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Review article

Smart Home Technologies and their Positive Outcomes for Improving the Life Quality in the Elderly: A Review Study

Khadijeh Paydar[1], Azam Zohrekermani[2], Abbas Sheikhtaheri[3], Somayeh Paydar[4*]

[1] Department of Health Information Management and Medical Informatics, School of Allied Medical Sciences, Tehran University of Medical Sciences, Tehran, Iran

[2] Department of Non-Communicable Diseases, Health Deputy and Health Center, Kerman University of Medical Sciences, Kerman, Iran

[3] Department of Health Information Management, School of Health Management & Information Sciences, Iran University of Medical Sciences, Tehran, Iran

[4] Department of Health Information Technology, School of Paramedical, Kermanshah University of Medical Sciences, Kermanshah, Iran

Abstract

Introduction: Smart home supports the elderly to continue living in their own home using information and communication technology independently. This study aimed to survey technologies of smart home and their positive outcomes on the life quality of older people.

Methods: This narrative review article was conducted in 2021 using Scopus, PubMed, Web of Sciences, and Science Direct Databases. After the final survey, 25 resources obtained the required validity based on the study aim. The studies without recording technologies of smart home and their positive outcomes were excluded.

Results: In the literature review, 31 leading technologies for the smart home were identified. These technologies were classified into 11 groups. Also, 16 positive outcomes were identified due to applying these technologies in the smart home for older people. The essential outcomes are increasing awareness, sense of security and independence of the elderly, empowerment, and boosting self-confidence, strengthening communication among the older people, and reducing social isolation of them.

Conclusion: Due to the problems of aging in our country, identified groups of smart home technologies can be applied based on the needs of the elderly to enjoy the positive outcomes of these technologies to improve their quality of life.

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* **Corresponding author**
Somayeh Paydar
somayeh.paydar@kums.ac.ir

Introduction

In recent years, in most countries, due to reduced fertility and increased life expectancy, the proportion of the elderly to the total world population is increasing (1, 2). As a result, most countries in the world face the challenge of population aging. According to reports from the United Nations, fertility and the number of children worldwide are expected to decline, and the number of older people will increase relative to the total world population. Hence, it is estimated that the proportion of people 65 and older compared to the total population will double by 2050 (1, 3-7).

Thus, as the world's population ages and the number of older people increases, diseases and disabilities are on the rise. For example, recent estimates suggest that between 1.5 million and 2.5 million Americans suffer from Alzheimer's disease (5, 8). In addition, the number of older people with chronic health problems is also increasing. Chronic health problems can lead to altered functional abilities and reduced ability in the elderly (9). 42% of the elderly 85 years and older have some form of

dementia.

Many older people also experience social isolation due to the experience of losing a spouse and close friends and are in dire need of safety measures. Besides, older people typically need the support of their families and social service systems and have significantly less control over decisions that affect their life than before (8).

Falls at home are the leading cause of injuries among the elderly. Such falls are usually due to the environment not being suitable for the needs of the elderly. The following two significant causes of injuries at home are burns and drug poisoning. Burns are usually caused by forgetting to turn off the stove or candle. The leading cause of poisoning is non-compliance with drug doses (4, 8, 10, 11). Demand for home care (distance) for preventing long-term hospitalization or nursing home care is also increasing. According to the above, the claims and costs of health care will also increase (5).

Most older people are aware of the natural consequences of aging, including decreased senses (touch, taste, smell, sight, hearing, and temperature), decreased mobility, endurance, muscle strength, mental changes, and the risk of diseases such as osteoporosis, arthritis, heart disease, high blood pressure, and diabetes. Nevertheless, older people prefer to live independently in their homes because they feel more comfortable and safer (8, 10, 12).

Significant studies have been conducted in medical informatics and related fields to develop appropriate technologies to support the elderly to improve the provision of health care in this group of society. Rapid advances in electronics, information, and communication technology (ICT), have led to improved performance of computers, sensors, and network technology, along with active research and development of smart fabrics, new textiles, smart paper, power supplies, wearable devices, digital imaging, and this make home care possible for people and make fundamental medical profession changes by creating remote interactions between physicians and patients (5).

Using valuable technologies such as smart homes to facilitate access and use, following the daily activities and time constraints of the elderly, and involving the elderly in their activities is one of the main strategies to promote their independence (5, 9, 13). Smart home technology is information-based (knowledge-based) technology that collects different types of data such as physiological, spatial, and movement data of individuals and it shares the information of the person living in the house with the individual, family members, and primary health care providers (5, 8, 9, 14). The smart home as a valuable and sustainable solution offers a new model for integrating technology and services through the home network to maintain independence, performance, health, and improve the quality of life of people, especially the elderly (2, 3, 15).

The smart home is an evolving technology and is looking for ways to improve the quality of life. The function of smart homes can be significantly expanded to meet the needs of the elderly. The use of various smart home technologies in the home of the elderly will provide a safe place for the elderly and improve their quality of life. A smart home can increase the life expectancy of the elderly in a modern society where digital technologies can provide the solutions they need. When the quality of life and security increases, their life expectancy and longevity will also increase. The technologies available in the smart home, in some cases, even help prevent disease in the elderly(1, 8, 10).

Therefore, given the demographic changes in the world and the risks in the life of the elderly, new strategies and policies to improve productivity in aging and maximize the capacity for home care and make smart seem necessary. In the present study, a smart home is a general concept for information and communication technology that supports the elderly to continue living in their own home independently (7, 16, 17). According to this definition, some previous studies that addressed this issue have been reviewed to identify the most critical technologies in the smart home and the positive consequences of using these technologies for the elderly.

Methods

This research is a narrative review that was conducted in 2021. Comprehensive searches were conducted in Scopus, PubMed, Web of Science, and Science Direct databases in order to identify the technologies used in smart homes for the elderly and the positive consequences of using these technologies, and a total of 267 articles were retrieved. The retrieved articles were reviewed and critically evaluated by the research team. Finally, 25 full-text English articles that introduced smart home technologies and the positive consequences associated with the use of these technologies for the elderly obtained the necessary conditions to include the study and extract research data from these articles were done. To report the technologies identified from the texts, researchers have developed a classification system containing 11 groups based on the different classification systems presented in previous researches (1, 6, 18, 21-24, 28).

Results

The study findings included smart home technologies for the elderly to achieve the study's objectives. Thirty-one technologies were identified according to Table 1 and classified into 11 groups.

Based on the reviewed texts, 16 positive outcomes were identified using smart home technologies for the elderly, as shown in Table 2.

Table 1. Smart home technologies for the elderly

Technology groups	Type of technology	Studies
Group 1: Monitoring of health status and physiological parameters	Health status monitoring by ECG (Electrocardiography), PPG (Photoplethysmography) sensors; Monitoring of physiological parameters (e.g., weight, measurement of respiration and heart rate, basal body and skin temperature, blood pressure, blood viscosity, and blood sugar level in patients with rare disease)	(5, 6, 8, 9, 14, 15, 17-23)
Group 2: Environmental monitoring and automation of environmental conditions using sensors	Automation using sensors (such as lighting, smoke, remote control, air conditioning, gas stove, faucet, microwave, washing machine, heating appliances)	(2, 3, 7, 8, 15, 18-20, 24-28)
	Monitoring the environmental conditions of the house using environmental sensors such as temperature, humidity, carbon dioxide level and security systems and early warnings (opening and closing of doors and windows)	(2, 6, 9, 15, 17-21, 25, 29)
	Sleep and chairs sensors	(2, 6, 9, 15, 17-21, 25, 29)
Group 3: Monitoring and tracking daily activities and behaviors	Location tracking (location finder by sensors)	(7, 20, 23, 26, 27)
	Voice recognition and voice activation assistant	(23, 25)
	Monitoring people's daily activities and behaviors (such as mobility, eating habits, brushing, talking, physical exercise)	(1, 2, 5, 17, 21-23, 25-27, 29-31)
	Prevention and detection of falls	(1, 8, 9, 14, 15, 17, 18, 21, 23, 27, 28, 30, 31)
Group 4: Providing emergency, medical and treatment assistance	Providing emergency assistance and emergency alerts (e.g., emergency alerts to the nearest medical center)	(9, 14, 15, 20, 25, 27, 30)
	Providing medical assistance periodic check-up and counseling services in dangerous situations	(21)
	Provide treatment through vital sign analysis systems	(5)
	Physiotherapy (movements that must be repeated at regular intervals) for patients with a history of stroke	(22)
Group 5: Assessment and monitoring of physical, mental, and cognith	Evaluation of mental and cognitive health (such as depression symptoms, chronic conditions, dementia, diagnosis of confusion)	(1)
	Health monitoring: providing support for chronic, rare diseases, dementia; also, for wandering and social isolation	(1, 6, 8, 23, 27, 31)
Group 6: Drug management systems and reminders	Reminder system for appointments and announcements of upcoming events, study and other items (especially for people with memory impairments)	(6, 9, 14, 15, 17, 18, 22, 27, 30)
	Drug management system (maintaining timely and accurate information about drug side effects and contraindications, maintaining pill inventory information, and contacting the pharmacy to order a new prescription)	(9, 14, 15, 18, 26-28, 30)
Group 7: Lifestyle and social support	Creating response services or doing homework and various methods of social communication (social support)	(8, 21, 24)
	Teaching a way for healthy lifestyle	(21)

Continue of Table 1. Smart home technologies for the elderly

Technology groups	Type of technology	Studies
Group 8: Security facilities and increase home safety	Intruder alarms to monitor and detect dangerous situations such as theft	(10, 15, 17, 21)
Group 9: Facilities for welfare, entertainment, and recreation	Smart devices and accessories (smartphones, smart mailbox)	(6, 17)
	Recreational and entertainment facilities (installation of lighting systems and their color change; providing interactive games)	(6)
	Digitize home information and create knowledge	(26, 28)
Group 10: Compensation service providers for the disabled and the elderly	Helping people with cognitive, sensory, and physical disabilities such as hearing and sight	(8, 15, 22, 30)
	Use robotic facilities to help the elderly (around the house)	(6, 18)
Group 11: Machine learning and artificial intelligence algorithms for modeling and forecasting	Enter data and send it to care centers	(5)
	Using artificial intelligence algorithms to predict hazards	(5, 9)
	Monitoring long-term disease-related activities and establishing long-term activity patterns (modeling lifestyles and activities); using machine learning technology in video analysis and behavior analysis	(7, 22)

Table 2. Positive outcomes of creating smart homes for the elderly

Positive Outcomes	Studies
Creating security (property, assets)	(6, 7, 15, 17, 19-21, 24)
Reduce the number of accidents (such as reducing the number of falls)	(5, 8, 29)
Reduce the number of hospital admissionsproviders for the disabled and the elderly	(30)
Reduce the length of stay of the elderly in the hospital	(30)
Increase awareness, sense of security and independence of the elderly	(2, 5-7, 14, 18, 19, 23-25, 30)
Empowerment, increasing self-confidence, strengthening communication among the elderly, and reducing social isolation of the elderly	(1-3, 6, 8, 9, 19, 26, 30)
Improve the feeling of comfort and peace, well-being and ultimately increase life satisfaction of the elderly	(5, 7, 19-21, 28)
Save on health care system costs	(3, 24, 27, 29-31)
Saving time	(3)
Energy management and detection of environmental anomalies	(7, 24, 27, 31)
Prevention of diseases and injuries and early intervention	(27, 29, 31)
Improving the relationship between technology and society	(24)
Increase safety (reduce fear and anxiety)	(6, 15, 17, 24)
Diagnosis of pattern in individuals and diseases prediction in line with it	(1, 22, 28)
Application of gait monitoring data in health care, rehabilitation, and physical therapy	(27)
Improve education, communication, and reporting among health care providers and the use of information in medical decision making	(28, 31)

Discussion

Older people's health is one of the health problems in most societies and dealing with these problems requires accurate policy and planning. Of course, if countries do not have a plan in this regard, they will face many problems. These problems have many consequences on the life of the elderly and cause them to lose their independence and have physical, psychological, social, and economic consequences. Consequently, it has crucial effects on the health systems of society. The phenomenon of population aging is due to the improvement of living standards, health, social and economic conditions, reduction of mortality, an increase of life expectancy, and birth control (32).

At present, Iran is experiencing the stage of transition of the age composition of the population from youth to old age. Besides, due to the increase in health, economic and social indicators, the life expectancy index has reached 74. Therefore, it is predicted that the population over 60 years in Iran in 2021 to reach more than 10% of the total population and in 2050 to reach more than 20% of this population and increasing the independence and quality of life of this group of society is of particular importance (33).

This study was conducted to investigate the technologies available in the smart home and their positive outcomes on improving the elderly's quality of life. According to the research findings, a review of studies showed that researchers with a qualitative approach have sought to provide existing technologies in the smart home to increase the quality of life of the elderly. Based on 25 selected studies, 31 technologies were reported in the studies (Table 1), classified into 11 main groups based on the type of technology. At the same time, Pal et al., in their study, pointed to five groups of major smart home technologies (6). Peruzzini et al. divided smart home technologies for the elderly into seven groups (21).

Findings showed that using group1 technologies, including all technologies related to "monitoring health status and physiological parameters," the health status of the elderly by ECG and PPG sensors is monitored. In addition, physiological parameters such as weight, respiration and heart rate, basal body and skin temperature, blood pressure, blood viscosity, and blood sugar levels are monitored in patients with rare disease (5, 6, 8, 9, 14, 15, 17-23).

Demiris et al. also introduce the smart home as a residence equipped with technologies that can monitor the health status of the elderly (15). Pal et al. also concluded in their study that monitoring the health of the elderly with rare diseases, chronic diseases, and dementia should be considered as one of the smart home technologies for this group of society (6).

Group 2 of technologies is related to "environmental monitoring and automation of environmental conditions using sensors" (2, 3, 6-9, 15, 17-21, 24-29). In this group, automation using sensors such as lighting, smoke, remote control, air conditioning, stove and oven, faucet, microwave, washing machine, heating devices, and monitoring the environmental conditions of the house using environmental sensors such as temperature, humidity, carbon dioxide levels and early warnings such as opening and closing doors and windows were the most critical issues mentioned in most studies. Pal et al., in their study, stated that environmental monitoring by environmental sensors such as smoke detectors, electronic door openers causes the independence of the elderly in their homes (6). Peruzzini et al., in their research, mentioned monitoring home environmental conditions such as temperature, humidity, and carbon dioxide levels as essential technologies in the smart home for the elderly (21).

Group 3 also includes technologies related to "monitoring and tracking of daily activities and behaviors" (1, 2, 5, 7-9, 14, 15, 17, 18, 20-23, 25-31). In this group, monitoring activities and daily behaviors of individuals such as mobility, eating habits, brushing, talking, physical exercise, and prevention and diagnosis of falls were among the most critical cases reported in most studies. Brennan et al. also concluded in their research that the use of smart home technologies has the potential to empower the elderly to perform their daily tasks at home (2). In addition, according to the Australian University of Technology and Engineering in the Tegart study, smart home technologies have improved the quality of life of the elderly by minimizing accidental falls and accidents at home due to early warnings (29).

Peruzzini et al. also mentioned the technology of monitoring people's daily activities and behaviors such as medication use, eating habits, physical exercise as one of the crucial technologies in their study (21). Since most older people live alone in their homes, there is no one to help them in an emergency. Smart home technologies inform the family and neighbors of the elderly or the hospital for help and support when needed (34).

Using Group 4 technologies, including technologies related to "providing emergency, medical and treatment assistance," emergency warnings are issued to the nearest medical center (5, 9, 14, 15, 20-22, 25, 27, 30). Jacelon et al. state that smart homes can predict normal and abnormal behaviors and then alert career and health care providers (9). Cheek et al. (30), Cocco et al. (8), and Demiris et al. (15), in their study, mentioned technologies such as emergency care and treatment for the smart home of the elderly.

Group 5 includes technologies related to the "monitoring of physical, mental and cognitive health," such as providing support for chronic and rare diseases, dementia, confusion, and social isolation (1, 6, 8, 23, 27, 31). One of the assistive technologies to reduce the mental and psychological problems of the elderly is the use of smart homes, according to Cocco et al.(8). Liu et al., in their study, stated that the assessment of mental and cognitive health, such as depression symptoms, chronic conditions, dementia, and diagnosis of confusion should be considered as one of the smart home technologies for the elderly (1).

Group 6 includes technologies related to "drug management systems and reminders" such as maintaining timely and accurate information about drug side effects and contraindications, maintaining inventory information of pills, reminder system related to drug use time, and appointments (6, 9, 14, 15, 17, 18, 22, 26-28, 30). The results of Yassein et al.'s study showed that the elderly and those with chronic diseases such as cancer, diabetes, hypertension, and heart disease need smart home technologies to remind their medication use, which reduces the risk of death threats due to misuse of drug doses and forgetting the time of taking drugs (34).

Using technologies related to "lifestyle support and socialization" such as teaching a healthy lifestyle, providing response services or doing household chores, and various social communication methods (8, 21, 24), besides, "security facilities and increasing home safety," like intruder alarms to monitor and detect dangerous situations, such as theft (10, 15, 17, 21), the elderly can live in a familiar and comfortable environment

and maintain their independence. Carlos Rubino de Oliveira et al., in their research, mentioned the support of lifestyle and sociality as one of the functional aspects of smart home technologies (24). Furthermore, Helal et al., in their study, also mentioned that the University of Florida had developed the Gator Tech Smart House for the elderly and the disabled, which provides security facilities as one of the technologies in designing this smart home (17).

In the group of technologies related to "Compensation service providers for the disabled and the elderly" (6, 8, 15, 18, 22, 30), the use of robotic technology in smart homes can improve their quality of life and functional independence through increasing the motivation of exercising, promoting social interactions with others, guiding the elderly to go to different places, helping the elderly with mobility limitations and talking to the elderly about news and weather (35). Cocco et al., in their study, stated that compensatory services for cognitive, sensory, and physical disabilities are as parts of the assistive technologies used in the smart home for the elderly in the United States (8).

Also, according to the research findings, a review of studies showed that technologies used in smart home for the elderly provide many positive outcomes for this group and society. The most important positive outcomes were "increased awareness, sense of security and independence of the elderly" (2, 5-7, 14, 18, 19, 23-25, 30). Since the elderly are more physically and mentally vulnerable than the young, smart homes can be an excellent answer to the challenges of the elderly, including their independence (30). Courtney et al. also reported that increasing the security and independence of the elderly using smart homes can improve the quality of life of the elderly (14).

"Empowerment, increase self-confidence, strengthen communication among the elderly and reduce social isolation of the elderly" were other critical outcomes mentioned in nine studies (1-3, 6, 8, 9, 19, 26, 30). Brandt et al. state that smart home technologies enhance self-confidence and improve communication among the elderly by empowering older people to do their activities at home and facilitating social participation for the elderly (19). Also, in the smart home, health monitoring technologies and home automation reduce isolation and increase self-confidence and sociability (6).

Demiris et al. introduce smart home as a residence equipped with technologies that protect the property of the elderly (15) and it will create more security by monitoring and detecting dangerous situations such as theft and creating an alert when necessary (21). Besides, another positive consequence of using smart home technologies is "creating security (property, assets)," which is mentioned in eight studies (6, 7, 15, 17, 19-21, 24).

"Improving the feeling of comfort and peace, well-being and ultimately increasing life satisfaction of the elderly" (5, 7, 19-21, 28) and "saving the costs of the health care system" (3, 24, 27, 29-31) were among the other positive outcomes mentioned in six studies. Smart home technologies reduce health care costs by preventing disease, injury, and early intervention (27, 29). It has resulted in cost savings of around $ 85 million in the Australian health care system in one year (29). These savings are also achieved by reducing hospital admissions and length of stay in hospitalization of the elderly (30). Chan et al., in their study, also identified these homes design as a cost-effective and promising way to improve feeling of comfort in this group of people (36). In addition, Brandt et al. have considered increasing the satisfaction of the elderly and consequently increasing the quality of life of this group as actual results of smart home technologies interventions (19).

Conclusion

Population aging will have long-term and significant effects on countries. Therefore, it is necessary to anticipate the necessary measures and strategies to reduce its effects on society. Solutions that, in addition to helping the elderly and improving their living standards, do not separate this group from society and enable them to continue their everyday life with less dependence on family and caregivers. One of these solutions is the need to use smart home.

The use of smart home technologies will have many positive outcomes for the elderly, ultimately improving the quality of life of the elderly. According to the results of this study, it can be acknowledged that technology groups of one (monitoring health status and physiological parameters), two (environmental monitoring and automation of environmental conditions using sensors), and three (monitoring and tracking daily activities and behaviors), have been more emphasized in the studies than other types of technologies.

Therefore, the attention of community officials should be directed to apply these technologies in the design, construction, and equipping of the smart homes and nursing homes and be considered. Also, the most positive outcomes of using smart technologies for the elderly include increasing awareness, feeling of security, independence, empowerment, increasing self-confidence, strengthening communication and reducing social isolation of the elderly, and creating more security in their home and nursing homes, which emphasizes the need to invest in these technologies.

Due to the aging population in Iran, it is possible to create a safe and peaceful environment for the elderly by using the technology groups identified in this study. Therefore, it is suggested that the government provide appropriate infrastructure for smart home technologies for the elderly for their homes and nursing homes.

Declarations

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Conflicts of Interests

There is no conflict of interest in this study.

Ethical statement

This article does not contain any studies with human participants or animals performed by any of the authors. Researchers have complied with all ethical requirements throughout research.

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Authors' contributions

This study designed by K.P, A.Z, A.S and S.P. S.P supervised the project. K.P, A.Z and S.P were responsible for search and data extraction. K.P and S.P also drafted the manuscript. K.P revised the manuscript critically. All of the authors read the manuscript and approved it for submission

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