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Article

Impact of Wireless Communications Technologies on Elder People Healthcare: Smart Home in Australia

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Abstract. Over the last three decades, there has been a dramatic rise in ageing populations in most countries. Older people are remaining in nursing home care due to the fact that general services and medical support are provided. However, these environments often negatively affect older people due to high cost, limited staff and the social impacts they have. A way to overcome these challenges is to place the elderly instead of the Nursing Homes in a Smart Home environment. In other words, by implementing such technology, older people are able to remain at home, instead of going to nursing homes and pay the extremely high cost.

The aim of this study is to describe the impact of wireless communications technologies on both nursing home and smart home. Using smart wireless sensors, wireless communication and ambient intelligent systems, it is possible to create systems capable of measuring vital signs of the patient at home. This is based on exchanging signals (information) between the sensor and the data server from already deployed sensors (infrared or camera) or wearable smart sensors, allowing older people to stay at home.

Keywords: E-health, telemedicine, telehealth, smart home, wireless communications.

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1. Introduction

Nowadays, most governments around the globe are faced with the problem of rapidly increasing ageing populations. This has become a major concern for many countries [1]. As a result, there will be greater demand for services in the area of general health, advanced healthcare, and sophisticated technology [2]. To meet this need, the technology sector has created *smart home*, a complete home care system with the ability to provide healthcare in the home. This may enable older people to remain at home, rather than choosing to live in a nursing home. This is complemented by telemedicine and tele healthcare, which means remote monitoring of health [3]. The advantage of this modern method is to provide remote access to the patient's vital elements via mobile phone or computer. In consequence, older persons would be able to stay at home in a safe environment without health concerns as even depression, emotional distress and stress conditions can be diagnosed and treated remotely [4]. As pointed out, the basis of this concept is wireless communications technology, used to facilitate the exchange of information through a wireless connection to a data base server. These data are recorded daily by sensors, cameras and wearable devices with the purpose of monitoring the vital elements of the patient. These elements are: blood pressure, heart rate, and any other signs that may indicate that an accident has occurred. These raw data then trigger emergency response and diagnosis [5].

2. Process of Implementing Smart Home Framework

The ageing population is growing rapidly in numbers and most older people must at some point select a nursing home as a basic healthcare solution [6]. Generally, this health care method incurs high expenditure, affecting the quality of life of the patient, limiting family visits and exposes older people to often unacceptable behavior and lack of respect by nursing home staff [7]. There is also often less focus on the health condition of the patient in nursing home, particularly in terms of emotional stress and depression [8].
Most of the concerns raised can be overcome through the development of a new framework based on smart home technologies that may allow older people to remain at home. This study aims to demonstrate that through the integration of wireless communications technology it is possible to replicate nursing home conditions in a *smart home* and thereby create a modern and more sophisticated solution for older people [9]. The main focus of this study is to describe the process of integration and implementation of this advanced technology [10].

The primary goal of this study is to provide a solution for older people that permits them to remain at home by using sophisticated smart home technology. This would be a huge benefit for people in terms of saving money, feeling safe, being around their families and also living in a happier environment 10. This could mean that instead of spending their money on nursing homes, older people take advantage of wireless communication technology supported by smart home technology. These are the key elements that may lead to the decision to remain at home for health care. In addition, this modern solution provides advanced features for all older people to remain active in their daily activities without any difficulties, supported by ambient intelligent systems [11]. Moreover, once all elements of the smart home have been integrated, older people are able to communicate with the system, perhaps to instruct it to increase the security level of the property and also to receive notifications about their scheduled times for medications [12]. A key element in this highly sophisticated system is e-health, one of the latest medical technologies for the healthcare of older people. E-health is based on sensor networks connected via Internet to a medical base station. Together, e-health and sophisticated home technologies therefore offer both smart home and medicine 4, making it possible to remotely monitor health thorough an internet connection and relay the data to medical staff or families [13]. At the centre of this configuration between user and receiver or monitor, and fed by remote connections, is a system based on compatible hardware and software [14]. In the data servers, all personal information of the user (patient) obtained from the sensors, is stored. This information must be secured in against unauthorized access or attack 9. One method to achieve high levels of security is through RFID login4, which means by using tag (ID) for login [15].

A detailed study was carried out the use of sensors, in nursing homes and in smart homes. The best and latest smart home solutions were selected for this study. This framework for this current selected solution is based on wireless communications technology (sensors), Fig. 1. The main purpose of these sensors is to exchange and store information in a data server at the healthcare home base 9. This system allows monitoring of the vital elements of the human body, such as heart rate, blood presssure, tachycardia or bradycardia [16].

This means, a remote monitoring system is created by wireless sensors connected via an internet connection [5]. Once the system is implemented, family members and nursing staff or doctors are able to monitor the health condition of the user (patient) through the internet connection on their smart phones or computers [17]. Another point is that this system is able to react in case of emergency situations or the detection of falls, creating an immediate emergency notification to the family and staff members via adequate applications [18]. Also, the system itself is limited to automated decisions and their performance. These limitations could be overcome by incorporating more advanced technology in the system [19]. Still, even with this current framework, older people could live more independtly at home and stress levels would be lower [20]. Moreover, the cost for healthcare would be cheaper compared with Nursing Homes healthcare (see Fig. 1).

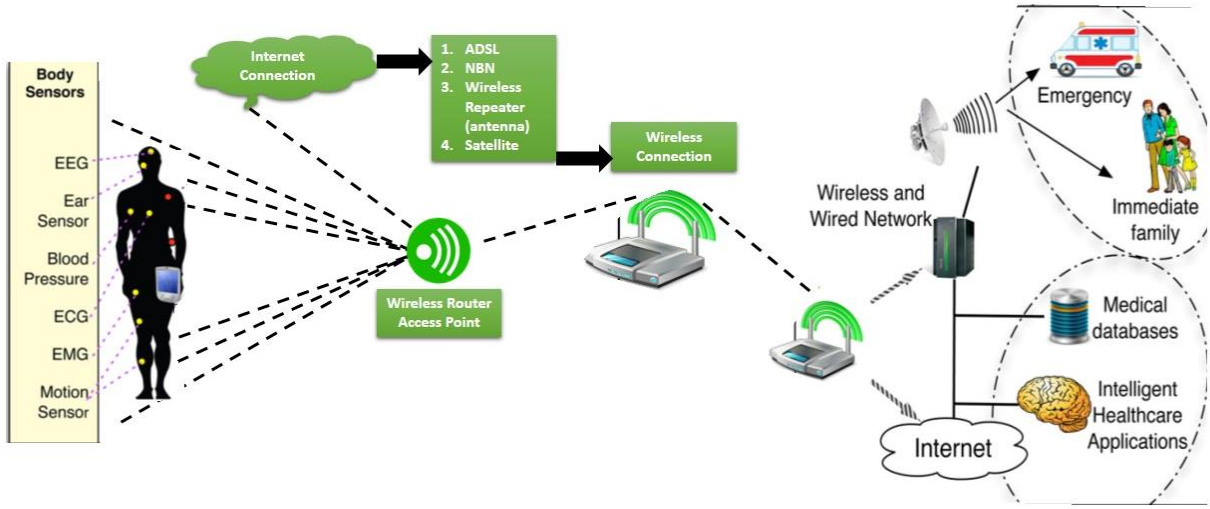

Fig. 1. Current Framework in wireless sensor netowrks in a Smart Home healthcare.

2.1. Current Framework with Limitations and Possible Mitigation

In the following figures, all factors and sub factors in Smart Home elder health care are described.. Basically, each factor considers strength and weakness. Another factor is security and privacy. At this point the positive points are: accessibility and availability, data integrity and convenience. On the other hand, sensitive data, cyber-attack, authentication and authorisation are the biggest concern. The infrastructure in Smart Home care is based on Wireless sensor networks. Strengths are: automation system, decisional, wireless communication. Negatively impacted are: security, privacy, limitated distance signal and design issues (see Fig. 2.)

Furthermore, there are positives in terms of cost: for government projects, insurance companies, Centrelink and family funds. All these resources are related to Smart Home health care of older people. Age related deterioration of health conditions is affecting everyone. Therefore, age, marital status and family relationships are the strong points in Smart Home care. Quality of life is another important point in Smart Home health care. Other strengths are: customer service, cost effectiveness, affordability, effective care and motivation. Weaknesses are safety, patient cantered and timely care (see Fig. 3.)

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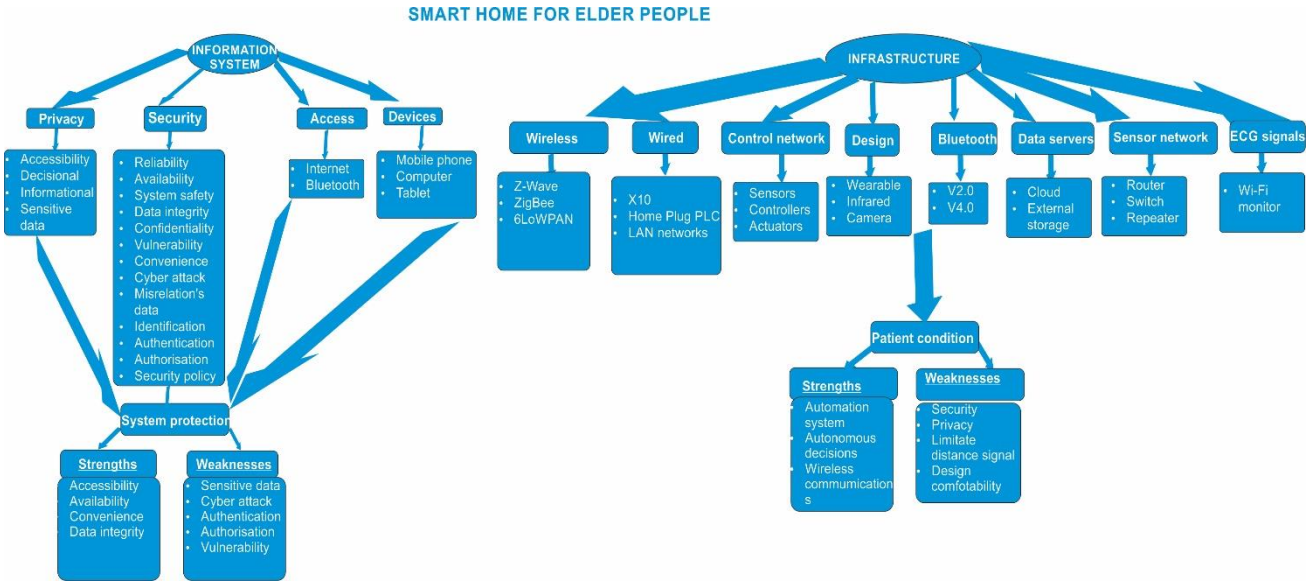

Fig. 2. Current Framework in a Smart Home healthcare with limitations and possible solutions.

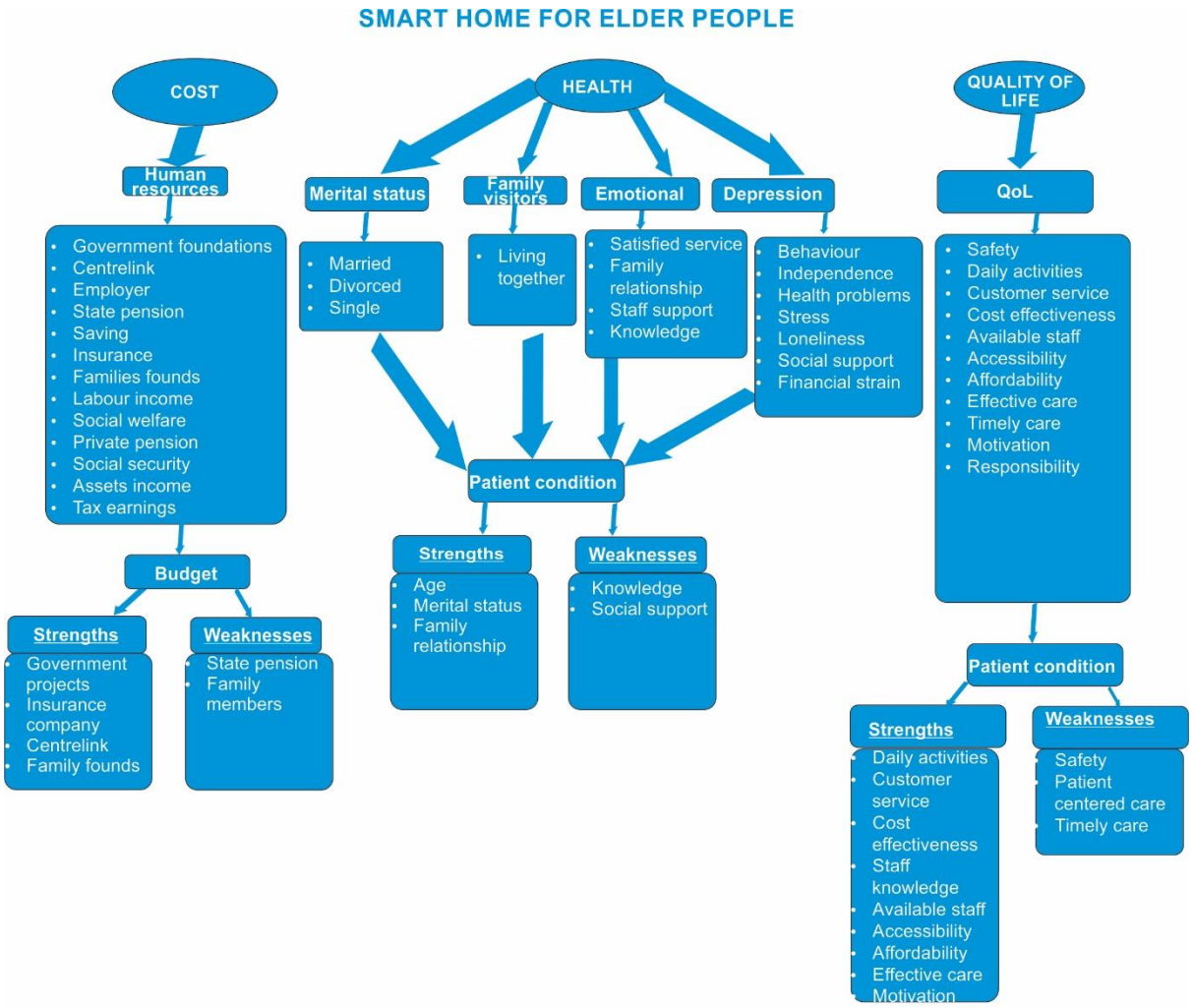

Fig. 3 Current Framework in a Smart Home healthcare with limitations and possible solutions.

2.2. Proposed Framework for Elder People Healthcare in a Smart Home

Overall several decades, Nursing Homes have been the most popular form of health care. Nowadays, technology is changing rapidly; therefore the Smart Home technologies could be the replacement for Nursing Homes. This would allow older people to stay at home and to monitor their health condition thorough wireless connections on mobile phones and computers.

Essentially, this framework reduces the living of cost and increases the quality of life for older people at home.

Basically, the main purpose of this system is to improve the health care of older people at home. Moreover, the system is based on wireless communication technology (sensors) which include wearable smart sensors, camera sensors, infrared sensors, motion sensors, touch sensors and voice sensors. All these sensors are connected wirelessly through an Internet connection. The function of these sensors is to collect information from the user (patient) and convert this into accurate information. This information is recorded daily and stored in the data server.

The integration of wireless communications technology is to help and improve older people's healthcare at home. In addition, Smart Home technology allows older people to be active in their daily activities without any difficulties, supported by ambient intelligent systems. This technique provides options for talking relation patient AmI, which means the user is able to ask for any medications or treatment of diseases. Also, this method provides medication reminders for older people to remind them when they need to take the required medicines. Older people are able to control this system via voice commands, touch commands or facial and body talk systems. All these methods are created to help older people to remain in home healthcare in less stressful conditions.

Another point is online medical support. This support is based on the same wireless sensors for remote monitoring of health conditions of the user. In other words, older people, families and nursing staff or doctors are able to monitor the vital elements of the patient and react in case of emergency through an online connection using the Internet. This feature allows people to feel safe in Smart Home health care through online medical support via direct connection to care teams. Furthermore, the system is intelligent and has features to react and to identify falls and emergency situations.

Another feature is that the system is able to correctly identify diseases via smart sensors supported by AmI and to notify the user of the correct solution. To be enable user to access to this system, that user has to be registered in the data server with a specific ID (username and password).

This authentication and authorisation process is designed to protect the private information of the user. In this case, security and privacy of this framework are supported by these two methods as well as by the firewall process. The user access is granted based on his ID through the router, firewall and data server. In case the user is not authorised, the firewall will refuse entry, after attempting to process IP and MAC addresses. The main point of this framework is that the cost is drastically reduced. Thus, smart power management allows control of the fully automated house by the user. In other words, this system can control the house by itself and can provide correct decisions to help older people. Also, payment fees for medical appointments and hospital consultations are drastically reduced through this framework. In addition, users need to pay only when a specific medical opinion is needed and for technical support in case of system issues. The framework of this system is represented in Fig. 4.

The participants of this study were older people, families and nursing staff. The data was collected by using an online survey.

To evaluate results, different questions were designed. The survey was conducted using Google Survey. All questions were given scores from 1 to 5, with 1 indicating a strong disagreement with the statement, a 3 indicating a neutral position, and a 5 indicating a strong agreement.

The collected data was analyzed using Microsoft Excel and SPSS (Statistical Package for the Social Sciences) tool. The first part of the survey was analyzed using Excel graphs, and the correlations between the results and demographics were analyzed using SPSS. The bivariate correlation results are given in Table.

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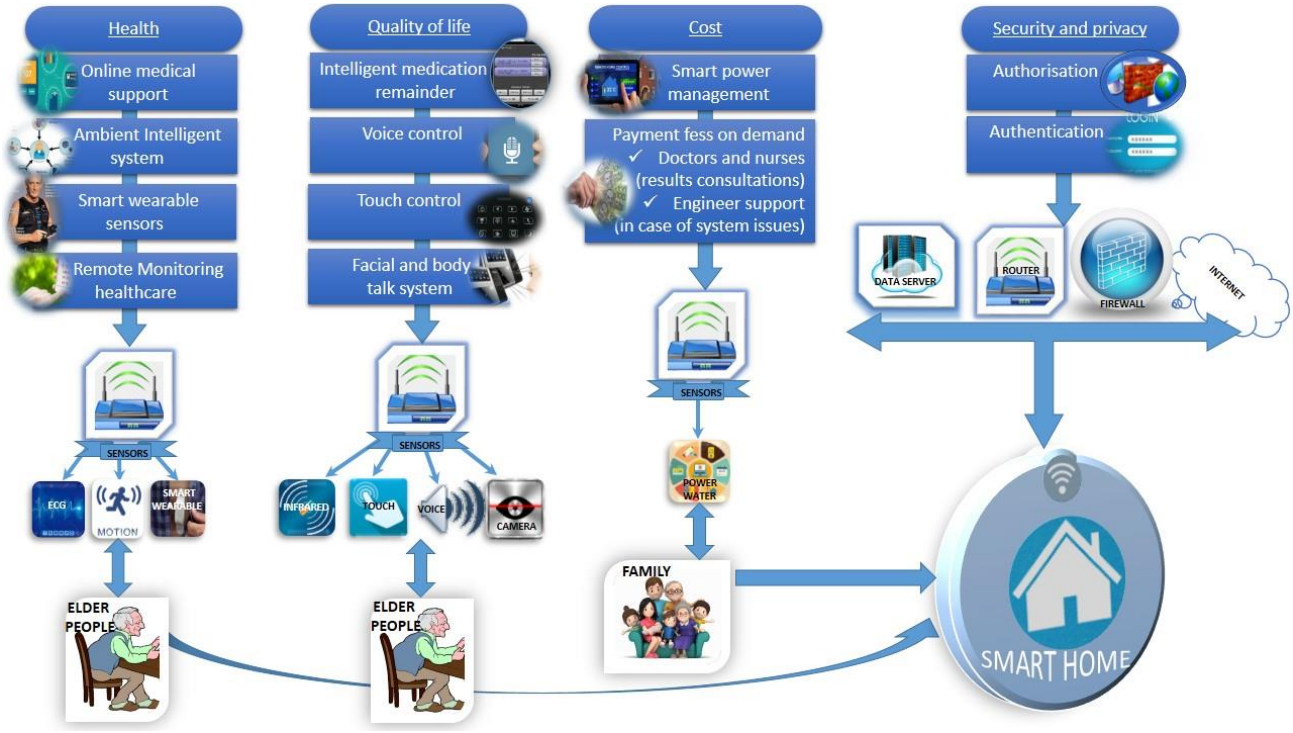

Fig. 4. Proposed framework for elder people healthcare in a Smart Home.

3. Discussion and Evaluation

3.1. Results Discussion

The goal of this study was to consider the real facts about Older People's healthcare in Nursing Home and a Smart Home. The findings clearly support that Smart Home healthcare is cheaper and more technologically for older people. Those who took part in this study clearly indicated that Smart Home healthcare can drastically improve the life of older people in their home environment. The survey results also confirm that older individuals can live more independently at home and they would be in better health.

Another reason for the success of this study is that the quality of life will be higher due to the framework being based on wireless communication technology. Furthermore, with this framework, safety is increased. This study has aimed to investigate the impact of the framework on older individuals with mental and general disabilities issues. The results show that Smart Home healthcare based on wireless communication technology constitutes a significant benefit for those groups. However, this system has several limitations in terms of management and control of the system, outsourcing founds, the need for a better storage system for personal information and also in the area of medical support.

Overall, the system is less costly than a nursing home. The integrated sophisticated technology is a significant factor for the success of the framework. The survey was carried out to back assumptions with data, based on matching health conditions of subjects with previously recorded statistics.

3.2. Proposed Enhanced Model

The main focus of this model (Fig. 5) is to overcome the limitations of the previous model. In addition, stakeholders will be able to manage and control this system, after appropriate training. Training solutions are required for all three types of stakeholders: older people, families and external medical staff. This training should be provided by specialist engineers involved with this technology. In terms of cost, Australian government and Centerlink funds can potentially be allocated to the installation of the system in the homes of older people at reduced cost. There are also benefits for the Australian government. Ambient Intelligent medical support is an advanced level of technological development with the ability to help individuals in a

range of difficult situations, through anInternet connection. This means medical advice can be provided by the system in a timely manner when required.

Basically, this support could be physical via online connection or from the system itself. A final point in this model is Cloud storage. Cloud storage provides significant benefits for stakeholders for keeping information rather than on physical devices. One of the positive points is that all information will be protected through advanced encryption methods (see Fig. 5.) However, there are limitations. While the system can detect certain common disease, it cannot give specific disease related decisions or offer advice about medication.

The integrity of the system is guaranteed by sensors and data with applications integrated in the system, such as: Dialling 000 emergency call, contact with medical personnel or families. The system is controlling the response and there is no a specific app. Limitations could be overcome by implementing backup internet connections (a second ISP) using a router, adding more advanced sensors for monitoring health, and increasing the security measures by integrating firewalls. The conclusion is that to ascertain if this system is capable of functioning in a real environment requires more live tests.

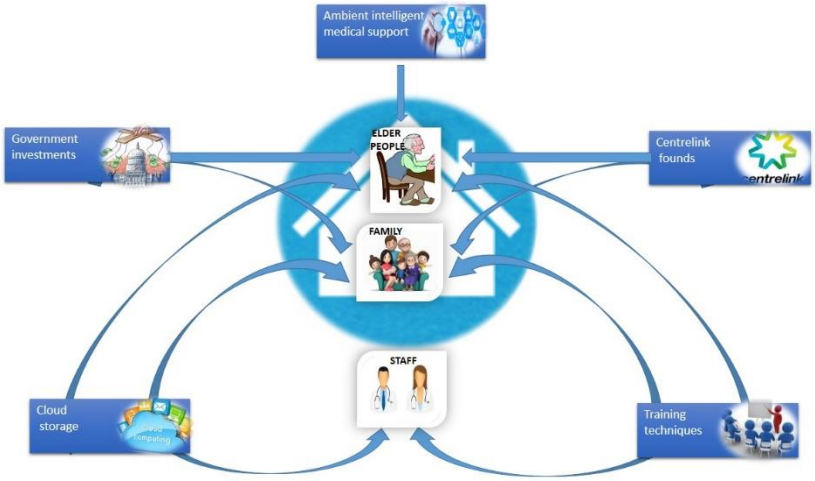

Fig. 5.

4. Correlation Analysis

The bivariate correlation results for survey are given in Table. The values of the Pearson Correlation range from -1 to +1, following the convention that the negative numbers represent a negative correlation and positive numbers represent a positive one.

We found that the "Pearson correlation" and "Cost" were strongly correlated: r(0.799**)$p < 0.01$. The "cost" was also strongly correlated: r(0.799**)$p < 0.01$.

The survey was only design to collect data from random people, who would like to use this technology. For the objective to be achieved, further tests are needed.

The survey was carried out with the participation of 25 random respondents.

The Pearson correlation results for the variables "age" and "marital status" are indicating interesting results. The "age" and "marital status" change in different directions, though the magnitude of the relation is very small (-.472). This is an unexpected result. But that is what a detailed bivariate analysis yielded.

While analyzing the significance (2-tailed) factor, if this value is less than .05, the correlation is considered to be significant (meaning that the researcher can be 95% confident that the relationship between these two variables is not due to chance). Based on the results given in Table 5, since the significance value is .000, we can say that there is a significant correlation between the "person" and "remote monitoring system" and "cost".

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Table 1. Correlation table for Older People perspective based on cost, health, quality of life and security.

Correlations								
		Select your age group	Select your gender	Select your marital status	The cost is the main issue to develop a Smart Home healthcare method	One of the purposes to implement the Smart Home technology is to improve the healthcare	Remote monitoring system is for controlling and managing the vital elements of the human body, which means this method is helpful in Smart Home healthcare	Smart Home healthcare is based on wireless communication technology, which means your personal data is secured
Select your age group	Pearson Correlation	1	-.021	-.472*	.051	.085	.197	.015
	Sig. (2-tailed)		.921	.017	.809	.687	.345	.945
	N	25	25	25	25	25	25	25
Select your gender	Pearson Correlation	-.021	1	.095	-.261	-.079	-.079	-.002
	Sig. (2-tailed)	.921		.651	.207	.707	.706	.993
	N	25	25	25	25	25	25	25
Select your marital status	Pearson Correlation	-.472*	.095	1	-.025	-.358	-.118	-.184
	Sig. (2-tailed)	.017	.651		.906	.079	.576	.379
	N	25	25	25	25	25	25	25
The cost is the main issue to develop a Smart Home healthcare method	Pearson Correlation	.051	-.261	-.025	1	-.289	.799**	.240
	Sig. (2-tailed)	.809	.207	.906		.161	.000	.248
	N	25	25	25	25	25	25	25
One of the purposes to implement the Smart Home technology is to improve the healthcare	Pearson Correlation	.085	-.079	-.358	-.289	1	.000	.282
	Sig. (2-tailed)	.687	.707	.079	.161		1.000	.172
	N	25	25	25	25	25	25	25
Remote monitoring system is for controlling and managing the vital elements of the human body, which means this method is helpful in Smart Home healthcare	Pearson Correlation	.197	-.079	-.118	.799**	.000	1	.301
	Sig. (2-tailed)	.345	.706	.576	.000	1.000		.144
	N	25	25	25	25	25	25	25
Smart Home healthcare is based on wireless communication technology, which means your personal data is secured	Pearson Correlation	.015	-.002	-.184	.240	.282	.301	1
	Sig. (2-tailed)	.945	.993	.379	.248	.172	.144	
	N	25	25	25	25	25	25	25
*. Correlation is significant at the 0.05 level (2-tailed).								
**. Correlation is significant at the 0.01 level (2-tailed).								

The bivariate correlation results for survey are given in Table. The values of the Pearson Correlation range from -1 to +1, following the convention that the negative numbers represent a negative correlation and positive numbers represent a positive one. We found that the "depression condition" and "emotional feelings" were strongly correlated: r(0.695*)p < 0.01. The "gender" was also strongly correlated: (0.412*)p < 0.01. The Pearson correlation results for the variables "age" and "marital status" are indicating interesting results. The "gender" and "customer service" change in different directions, though the magnitude of the relation is very small (-.0.249). This is an unexpected result. But that is what a detailed bivariate analysis yielded. While analyzing the significance (2-tailed) factor, if this value is less than .05, the correlation is considered to be significant (meaning that the researcher can be 95% confident that the relationship between these two variables is not due to chance).

Table 2. Families participants of aged care.

Correlations								
		Select your age group	Select your gender	Select your marital status	One of the purposes to implement the Smart Home technology is to improve the healthcare	The cost is the main issue to develop a Smart Home healthcare method	Remote monitoring system is for controlling and managing the vital elements of the human body, which means this method is helpful in Smart Home healthcare	Smart Home healthcare is based on wireless communication technology, which means your personal data is secured
Select your age group	Pearson Correlation	1	-.114	.243	-.238	-.261	-.206	-.179
	Sig. (2-tailed)		.565	.213	.223	.180	.293	.361
	N	28	28	28	28	28	28	28
Select your gender	Pearson Correlation	-.114	1	-.103	-.161	-.167	.040	.412*
	Sig. (2-tailed)	.565		.604	.413	.397	.840	.029
	N	28	28	28	28	28	28	28
Select your marital status	Pearson Correlation	.243	-.103	1	.031	-.043	-.062	-.039
	Sig. (2-tailed)	.213	.604		.876	.829	.756	.843
	N	28	28	28	28	28	28	28
One of the purposes to implement the Smart Home technology is to improve the healthcare	Pearson Correlation	-.238	-.161	.031	1	-.349	.039	-.047
	Sig. (2-tailed)	.223	.413	.876		.069	.845	.814
	N	28	28	28	28	28	28	28
The cost is the main issue to develop a Smart Home healthcare method	Pearson Correlation	-.261	-.167	-.043	-.349	1	-.053	-.263
	Sig. (2-tailed)	.180	.397	.829	.069		.787	.176
	N	28	28	28	28	28	28	28
Remote monitoring system is for controlling and managing the vital elements of the human body, which means this method is helpful in Smart Home healthcare	Pearson Correlation	-.206	.040	-.062	.039	-.053	1	.447*
	Sig. (2-tailed)	.293	.840	.756	.845	.787		.017
	N	28	28	28	28	28	28	28
Smart Home healthcare is based on wireless communication technology, which means your personal data is secured	Pearson Correlation	-.179	.412*	-.039	-.047	-.263	.447*	1
	Sig. (2-tailed)	.361	.029	.843	.814	.176	.017	
	N	28	28	28	28	28	28	28
*. Correlation is significant at the 0.05 level (2-tailed).								

The bivariate correlation results for survey are given in Table. The values of the Pearson Correlation range from -1 to +1, following the convention that the negative numbers represent a negative correlation and positive numbers represent a positive one. We found that the "Security and Privacy" and "gender" were strongly correlated: r(0.412*)p < 0.01. The "Quality of life" were also strongly correlated to Security and Privacy (r = 0.447*) where p < 0.01. The "cost" and "health" change in different directions, though the magnitude of the relation is very small (-.0.349). This is an unexpected result. But that is what a detailed bivariate analysis yielded. While analyzing the significance (2-tailed) factor, if this value is less than .05, the correlation is considered to be significant (meaning that the researcher can be 95% confident that the relationship between these two variables is not due to chance).

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Table 3. Staff participants of aged care.

Correlations							
		Select your gender	To what extend you are interested in Smart Home technology	Moving in nursing home can lead to depression	Moving in nursing home and fare away from their families can lead to emotional and stressful situations	Rate the safety in nursing home	Rate your satisfactory level for customer service in nursing home
Select your gender	Pearson Correlation	1	.480	.031	.255	.240	-.249
	Sig. (2-tailed)		.070	.913	.359	.389	.371
	N	15	15	15	15	15	15
To what extend you are interested in Smart Home technology	Pearson Correlation	.480	1	.163	.429	.461	.152
	Sig. (2-tailed)	.070		.563	.111	.084	.588
	N	15	15	15	15	15	15
Moving in nursing home can lead to depression	Pearson Correlation	.031	.163	1	.695**	-.487	-.192
	Sig. (2-tailed)	.913	.563		.004	.066	.493
	N	15	15	15	15	15	15
Moving in nursing home and fare away from their families can lead to emotional and stressful situations	Pearson Correlation	.255	.429	.695**	1	-.115	-.164
	Sig. (2-tailed)	.359	.111	.004		.684	.558
	N	15	15	15	15	15	15
Rate the safety in nursing home	Pearson Correlation	.240	.461	-.487	-.115	1	.472
	Sig. (2-tailed)	.389	.084	.066	.684		.076
	N	15	15	15	15	15	15
Rate your satisfactory level for customer service in nursing home	Pearson Correlation	-.249	.152	-.192	-.164	.472	1
	Sig. (2-tailed)	.371	.588	.493	.558	.076	
	N	15	15	15	15	15	15
**. Correlation is significant at the 0.01 level (2-tailed).							

5. Conclusion

In conclusion, these days the aging population is growing rapidly everywhere. This means the increased demand for nursing home healthcare has become a major concern for every country in the world. Possible solutions come from the rapid evolution of technology, with an example being smart home healthcare a particularly suitable solution for older people which allows them to remain at home and so reduces the need for nursing home places. This technology provides numerous benefits for older people in their daily tasks, as it supports their activities through automated systems and smart sensors.

This framework has outline a model that provides a high standard of living for older people if they choose to remain in a smart home with healthcare instead of going to a nursing home. Therefore Smart Home healthcare would be the best solution for older people because it allows them to remain at home. Clearly, it is in the best interest of governments to be part of such an initiative with investments in technology, to curb the spiraling cost caused by age-related overpopulation in nursing homes as the system would help people to remainat home and feel safe. This remarkable technology is the future for such groups, increasing happiness and monitored health.

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