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REVIEW ARTICLE

Technological Solutions for Older People with Alzheimer's Disease: Review

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Abstract: In the nineties, numerous studies began to highlight the problem of the increasing number of people with Alzheimer's disease in developed countries, especially in the context of demographic progress. At the same time, the 21st century is typical of the development of advanced technologies that penetrate all areas of human life. Digital devices, sensors, and intelligent applications are tools that can help seniors and allow better communication and control of their caregivers. The aim of the paper is to provide an up-to-date summary of the use of technological solutions for improving health and safety for people with Alzheimer's disease. Firstly, the problems and needs of senior citizens with Alzheimer's disease (AD) and their caregivers are specified. Secondly, a scoping review is performed regarding the technological solutions suggested to assist this specific group of patients. Works obtained from the following libraries are used in this scoping review: Web of Science, PubMed, Springer, ACM and IEEE Xplore. Four independent reviewers screened the identified records and selected relevant articles which were published in the period from 2007 to 2018. A total of 6,705 publications were selected. In all, 128 full papers were screened. Results obtained from the relevant studies were furthermore divided into the following categories according to the type and use of technologies: devices, processing, and activity recognition. The leading technological solution in the category of devices are wearables and ambient non-invasive sensors. The introduction and utilization of these technologies, however, bring about challenges in acceptability, durability, ease of use, communication, and power requirements. Furthermore, it needs to be pointed out that these technological solutions should be based on open standards.

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1. INTRODUCTION

Developed countries are currently undergoing demographic changes which entail the rising number of senior citizens. This particular demographic group is prone to suffering from numerous chronic diseases. The link between old age and chronic disease is illustrated [1], according to which up to 19 million people provide day-to-day primary assistance to their elderly family members.

As for Alzheimer's disease and other dementia patients, the costs of treatment and care for these patients are projected to increase from the estimated 203 billion USD to the whopping 1.2 trillion USD per year in the United States by the year 2050 [2]. The challenge of the ageing population and the increasing number of AD patients means that the society in general and individual families in particular need to be prepared for an increased economic and psychological burden. On the other hand, the 21st century saw an unprecedented rise in the development of advanced technologies that enter all aspects of our lives, including healthcare.

There are already a number of technologies in use, including digital devices, smart sensors, and intelligent applications, that assist elderly people with their everyday needs in their own homes. Developing a strategy for an integrated technological solution would resolve many issues faced by elderly patients and would lead to improving their quality of life, health, and safety [3-6].

Even the simplest technology tools offer Alzheimer's patients a great degree of help. To begin with, reminders in the form of messages can be recorded on a device at home and then played back out loud at the appropriate time. Some devices can even play messages based on the person's activity.

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Medication management technology can be as simple as a pillbox marked with days of the week or as high-tech as automated pill dispensers which beep and open to remind caregivers and those with dementia to take their medication [7].

For dementia patients, wandering outside of their homes unattended can present a serious issue, which is where GPS location and tracking devices come in to solve such emergency situations promptly [8]. More advanced tools include picture phones, which are specifically designed for people who cannot remember phone numbers and may need to contact someone quickly [9]. Some of the phones come with transparent buttons where photos can be placed, so that the person can just push the button associated with the photo to make a call easily.

More complex tools still in the research phase include monitoring the use of common electrical appliances and making sure their user does not forget to switch them off; also, home monitoring solutions using sensors, cameras, and scanners are being developed [10].

Technological solutions are divided into different groups according to their use. *e.g.*, four main groups of ambient assisted living (AAL): daily task facilitation, mobility assistance, healthcare and rehabilitation, and social inclusion and communication have been introduced [11]. Ranasinghe *et al.* distinguish the application of motion systems, health monitoring, and activity recognition. Chan, Marie *et al.* propose grouping technology solutions into four categories: invasive wearable, non-invasive wearable, combined and others. This approach is important from the technology point of view because wearable or other invasive sensors have bigger concerns regarding their reception by patients (battery issues, technology acceptance). There is a whole range of categorizing options that usually take into account either the nature of the technology or the needs of senior citizens. The authors of this study consider technological solutions to be hardware, software, services, and sensors that are used as a single package for one or more purposes. Technology solutions for people with Alzheimer's disease fall under the assistive technology group of technologies and include information and communication technologies (ICT), sensor devices, actuators, and sound devices.

This paper aims to present an up-to-date overview of technological solutions available for assisting elderly patients suffering from Alzheimer's. To start with, the challenges faced by these patients and their caregivers are specified. Then, a review of technological solutions on the market is performed. Finally, both the benefits and the drawbacks of technology-assisted treatment and care for Alzheimer's patients are discussed.

2. METHODS

This scoping review is performed to identify and summarize up-to-date advances of technological solutions for improving the health and safety of senior citizens living with Alzheimer's disease.

2.1. Search Strategy and Eligibility Criteria

During February 2018 four investigators performed a systematic literature search of the Web of Science, PubMed, Springer, ACM digital library and IEEE Xplore digital library. The period of interest covered the years from 2007 to 2018, and the electronic search included the following keywords: Alzheimer's disease, dementia, ambient assisted living, technology solution, software, wearable sensors, and smart home.

In the Web of Science database, 301 studies were identified. Only two types of documents were considered eligible for the purpose of this study: "article" and "review". It reduced the initial set of papers to a total of 172 research articles, which were selected for further processing. For the PubMed, ACM digital library, Springer and IEEE Xplore, a semi-automated framework or aiding surveys was used [13]. The framework first used the search tools of the libraries with the following keywords: Alzheimer solutions, Alzheimer technology, Alzheimer sensors, Alzheimer AAL, Alzheimer assisted, and Alzheimer ICT. Then, after eliminating duplicate records from the retrieved papers, it analyzed the title, abstract and keywords section of each paper evaluating whether any of the following properties or their synonyms (listed in parenthesis) are mentioned: AAL (or assisted and ELE - Enhanced Living Environment), Alzheimer, sensor (or hardware and device), software (or algorithm), solution (or product) and technology.

The paper distribution per year and property (keyword) is presented in Table **1**.

A total of 6,404 publications from the databases were selected according to the properties. From the automatically analyzed publications, those that contained at least 4 of the properties were selected for further processing. The false positive papers that contained the relevant properties, but after manual inspection were found not to be relevant and were discarded. The total number of publications selected for further processing was 107 papers and articles. The set of articles for further processing from both the manual and semi-automated search was further reduced to the final number of 17 full-length papers, following initial paper screening, which excluded papers not related to the topic of research as described below.

2.2. Data Extraction and Study Quality Evaluation

Four researchers working independently extracted from each publication the following data: author, the title of the study, country, and type of study. A study was eligible for the inclusion if the following criteria were met:

- Published after 2007.
- Described the use of technology solutions for senior citizens with dementia, where Alzheimer's disease is also included.
- Described the use of technology solutions for everyday activities for people with Alzheimer's disease.
- Described the efficiency of technology use for patients with Alzheimer's disease.
- Written in English language.

A publication was excluded if:

- Written in another language than English.

Table 1. Paper distribution by property and year.

Keyword \ Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
AAL	155	202	178	198	194	283	277	445	407	369	46
Alzheimer	235	358	320	369	359	474	542	787	767	585	80
Sensor	47	61	52	59	69	87	63	88	88	88	11
Software	32	53	49	55	47	71	77	101	81	89	8
Solution	64	95	92	81	80	108	110	145	158	144	18
Technology	51	83	82	95	91	102	116	143	132	131	13

- Described a theoretical model and approaches to suggested solutions (algorithm, mathematical model, statistical model).
- Focused on a technical description of the solution (*e.g.* use of Brain-Computer Interface, hardware computing, system architecture, sensor design).
- Described systems for the diagnosis of the disease.
- Described healthcare management systems.

The process of publication search and information selection is presented in Fig. (**1**).

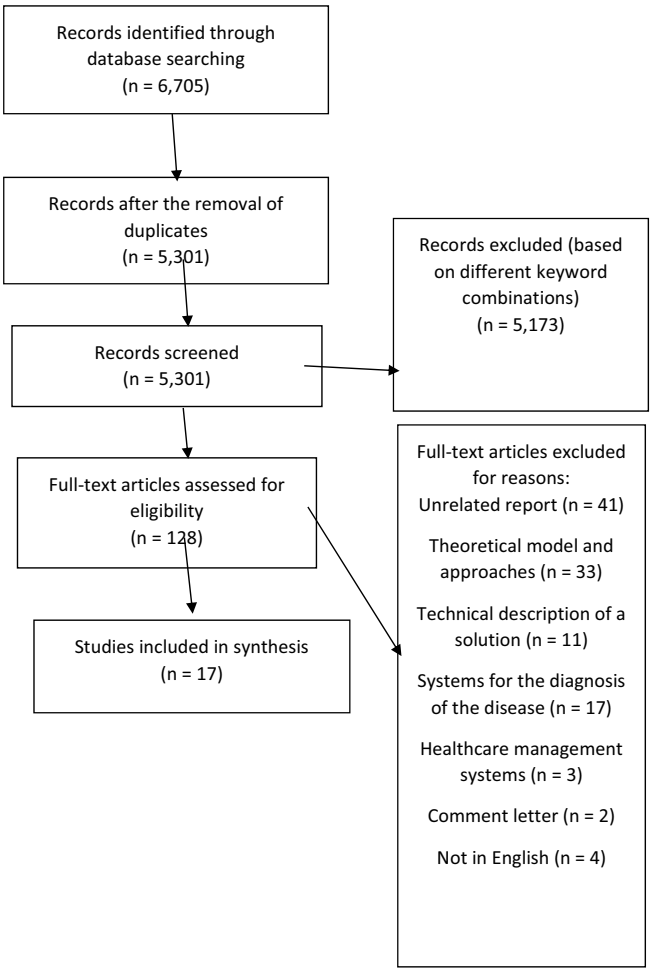

Fig. (1). Publication search process.

3. RESULTS

3.1. Specific Needs of Senior citizens with Alzheimer's Disease

The onset of this disease and other dementias is first noticeable in minor behavioral changes of the afflicted person [14]. Further on, patients experience difficulties with short-term memory, learning, counting, and decision making. Alzheimer's disease primarily affects the patient's mental abilities, eventually to the extent that the patient struggles to understand and make himself or herself understood. Soukup *et al.* (2013) [15], pointed out that the loss of mental abilities is radical and progresses fast. Individual symptoms of Alzheimer's disease may vary from patient to patient, depending on the patient's personality, lifestyle, and overall health condition. While AD is traditionally divided into three stages, early, mild, and advanced, not all patients experience a clear-cut progression from one stage to another [16]. Symptoms manifested by the patient may not always correspond to the particular stage of the disease, and not all symptoms must be manifested. In general, the transition from one stage to another may take several years. Patients in different stages of the disease have different sets of requirements, which are summed up in Table **2**.

Patients suffering from AD benefit from a safe physical environment, which inspires in them confidence, promotes independence and ensures their safety. Rather than the physical quality of the environment, its pleasantness and general feel as perceived by the patient are important. AD patients may feel best in their own homes, provided that they are supported by technological solutions which assist them with their everyday tasks. These solutions are also the focus of this study.

3.2. Technological Solutions for Senior citizens with Alzheimer's Disease

Current technological solutions for improving health and safety for senior citizens with Alzheimer's disease are described in Table **3**. For each study, the type of technology, the main findings, the link to the AD stage, and also the limitations of the studies are described.

Based on their physical characteristics, technological solutions are divided into four groups: wearable, non-wearable invasive, non-wearable non-invasive, and others. This categorization is also used to describe other features of the de-

Table 2. Treatment and care required in the three stages of Alzheimer's disease (based on [16, 17]).

Stage	Activities Affected by AD	AD Symptoms
I. Early	Memory, speech, complex organization, social skills, judgement and logical thinking, mobility, senses	Impaired short-term memory; all skills and senses worsen; but substitute may be used to eliminate problems
II. Mild	Memory, speech, complex organization, social skills, judgement and logical thinking, mobility, senses	Loses the ability to take care of oneself; loses the ability of independent judgement; Orientation deteriorates
III. Advanced	Ability to do anything complex (including dressing oneself) is lost and the patient is fully dependent on care providers and family members Memory fails – sinusoid daily oscillations of illness Difficult movement, often bed-bound patient	Need assistance with daily activities and personal care changes in physical abilities, including the ability to walk, sit and, eventually, swallow, have increasing difficulty communicating

Table 3. Summary of studies.

Authors, Year	Title	Type of Technology	Main Findings	Prevailing Stage of AD	Limitations
Jekel *et al.,* 2016 [27]	Development of a Proxy-Free Objective Assessment Tool of Instrumental Activities of Daily Living in Mild Cognitive Impairment Using Smart Home Technologies	smart home, activity sensors, video cameras	It was showed that smart home technologies bring the chance for an objective and ecologically valid assessment of Instrumental activity daily living	I-II	pilot study small sample no full automation
Radziszewski *et al.,* 2017 [28]	Designing Calm and Non-Intrusive Ambient Assisted Living System for Monitoring Nighttime Wanderings	, sensors, servers and controllers, effectors and user interactions	Describes an ambient technology-based system that limits nighttime wandering and promotes safe sleep.	II	untested in real environment
Lazarou *et al.,* 2016 [29]	A Novel and Intelligent Home Monitoring System for Care Support of Elders with Cognitive Impairment	Wearables, sleep monitoring object motion, presence, and utility monitoring, usage sensors	Proposes a monitoring system to increase the patient's independence and help clinicians to evaluate the patient's changing condition and needs.	I	anomalies may be incorrectly interpreted due to a lack of context reporting should not be mandatory but should only note key events instead
Rudzicz *et al.,* 2015 [30]	Speech Interaction with Personal Assistive Robots Supporting Aging at Home for Individuals with Alzheimer's Disease	a personal assistive robot based on iRobot (operating speed: 28 cm / second)	Discusses technical and other challenges that need to be overcome for robots to provide speech-based assistance to patients in their homes.	I-II	small sample, technical limitations in acoustic and language models human-to-robot and robot-to-human conversation needs improvement a follow-up study required
Hussain *et al.,* 2014 [31]	Recommendations Service for Chronic Disease Patient in Multi-model Sensors Home Environment	Smart Clinical Decision Support System (CDSS) integrated in the SC3 platform, sensor- and camera-based monitoring, patient medical record management for medication intervention	Describes smart CDSS services drawing on the experience and knowledge of physicians and published theoretical research. Recommendations are derived from the knowledge base and are based on the patient's current condition.		existing infrastructure limitations in managing a huge volume of data in real time data security concerns

(Table 3) contd….

Authors, Year	Title	Type of Technology	Main Findings	Prevailing Stage of AD	Limitations
Núñez-Naveira *et al.,* 2016 [32]	UnderstAID, an ICT Platform to Help Informal Caregivers of People with Dementia: A Pilot Randomized Controlled Study	e-learning platform to support informal caregivers	Reports that the use of the e-learning platform significantly contributed to the wellbeing of caregivers, whose depressive symptomatology decreased, based on the Center for Epidemiologic Studies Depression scale.	Not specified	needs modifications to cater for caregivers of different national, social, and cultural backgrounds
Blackman *et al.,* 2016 [33]	Ambient Assisted Living Technologies for Aging Well: A Scoping Review	smartphones, GPS technologies, Internet, ATM, mobile, and TV systems, dietary assessment and cognitive health monitoring, assistance with navigating outdoors , interactive agenda and diary systems , connection to alert systems	Identifies and describes 59 technological tools; discusses AAL with respect to gerontology.	I	the information gets rapidly outdated
Ienca *et al.,* 2017 [34]	Intelligent Assistive Technology for Alzheimer's Disease and Other Dementias: A Systematic Review	mobility and rehabilitation aids, socially assistive robots, wearable and handheld multimedia devices	Illustrates the fast expansion of IATs and the growing variety of their application for AD patients. Confirms persisting structural limitations prohibiting a wide use of the technology, including lack of clinical validation.	Not specified	the technology gets obsolete fast and is replaced by new solutions
Siegel *et al.,* 2017 [35]	Information Technologies for Active and Assisted Living—Influences to the Quality of Life of an Ageing Society	environment and patient monitoring, tele-care and videoconferencing , rehabilitation, reminder systems and brain games, mobile localization system	Suggests that communication technologies improve the patient's quality of life; technological solutions promote the patient's independence and compensate the patient's disabilities.	Not specified	becomes outdated fast
Stavropoulos *et al.* 2017 [36]	DemaWare2: Integrating Sensors, Multimedia and Semantic Analysis for the Ambient Care of Dementia	DemaWare2, an Ambient Assisted Living framework, sensors, wearables, computers	Proposes a holistic approach using a combination of sensors to provide unobtrusive support and care.	Not specified	insufficient portability complex installation
Cavallo *et al.,* 2015 [37]	An Ambient Assisted Living Approach in Designing Domiciliary Services Combined with Innovative Technologies for Patients with Alzheimer's Disease: A Case Study	smart sensor system, including a GSM module	Describes a case study whose outcome suggests that technological solutions greatly improve the quality and efficiency of the work of caregivers, as well as the wellbeing and quality of life of both caregivers and their patients.	II	small sample size
Robert *et al.,* 2013 [38]	Recommendations for ICT Use in Alzheimer's Disease Assessment: Monaco CTAD Expert Meeting	Accelerometry/Actigraphy, Video 2&3D – ambient, Video 2&3D – wearable Speech tracking, Multi-modal sensors Infra-red sensors, Tracking technologies (Global Positioning System), Smartphone and tablet, Serious game	Examines and assesses the options of ICT implementation in care for AD patients, particularly real-time monitoring and subsequent evaluation of the patient's performance. Also explores the potential of serious games in encouraging patients to goal-directed actions.	Not specified	lack of systematic approach
Westerberg *et al.,* 2010 [39]	Sleep Influences the Severity of Memory Disruption in Amnestic Mild Cognitive Impairment: Results from Sleep Self-Assessment and continuous Activity Monitoring	wrist-worn device, activity senso, computer	Emphasizes the significance of consistent quality sleep for promoting the patient's memory.	I	lack of significant differences between different groups, further analysis of the relationship between sleep and memory disruptions is needed
Kenigsberg *et al.,* 2017 [40]	Assistive Technologies to Address Capabilities of People with Dementia: From Research to Practice	Information and Communication Technologies (ICT), Assistive Technologies (ATs), AAL, GPS bracelets, databases	Identifies that ATs assist patients not only with their physical needs but also promote their emotional wellbeing.	Not specified	the information becomes outdated fast
Wang *et al.,* 2017 [41]	Interactive Wearable Systems for Upper Body Rehabilitation: A Systematic Review	Wearables, movement tracking and posture monitoring systems	Examines the potential of smartphones and wearable devices in monitoring and providing feedback to the patient.	Not specified	requires advanced textile sensors, lacks clinical validation

(Table 3) contd….

Authors, Year	Title	Type of Technology	Main Findings	Prevailing Stage of AD	Limitations
Realdon *et al.,* 2016 [42]	Technology-Enhanced Multi-Domain at Home Continuum of Care Program with Respect to Usual Care for People with Cognitive Impairment: The Ability-TelerehABILITation Study Protocol for a Randomized Controlled Trial	IRP tablet a sphygmomanometer, for monitoring blood pressure, a pulse oximeter for measuring oxygen blood level and heart rate, a scale for the detection of body weight,a FitBit to track physical and sleep activity	Provides results illustrating the benefits of a combination of technologies used by the patient to promote autonomy and self-sufficiency.	I-II	small sample size
Olsson *et al.,* 2013 [43]	A Passive Positioning Alarm Used by Persons with Dementia and Their Spouses – A Qualitative Intervention Study	passive positioning alarm	Concludes that the use of the alarm over time increased the patient's trust in the device and in his or her own ability to operate it.	II	only spouses could use the alarm to monitor the outdoor walks of dementia patients

vices in the studies under analysis. These studies are characterized by the types of devices, processing, activity recognition and use-cases. Only 11 studies are included. Four review studies and two original articles were excluded because of the unavailability or irrelevance of information for these categories. The characteristics of the selected studies are presented in Table **4**.

Based on the reviewed papers, most of the technological solutions for senior citizens with Alzheimer's disease are focused on monitoring the patients and improving the working conditions of their caregivers. Several of the systems are also equipped with activity detection that is conducted with different methodologies, such as machine learning, ontology-based classification, and rule-based classification. The types of sensors used for the reviewed systems varied based on their application and included both wearable sensors and ambient sensors (invasive and non-invasive). As to the type of device, the most popular technological solutions are wearable devices (8 studies) and ambient non-invasive sensors (7 studies). With respect to processing, the most common solution is processing on a local computer or ad hoc (5 studies). Finally, as to the type of use, the most commonly discussed are devices for activity detection and monitoring (8 studies). The application of technological solutions is not limited to senior citizens with Alzheimer's disease only since some of the examples in the reviewed literature also discussed technological solutions for evaluating and improving the status of caregivers and for e-learning.

Table 4. Characteristics according to sensor types, data processing type, the usage of activity recognition and use-case.

	Sensor/Device Types			Processing Type		Activity Detection and Recognition			Use-case		
Authors, title of study	**Wearables/ phones/ tablets**	**Ambient sensors (invasive)**	**Ambient sensors (non-invasive)**	**Processing on local computer or ad hoc**	**Cloud based processing/online service**	**Uses machine learning algorithms for activity classification**	**Uses rule /ontology-based approach or separate subsystem for each activity**	**Not related to activity detection**	**Monitoring**	**Rehabilitation**	**Experimental study**
Jekel *et al.* 2016		X	X	X			X		X		X
Radziszewski *et al.,* 2017			X		X			X	X		X
Lazarou *et al.,* 2016	X	X	X	X		X			X		X
Hussain *et al.,* 2014	X	X	X		X	X			X		
Núñez-Naveira *et al.,* 2016			X					X		X	X
Stavropoulos *et al.*	X	X	X	X			X		X		X
Cavallo *et al.,* 2015	X		X	X			X		X		
Westerberg *et al.,* 2010	X							X			X
Wang *et al.,* 2017	X							X	X	X	X
Realdon *et al.,* 2016	X			X				X		X	X
Olsson *et al.,* 2013	X							X	X		

4. DISCUSSION

The reviewed papers indicate that the use of technologies for support and care for people with AD is growing. The papers reflect a great diversity of technological solutions for senior citizens with AD; both solutions that are already available and solutions under development. The analyzed literature implies that the most desirable feature for smart homes of AD patients is monitoring the patient's vital signs and changes in health condition via wearable devices [18]. Chan *et al.* [19, 20] also confirmed the continuing challenges in the application of technological solutions, including a lack of clinical evidence and, furthermore, an insufficient understanding of sociocultural aspects, such as differences among groups and the acceptability of technological devices for the patients and their caregivers. Ultimately, technological solutions have an undeniable potential in promoting safety and rehabilitation of patients, preventing their social isolation, and prolonging their autonomy, thus avoiding their premature institutionalization [12]. For caregivers, there is evidence to suggest that since the introduction of telecare into their caring situation, they have benefited from more peace of mind, a better night's sleep, improvement of the relationship with the person(s) they cared for, the opportunity to continue with activities they might otherwise have to give up, the ability to remain in paid employment in some cases, and more confidence about the safety and comfort of the person they cared for. The essential benefits and limitations of technological solution for people with Alzheimer's are described in Table **5**.

Table 5. Benefits and limitations of technological solutions for senior citizens with Alzheimer's.

Benefits	Limitations
• compensating disabilities • promoting social inclusion • increasing safety • possibly reducing costs of care • prolonging the patient's autonomy at home • no need for clinical studies • possible healthcare savings for the society • enhanced physical and mental wellbeing	• lack of clinical evidence • shortcomings in respecting sociocultural differences • privacy and data security concerns • need for initial investment • risk of negative reception by patients and caregivers

From the technological point of view, the greatest challenge is presented by the acceptability, durability, ease of use, communication, and power requirements of these wearable devices. Moreover, standards that are related to specifying elements of assistive living technology are almost unavailable for the system developers [21]. Many authors agree that assisted living systems should be based on open standards that combine cloud-based IoT, web service approach, and medical limitations [22-24]. The cloud collects data from multiple sources and processes the data. Data from external sources can be collected and processed by the global data fusion component. The cloud can process data from multiple locations and create machine learning models. The output is a continuously improving knowledge base. This knowledge base is used for services such as creating customized recommendations for diet and exercise, improving diagnostics systems, providing updates to health providers, and adding further information in medical databases.

The most important requirements that should be satisfied by the system include security, privacy, high availability, and operability. Security and privacy challenges can be addressed by implementing best practices to protect the network and the data. Redundancy and automatic failure are needed to provide high availability, especially in cases where the health care recipient's life depends on the assisted living system. The increased complexity requires that ensuring components be connected and interoperable by using frameworks intended to ensure mutual compatibility.

The nodes closest to the devices or things are called edge nodes. In healthcare systems, these nodes can be smart e-health gateways. The gateway serves as a bridge for medical sensors and home/hospital building automation appliances to IP-based networks and cloud computing platforms.

As to the social aspect of this topic, research suggests that senior patients and their caregivers are willing to accept technological solutions and, after overcoming the initial hesitation, are ready to actively use them. In this respect, it is essential for the technological solutions to be easy to operate and easy to carry around. Surveys investigating the attitudes of elderly patients to new technologies show that they appreciate the benefits of the technology and comparatively easily accept non-intrusive devices and tools. Intrusive gadgets and wearables are not universally popular. The target group, however, values the increased autonomy, independence, safety, as well as the social connectivity that these devices bring [25, 26].

CONCLUSION

Due to the aging of the population and the increase of people with Alzheimer's disease, the use of technological solutions for these people becomes significant. Although, on the one hand, the amount of technological solutions is growing rapidly among people with dementia and their caregivers, enthusiastic about using technologies to keep their independence, improve their cognition, mood and social functioning and lessen service use; on the other hand, this increased availability and use is hindered by legislative aspects and greatly challenged by the diversity of governmental approaches in individual countries.

The priority given to assistive technology by different local authorities varies and there is no national guidance on how assistive technology should be provided. In some areas (*e.g.* rural), people with Alzheimer's disease have much poorer access to assistive technology than patients living in other areas (*e.g.* urban areas). Another related aspect is the question of awareness of formal and informal caregivers about technological solutions. Advisers or other relevant staff within services for senior citizens living with Alzheimer's disease should be provided training concerning

assistive technology. This would allow them to better inform people with dementia and their caregivers of products that may assist their care and also signpost them as to how they can access assessments for assistive technology. However, there is much work still to be done to raise awareness amongst health and social care professionals, and this must be addressed to ensure that the potential of assistive technology is recognized.

The use of wireless devices and storage of information on the internet also leads to potential security concerns. Furthermore, privacy and ethical issues are raised when these technologies are applied for assessing exposure to environmental stressors. Issues of data ownership and data protection need to be clarified and structured to allow ubiquitous environmental health monitoring to become an everyday reality. Many devices and apps identified in this article are available to the public, and people must agree to terms and conditions regarding their privacy associated with the use of these products.

It is therefore recommended that practitioners, policy makers, care insurance and care providers should work together with technology developers and researchers to prepare strategies for the implementation of assisting technologies in different care settings. This may help future generations of persons with dementia to use available and affordable technologies and, ultimately, to benefit from them. Conclusions drawn, and analyses made in this study are applicable to other forms of dementia and not limited to Alzheimer's disease only.

CONSENT FOR PUBLICATION

Not applicable.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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