-time location information to remote carers [43].

These devices use an accelerometer and a tiltmeter. Importantly, a tiltmeter can determine the orientation of the wearer. When an impact is greater than a predetermined threshold, the accelerometer detects it [43]. These sensors can therefore reduce the possibility of any false alarms.

Currently, three types of such devices are available:

- Tunstall: They primarily detect the impact and then the angle of tilt of the wearer. It generates an alarm after producing a 15 s warning, if horizontal. The alarm can be cancelled during the warning time. Some users find difficulty in wearing it all the time, for example, during bedtimes.

- Tele-alarm: These sensors consist of an accelerometer and a tiltmeter and can measure tilt continuously. Whenever the change in tilt is greater than 45 degrees and is followed by an impact, it generates an alarm. Unlike Tunstall, they can be worn at any time; however, they do not provide any warning of an impending fall.

- Technology in healthcare: It detects the rate of change of body tilt angle. The body tilt angle during a fall provides a measure for the change of posture. When the tilt rate is greater than 30 degrees/second, it generates an alarm.

All the above devices generate alarms when installed in the PLWD's home, as well as in the remote care centre, through a telephone network. The operating principles of Tunstall and Tele-alarm devices are the same, but their triggering mechanisms differ subtly. These devices can also be used as wandering detection systems, transmitting a radio signal via a multi-link to the community centre whenever a user goes out of the detectable range. Some PLWD do not like the idea of wearing an extra device. Hence, most of these devices come with a button to send the radio signal to a community service. The user still needs to remember to carry it while going outside. In addition, the patients suffering from other dexterity issues or disabilities, such as arthritis, can face difficulties in fitting the device. Moreover, PLWD with hearing problems may not recognise the beep sound to cancel the alarm. Therefore, more research is required to improve the utility of this technology. Since such devices can send the activity information automatically to remote devices, which can be eventually monitored by the carers or clinicians, these are potentially one of the more important devices which could support PLWD and carers during the pandemic situations.

3. Safety and Security

Such devices are used to monitor the activities of PLWD, which could be sometimes dangerous. For example, water flow or gas supply technology can be used to automatically disable them during emergency situations, security keys can be used for emergency access to the home, geofencing can reduce the risk of uncontrolled wandering, and telephone

blockers can be used to redirect or reject unwanted calls that are not in a predefined list [44]. Safety and security are major areas of concern for PLWD, and there are several technologies available to fulfil these needs [45].

Various types of sensors exist for safety and security, which can be placed in several places of the house, such as the under the chairs, beds as pressure mats, or in the doorways and exits [46]. There can be several ways to alert the users when the sensors are activated, e.g., the alert signal can be sent to a different device, such as a buzzer. Such sensor technology, designed with safety in mind, can alert the carers and PLWD in various instances, such as when then the PLWD leaves the bed or opens the door. However, the literature on these devices is scant. Users usually provide positive feedback to such alert systems [47][44][48][49]. Some users also have positive impressions of the devices, such as door alarm and pressure mats, based on their usages [46][49]. Furthermore, participants in one trial found several ATs, movement sensors, and door alarms to be efficient aids in avoiding admissions to the hospital or care homes [35].

3.1. Home Security

Several technologies can be used to improve the home security [44]. For example, the door alerts use electromechanical sensors to detect wandering or intrusions and can send an alarm remotely to the local authorities or community centres via a video monitoring system. The infrared movement detectors are also used for the security of PLWD, by sending alarms remotely to the caregivers, and they can be treated as burglar alarm systems. The automated fire alarm can send an alert signal to the fire services remotely in the presence of smoke or an unexpected temperature increase. These systems are also frequently linked to ambulance, rescue, and police services [9]. In a pandemic scenario, the restriction of commercial and community services has resulted in more PLWD working or staying at home, which has amplified the importance of such home surveillances devices for controlling crime and ensuring safety.

3.2. Social Alarm Systems

These systems provide necessary help during emergency [50][51]. Rather than being proactive and preventive, such technologies are reactive and sensitive and can be helpful during a time of need. Some studies show that by using such a system, the total number of hospitalisations decreased by 25% and the hospital inpatient days dropped, on average, from 9.2 to 5.7 days [2][5]. The social alarm systems are normally linked with several emergency services, such as fire alarm service, crime surveillance, ambulance service, community centre service, etc. Using the above system, the West Lothian Council has a long-established UK-based project which has demonstrated several benefits [1]. Such systems can also be beneficial in providing services offered by community call centres to PLWD suffering from loneliness and depression. These systems can be especially beneficial in times of a pandemic when social interactions are difficult.

3.3. Pressure Mats

The mobility from a chair or a bed of PLWD can be detected by a change of pressure on these mats, through electromechanical sensors. They can send the real-time information to carers through an audio–visual alarm system [52][53][54]. They can be used as both a standalone aid and a communication link with the nurse or carer. They can also serve the purpose of detecting wandering and can be used in fall prevention. Products such as the door alarms and pressure mats were found to be helpful in some particular cases [46][49].

3.4. Telephone Blockers

Along with the requirement of precautions related to physical safety, the PLWD are often susceptible to financial risks. One of the ways that criminals (“scammers”) victimize the user is through phone calls. Commonly, details are listed and shared with other scammers. It is reported by around 70% of carers that the PLWD are routinely called by scammers [55].

AT devices have been designed to automatically block unrecognised phone numbers, permitting access only to a “safe list” indicated by the user [3].

3.5. Item Locator

Cognitive impairment creates additional anxieties. Around 62% of carers report the loss or displacement of objects by PLWD to be stressful [56]. An item locator can help the PLWD by guiding him or her in locating the desired items. The way an item locator helps the PLWD is through its parts, called a “tag” and a “hub”. The “tag” is a smaller device which the user needs to attach to the item which he/she frequently forgets to locate, e.g., a key or a TV remote. The “hub” is a relatively larger device which is used to communicate with the “tag”. When the user presses a button on the “hub” it communicates with the “tag”, which produces a beep sound to easily locate the lost item. The functionality of item locators is more or less similar in various brands.

Trials on item locators were conducted in the ENABLE project [47][57] by its Irish, English, Norwegian, and Finnish arms; however, the sample sizes were small, so the trials were conducted on a few devices only. The dropouts in the study were because of the high technical faults, leading to frustrations among the participants towards using the item locator. However, as the product was just a prototype produced in 2003, these technical faults might be most likely because of the specific device. The caregivers believed that it would provide independence to the PLWD by showing them the way to locate the lost items, before the trial was conducted in the focus groups [58].

Moreover, it was reported that in actual practice, PLWD did not find the item locator to be easy to use, but rather this required prompts and additional help [58][57]. Some people did report a degree of usefulness [58][59], such as the reduction in search time and stress. In this study, there was no such technical difficulties with the device reported during the trial. Most of the participants used items such as keys and handbags to tag. One caregiver reported that the privacy of the loved ones was preserved because of the item locator, as their belongings did not have to be looked through while searching for the lost item.

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