Use Of Smart Device In Healthcare

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Abstract

Elderlies with either CAD (Coronary Artery Disease) or stroke, which are the most common complication of diabetes, have a high risk of unexpected falls or accidents. Falls that elderly patients experience may not cause deadly effects; however, small injuries can cause more frequent falls and life quality decline. Falls that occur in houses can be prevented and meticulously monitored with the use of robust fall detectors. Home monitoring devices using Artificial Intelligence are a far better choice than wearable devices that cannot be worn while sleeping or using the bathroom and can cause irritation. The positive impact of using home monitoring devices extends from enhancing the quality of life for seniors, offering a peaceful mind for the seniors and the caregivers, and minimizing the negative impact when accidents occurs, to reducing the costs of regular transportation usage and employing caregivers.

Introduction

Artificial Intelligence (AI) is a technology that enables computers to simulate human intelligence behaviors, such as understanding language and recognizing speech and pictures. (Rouse, 2020; Cambridge Dictionary, 2020; BBC, 2019). AI not only can interpret data but also learn from data to achieve specific goals designed for the program (CrashCourse, 2019). It has the potential to have a great impact on society and the economy by influencing every single field of industry from science to arts, and health care (Chowdhury, 2017).

In this regard, by tracing the historical figures and through the analysis of the future projections based on the past trends for the period between 2000 and 2050, the elderly population (aged 60 and more) are expected to double from 12% and take up 22% of the entire population (PAHO, 2020). Following this rapid increase, the global demographic is projected to double by 2050: 1 billion in 2015 and 2.1 billion in 2050 (Sanyal, 2018; Dossman, 2018). With the accelerated shift in demographics for senior citizens over 60 years of age worldwide, the senior living industry is also changing to fulfill their high demands by developing technologies (Artificial Intelligence) that cater to them. Some of the developments of the growing body of research include solutions for providing updates to family members or doctors about the patient's status, creating virtual companions to reduce loneliness and isolation, and developing wearable devices to detect abnormal physical changes and expand

home monitoring services (Welbi, 2020; Sanyal, 2018; Dossman, 2018).

Therefore, this paper focuses on AI, specifically smart devices, changing the elderly health care system. The target audience of this research is the elderly population aged 60 or more, undergoing diabetes with Coronary Artery Disease (CAD) complication and stroke. Corresponding to the current trends within the senior health care industry, this paper introduces three (3) different smart device companies and analyzes their services.

What is Diabetes?

Diabetes is a "*disease that occurs when your blood glucose, also called blood sugar, is too high*" (Diabetes Australia, 2020; Diabetes.org.uk, 2020). It is caused when insulin, a hormone which "regulates how the body uses and stores glucose and fat", is not produced in our body or when it fails to function well (Diabestes.co.uk, 2019). It is a chronic disease that affects how the body converts food into energy and has the potential to affect the entire human body (CDC, 2020; Diabetes Australia, 2020). There are two types of diabetes, Type 1 and Type 2. A human's body with type 1 diabetes is unable to produce insulin which makes the person compulsory to take insulin every day to survive. Children, young adults are likely to be diagnosed with Type 1 diabetes although anyone can have Type 1 diabetes. Unlike Type 2, Type 1 cannot be prevented. On the other hand, Type 2 diabetes is when your body does produce insulin but not sufficiently which mostly happens to middle-aged and elderly but has a possibility of developing in any age (Diabetes Australia, 2020; niddk.nih.gov, 2020). Approximately 90~95% of people with diabetes are Type 2.

Despite the above-mentioned differences, both types of diabetes prevent glucose from approaching your cells and build up in the blood vessels which have a high possibility of causing numerous complications (Diabetes.org.uk, 2020). People with diabetes are likely to have an increase in the number of going to the bathroom and correspondingly feel much more thirsty than usual. Also, they would lose weight without effort, but on the other hand, they always feel hungry. Worse and blurred vision and darker and darker skin colors especially on the creases of neck, armpits, or groins are one of the early symptoms of diabetes. Furthermore, you might recognize your wounds healing slowly than usual or yourself feeling extremely fatigue (Cleveland Clinic, 2018; Galan, 2020).

After the brief overview of diabetes and its types, the next two sections of the research paper focus on the two major complications associated with diabetes. The aim is to gain an insight into how diabetic complications necessitate the use of the smart device to help elderly care in terms of health care.

Diabetes Complication 1 - Coronary Artery Disease (CAD)

The first major complication of diabetes is Coronary Artery Disease (CAD), which is one type of heart disease. Generally, the patients with heart disease have plaques built up in their arteries which leads to narrowed arteries. Narrowed arteries prevent normal blood flows to happen as they might reduce or block the flow. Heart disease is the leading cause of death regardless of gender, race, or ethnicity where one person dies every 37 seconds in the United States.

Among the different heart diseases, CAD is the most common type of them. As per recent CDC statistics, 365, 914 people were killed from the CDC in 2017 (CDC, 2020). As people become aged, they are much susceptible to CAD. For those who are 80 or more, CAD is the number one cause of morbidity and mortality. This is experienced both in men and women. CAD is present in approximately 50% of women and 70-80% of men. This disease is much a greater risk to the elderly as they suffer from more extensive coronary atherosclerosis compared to younger adults. They are also highly prevalent in multivessel diseases. Patients who suffer through CAD are likely to encounter other complications such as chronic disability and may lose independence in their senior life. They will experience significantly decreased quality of life (Madhavan, Gersh, Alexander, Granger, & Stone, 2018). However, CAD symptoms are less obvious and subtle to older patients. Typical symptoms of chest discomfort are not diagnosed acutely and they rather experience dyspnea. Even worse, 65+ people have more than 20% of prevalence to CAD 70+ show a drastic rise of over 30%. Being aged put people to a higher chance. As the situation gets worse for the elder population, it is essential to develop better strategies to diagnose, treat, and chronically care for the senior population (Forman, 2020). Concerning diabetes, individuals specifically elderly people who are suffering from diabetes are at higher risk of CAD as age is recognized as a strong predictor for CAD. CAD and diabetes both share similar inflammation and oxidative stress mechanism (Halter, et al., 2014; M.Al-Nozha, M.Ismail, & Nozha, 2016).

Diabetes Complication 2 - Stroke

On the other side, stroke is the second most prominent complication of diabetes. Diabetes patients are statistically much more susceptible to strokes, which occur when the blood supply to the brain is interrupted or reduced (Diabetes.co.uk, 2019). Stroke is a no.5 cause of death and one of the primary causes of disability in the United States (Stroke.org, 2020). According to the American Diabetes Association, the chances of having strokes for diabetes patients are 1.5 times higher than those who do not have diabetes (Stroke.org, 2020). One research has reported much higher likelihood stating that the risk is four times higher for diabetes patients (Tun,

Arunagirinathan, Munshi, & Pappachan, 2017). This is because diabetes is a stimulus of heart diseases which include heart attacks and strokes. Strokes may lead to falls and permanent damage to the brain such as communication problems, paralysis, and visual problems (Diabetes.co.uk, 2019).

However, how the stroke would affect the physical and mental health of humans depends on where the blood flow has failed to reach (American Diabetes Association, 2020). Patients who have acute hyperglycemia and diabetes are likely to encounter risks of higher mortality, poorer neurological and functional outcomes, longer hospital periods, higher readmission rates to hospitals, and recurrence of strokes--higher stroke incidence (Lau, Lew, Borschmann, Thijs, & Ekinci, 2018). Moreover, diabetes patients frequently have coexistent hypertension, which is another risk factor of stroke (Chen, Ovbiagele, & Feng, 2016). Thus, it is an inevitable fact that diabetes is a critical matter of risk for stroke and that there exists a strong association between diabetes, strokes, and cardiovascular diseases. Patients with diabetes are at a significantly higher risk of stroke and higher mortality rates (Tun, Arunagirinathan, Munshi, & Pappachan, 2017).

On a similar context, fall is the significant cause behind the stoke-related mortalities and morbidities (Tutuarima, van der Meulen, de Haan, van Straten, & Limburg, 1997). Stroke patients experience more frequent falls during their hospital admission. Of the 720 patients, 14% fell at least once, and of those patients, 66.3% did not fall anymore while 18.3% fell twice and 15.4% fell three or more times. There were 8.9 out of 1000 patients every day who fell. Falling once does need attention. Falling twice, they are likely to have doubled the risk of falling. Also, those who fell during their hospitalization were more prone to falling after discharge. Most of the falls occurred during the daytime and the places varied. 51% were in the patients' room, 20% were during their visits to the bathroom or toilet. 23% of the falls happened in bed and 24% were when patients were sitting on a chair. Of those total number of falls, about 25% caused slight-to-severe injuries. 8% (14 patients) had hematoma or open wounds and 2% (3 patients) had hip fractures. Despite other injuries were minor and did not require sophisticated medical attention, 25% cannot be ignored (Chen, Ovbiagele, & Feng, 2016).

Another research study investigating the patients' falls has revealed that of 108 patients, 73% fell after their discharge of hospital stay within six months (Forster & Young, 1995). Those fall accumulated to a total of 270 falls. Patients who fell two or more times were socially inactive and were in a more depressed mood. It seemed that their fear of falls affected their lifestyle. Overall, the concern was that so many patients fall in their homes after discharge which could result in small injuries like wounds. The research suggests that patients at risk should be given much more careful advice and guidance before their end of hospitalization (Forster & Young, 1995).

Both the complications of diabetes have highlighted the need for appropriate care and guidance for the elderly. Smart devices are expected to meet the specific needs and interests of the patients. The next section of the research addresses how the smart device can be used to help in elderly health care.

How Smart Device Helps Elderly Care in Terms of Health Care

Modern-day technologies share a positive prospect of solving the challenges regarding the health care of elderlies. Experts claim that combining recent technologies such as wearable devices and home-based monitoring systems with smartphone applications would be able to provide a quality home-based health care service that paves a path to better management and accurate monitoring of senior patients (Al-khafajiy, et al., 2019).

Furthermore, smart devices are also likely to increase in life expectancy and to decline the fertility rates, which have elevated among the elderly population at present (Chen, Ovbiagele, & Feng, 2016). They are highly prevalent to chronic diseases compared to other age groups (Al-khafajiy, et al., 2019). Moreover, for them, chronic diseases are more of an issue than acute symptoms (Chen, Ovbiagele, & Feng, 2016). Typical old-age related health problems are comprised of high blood pressure, high blood cholesterol, cerebral thrombosis, etc. (Wang, Yang, & Dong, 2017).

Additionally, in terms of cost of CAD treatment, CDC statistics indicated that the treatment of chronic diseases is responsible for 86% of total U.S. health spending (Kern, 2016) (Kern, 2016). Managing the costs for elderlies has been a burden to the welfare system of the society (Chen, Ovbiagele, & Feng, 2016) and experts claim providing adequate care along with new solutions is imperative (Kern, 2016). The burden of elderly health care not only lies on those particular seniors but also on the caregivers, nurses, or family members as elderlies are unable to independently take care of themselves. Besides the financial burden, the caregivers and family members are also required to pay extra attention to seniors to ensure their safety and health (Russey, 2018). Those with diseases that require continuous monitoring and hospital visits, need to pay more for regular transportation fares, employment costs, long hospital stays, etc. (Al-khafajiy, et al., 2019; Kekade, et al., 2018; Wang, Yang, & Dong, 2017). Consequently, these are very likely to provoke financial pressure on the families of elderlies. The ultimate goal of using smart devices is to reduce the financial burden to families and to foster healthier, independent lives for seniors.

This reality calls on a significant improvement for health care officials, and it has become an urgent problem to solve in modern society. Until recently, patients were manually monitored in clinics. However, the advent of modern-day technologies is prospected to have profound implications on the current health care system,

which would lessen the excess burdens of society and patients (Al-khafajiy, et al., 2019). Corresponding to the recent trend, research on remote monitoring technology and attractive solutions, as well as the demands and respectability, have increased (Al-khafajiy, et al., 2019; Kern, 2016). Specifically, wearable devices and home monitoring smart devices have brought to light the incorporation of technologies to senior health care. These devices offer a remote, yet safer, and more convenient environment primarily because it enables continuous monitoring of elderlies. To elaborate, better management and communication between patients and physicians, or health care providers are possible (Kekade, et al., 2018; Al-khafajiy, et al., 2019). Benefits are a real-time immediate response to unpredictable moments, such as falls, sudden illness, heart attacks, and detection of abnormal health issues based on long-term monitoring (Wang, Yang, & Dong, 2017; Kekade, et al., 2018; Al-khafajiy, et al., 2019). In other words, these early interventions of health issues are likely to improve the process of clinical decision-making as physiological data including blood pressure, heart rate, ECG would be regularly collected for vital signs. Consequently, the adverse effects would be minimized (Wang, Yang, & Dong, 2017). Additionally, elderlies who need to regularly visit hospitals or stay in the hospital for a long time could also save their transportation costs (Kekade et al., 2018). In all, utilizing smart devices for senior health care is highly advisable to reduce the costly burdens by forestalling negative effects or risk of diseases and ensure a healthy and safe environment for the elderly.

Hence, the next section of the report presents a comparative analysis of the wearable device and home monitoring devices.

Wearable Device vs. Home Monitoring Device

A report published by the World Health Organization discloses that around 28~35% of elderlies aged 65 and over experience fall each year, while the rate increases to 32~42% for elderlies aged 70 and over. This statistic indicates age-related biological changes to the body exponentially increase the rate of falls. Thus, it is evident that the ageing society experiences high incidents of falls and related injuries. In response to the risk posed to the seniors, robust fall detectors in the form of either wearables or camera-based sensors cast a positive outlook to the current issue. They can ensure direct response which would eventually reduce the fear of falling and injuries, with improved safety and security at home. Here, robust fall detectors infer to devices that can classify the difference between falls and non-falls (Igual, Medrano, & Plaza, 2013).

Fall detectors can be categorized into three: wearable sensors, ambient sensors, and camera-based sensors (Vallabh & Malekian, 2017, p. 1). However, in the context of our target audience, camera-based sensors, home-monitoring devices seem to be the optimal choice. The reasons are

based on a comparative analysis between wearable sensors and camera-based sensors. Camera-based sensors are adapted to provide monitoring and fall detections without interfering with the elderly's daily lives. They are contactless with the user (Vallabh & Malekian, 2017, p. 12). On the contrary, wearable sensors should be worn on the body of the patient, usually placing the belt around the hip. This provokes problems such as forgetting to wear the devices and neglect.

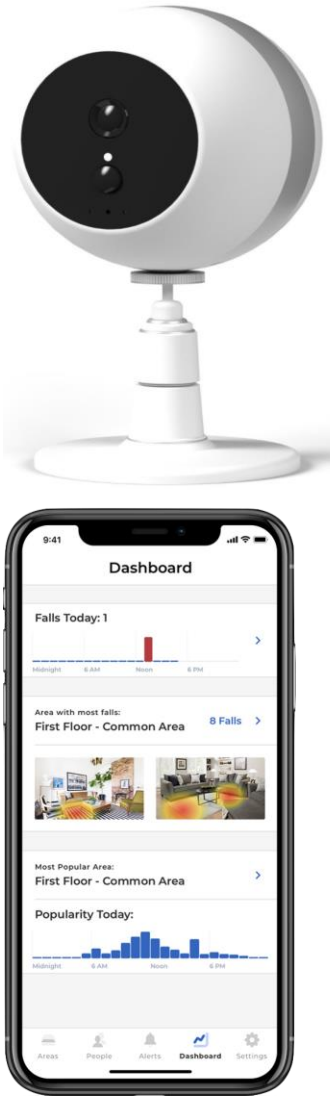
Moreover, it is important to understand that the devices cannot function while the client is changing their clothes or either sleeping. This is a great flaw, pointing out the fact that the device is not able to detect falls when a patient is getting up from a bed, which has a high risk of imbalance (Harris, Eng, Marigold, Tokuno, & Louis, 2005). What's more, since these devices are prone to water and hinder comfortable bathing, they cannot be used in the bathroom, which is also a place of high occurrences of falling (Vallabh & Malekian, 2017, p. 9). Wearable sensors can detect both indoors and outdoors, giving more flexibility to the detection range (Vallabh & Malekian, 2017, p. 6). However, it can be depicted that elderly patients have a far less chance to go outdoors without accompanies; they do not need monitoring devices outdoors. In other words, giving up the flexible practicality of indoor camera-based sensors is an unreasonable choice.

The next sections of the research further elaborate on the discussion by presenting some examples of home monitoring devices.

Examples of Home Monitoring Devices

1. Cypress

https://www.altumview.com/

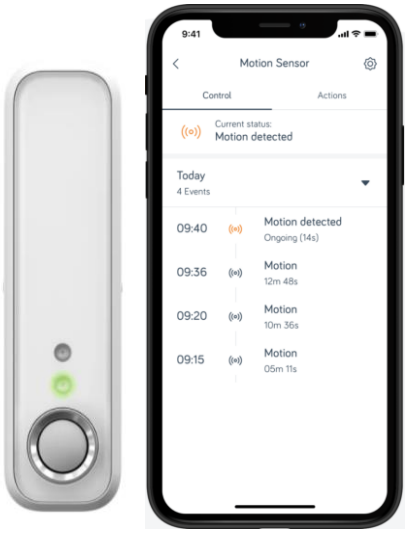


The first home monitoring device i.e. Cypress is a device that works with artificial intelligence (AI), with many algorithms working at once. Since the device is based on AI, it can detect falls, waving hands for help, etc, which are recognized as abnormal movements. Unlike typical motion

sensors, Cypress is a smart device that can detect much more complicated behaviors. The detection range of the sensor is up to 30" with a 128-degree viewing angle. When the elderly are to utilize Cypress in their home, usually one sensor is installed per one room. The biggest advantage of Cypress is its ability to process received data within the sensor itself and the capability to preserve the privacy of seniors. In other words, no personal information of the individual is recorded and the device encrypts communication by converting the image to stick figures when providing incident recreation. One device costs $600 US dollars, with a monthly maintenance cost of $10. In one household, it is assumed that 3-4 devices are used. Cypress enables real-time notifications which means that active monitoring of caregivers or doctors is not needed, providing passive monitoring. Not only to detect falls but also to prevent falls, the device offers a daily analysis of the senior's movement which lets the caregivers make better choices of furniture placing, etc. When fall is detected, they can receive a visualization of the incident using heatmaps that highlight the area of occurrence. Moreover, with the use of infrareds instead of actual cameras, they can detect falls even during the night time.

2. Hive Home

https://www.hivehome.com/



The second home monitoring device i.e. to use the motion sensor, Hive Hub, a device that connects and manages all the Hive products, should also be purchased. The hive hub functions remotely with the Hive Mobile App. One motion sensor costs £29.00 and one hive hub costs £80.00. There is no monthly fee for this device. The Hive motion sensor is capable of detecting the presence of a person (motion) and sending reports that contain the time and duration of the activity. The caregiver is notified, but they may turn off alarms if they are present in the home. When the user wants to share the data with multiple people, they should share the same username and password. Additionally, data on the seniors' activity is tracked for the last 7 days. The motion sensor is also able to turn on and turn off lights when motions are detected, preventing incautious falls during the night. The Hive motion sensor can be

easily attached to any wall or corner of the house but should be placed away from windows or any heat sources since they use infrared detections; being close to those places may create false detections and alarms. It is recommended to be attached at corners as it provides the largest detecting boundary. Typically, the range of detection area is 5m. It is recommended that the device is located at a place where the seniors frequently are at. This includes places like the common area, living room, bedroom, etc. For privacy preservation, toilets are not encouraged. Despite the benefit to detect motion, there may be limitations to detect specific movements such as falls. For more detailed observations, using the Hive Indoor Camera is also recommended.

3. TruSense
https://www.mytrusense.com/independent-living-2/how-it-works/

The third home monitoring device i.e. TruSense provides a safe and healthy living environment for seniors by incorporating high-quality monitoring devices. It also provides a user-friendly dashboard to the users. One of the devices that our target patient can use is the Fall Detection Motion Sensor. The fall detection motion sensor alerts the caregivers if a probable fall occurs to the elderly. The sensor alerts fall when elderlies have not moved for a long period at an area of high risk to falls which includes places such as stairs or bathrooms. To use this motion sensor, users should also purchase the Hub. The Hub functions to communicate properly with other devices and send accurate information. Trusense, an unobtrusive Passive Monitoring tool, enhances the protection of seniors alone at home with deeper health insights and peace of mind for the caregivers. Seniors in this way can still be independent at a much lower rate of risks to safety or health issues. After gaining an overview of the different types of smart devices available for home-based health care of elderly, the subsequent section provides an analysis of how cost-effective it can be using smart devices at home instead of having a doctor check-up regularly.

Cost-effectiveness of Smart Devices to be used at Home vs. Doctor Checkups

Remote medical care devices are identified as revolutionary aspects of technology to improve the health care for the wider range of patients including quality home-based care for elderly (Jagadeeswari, Subramaniyaswamy, Logesh, & Vijayakumar, 2018). Due to the lower cost of devices and networks used at homes as well as increased security levels, these healthcare devices

are turning out as cost-effective relative to the doctor checkups. It helps the patient in the timely provision of care and in saving money used to travel and visit their doctors on a routine basis (Popovich, 2015). Additionally, the home-based care devices also eliminate the unnecessary procedures associated with the patient's assessment of clinical history as well as other medical aspects every time the patient visits to the doctor. These devices maintain up-to-date records of the patient's clinical conditions and history for the doctors, which is transferred to them electronically when needed (Ventola, 2014).

However, contrarily the use of these remotely connected medical devices demands adequate maintenance to enhance technical performance on time. Consequently, the patients are required to return these devices to the field technician performing on-site maintenance that may need additional funds and time. In assessing the cost-effectiveness of the medical devices, it is extremely important to identify that management of these devices puts a heavy burden on the care provider. Besides medical devices, remote medical applications also require funds for replacement and upgrading after a specific period (Ventola, 2014).

Conclusion

In conclusion, it can be stated that based on the overall discussion, the use of the smart device in healthcare has appeared as significant specifically for the elderly population suffering from diabetes and CAD both. However, in generalizing these findings, two limitations should be considered. First, there remains a mismatch between the data and the origin of the devices. The data and research are majorly based on the statistics of the United States while the devices are from three different countries: The United States, the United Kingdom, and Canada. Statics of the United States include most of the research, as well as the economical effectiveness. While numbers may vary regarding hospital visits and insurance costs, it is reasonable to conclude that nonetheless, the usage of smart devices decrease the costs of employing caregivers and transportation fees and thus, it is economically beneficial and did not largely affect our results. Second, there was a limited type of smart devices that could be employed to benefit diabetes patients with either CAD or stroke. It seems like this is because of the lack of prior exploration of the topic and its impacts on our specific target patients. More abundant research and the pool of devices could have allowed for a larger pool of choice when finding the right device. Thus, the three home-monitoring devices chosen have limitations themselves. Two of the three are not specifically designed to detect falls. Smart devices that detect falls were mostly wearable devices, which were not suitable for our target audience. However, alternatives and suggestions are mentioned along with the descriptions and note that this paper aims to provide information regarding the advantages

of using smart devices, not patient-specific solutions. In a nutshell, regardless of some of these limitations of this paper, this paper has its significance of introducing a novel method and specifically three home-monitoring devices that take care of the senior diabetes patients with the complication of CAD and strokes and the following positive outcomes.

Moreover, it is evident from the research insights gathered that in a society that faces the challenge of a constant increase in the senior population, the use of smart devices at home for seniors, particularly home-monitoring devices for fall detection, not only benefits the seniors themselves but is also a highly economical choice. Diabetes patients with a complication of either CAD or stroke are much more likely to experience falls at home, which could result in minor injuries, but in worse cases cause significant damages that degrade the quality of life of seniors. Robust home-monitoring devices prevent such falls by analyzing past incidents; they immediately detect falls and contact the caregiver or hospitals. This decreases the likelihood of paying high costs for regular hospital visits, transportations. Along with these benefits, those also reduce the burden and anxiousness of caregivers and allow seniors to live a healthy and independent life.

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