The Review of Technology in Monitoring the Heart Health of the Elderly

Muhammad Sobri¹, Mohamad Taha Ijab², Norshita Mat Nayan², Alexander Edo Tondas³ and Fipiariny. S⁴

¹Faculty of Vocational, Universitas Bina Darma, Palembang, Indonesia
²Institute of Visual Informatics, Universiti Kebangsaan Malaysia, Selangor, Malaysia
³Department of Cardiology & Vascular Medicine, Mohammad Hoesin General Hospital, Indonesia
⁴Study Program of Accounting, Politeknik Sekayu, Sekayu, Indonesia

Abstract. This paper reviews the technology to assist the elderly in monitoring their heart health. Post-COVID19 pandemic, heart disease is back as the main cause of death among the global citizens, especially the elderly. Technology plays a big role in ensuring that elderly can monitor their heart health more easily and effectively. Among the technologies that can be used are wearable devices, mobile ECG devices, mobile applications, pacemaker implants, and IoT sensors. Some of the potentials of heart health monitoring technology include helping to monitor health independently, in real time, remotely, schedule medication intake, schedule heart rate recording, schedule light physical activity, and communicate directly with specialist doctors to discuss the status and level of their heart health. However, the potential of such technology has several challenges such as usability, affordances, cost, and trust in data confidentiality and privacy.

1. Introduction

According to the World Health Organization (WHO), chronic disease refers to any disease that lasts more than 3 months and also interferes with a person's daily life[1]. Among the examples of chronic diseases are heart disease, high blood pressure, diabetes and cancer. In general, there are three health issues that elderly people need to pay attention to, among them they need to be more aware of their health level by doing regular health screenings at clinics, government or private hospitals to detect diseases especially heart disease, diabetes and high cholesterol. Further, the elderly need to adopt a healthy lifestyle which includes giving up smoking, eating a balanced diet, getting enough rest and sleep, and engaging in spiritual or hobby pursuits.

WHO states heart disease is the leading cause of death worldwide, with an estimated 17.9 million deaths each year[2, 3]. There are several types of heart disease. According to medical experts, these include ischemic heart disease, coronary heart disease, congenital heart disease, valvular heart disease, congestive heart disease, arrhythmic heart disease, hypertensive heart disease, myocarditis heart disease, pericarditis heart disease, and endocarditis heart disease.

*Corresponding author: taha@ukm.edu.my

© The Authors, published by EDP Sciences. This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (https://creativecommons.org/licenses/by/4.0/).
disease[4]. The most deadly heart disease is ischemic heart disease, which is a condition where blood flow to the heart stops due to blocked blood vessels[5]. This causes a lack of oxygen and nutrients received by the heart which causes pain in the chest and subsequently a heart attack[6].

Ischemic heart disease is different from other heart diseases because in terms of the cause of death, it is the main cause of death while other heart diseases, although they are fatal, but treatment can still be done on the structure of the heart or on the electrical system of the heart[6]. In terms of diagnosis, ischemic heart disease is usually based on examination results such as electrocardiogram (ECG) and angiography, while other heart diseases are diagnosed with other examinations such as ultrasound. In terms of medication, ischemic heart disease is usually treated by opening blocked blood vessels or other methods to prevent the risk of blockage, while other valvular heart diseases are usually treated interventionally without major surgery on the heart valve or heart valve [7].

The current development and explosion of technology in the era of the 4th Industrial Revolution or Industrial Revolution 4.0 (IR4.0) has a great role and potential in monitoring the heart health of the elderly. Technologies such as sensors and Internet of Things (IoT) sensors can continuously monitor the heartbeat of the elderly and provide accurate data about their heart health. The use of such technology allows continuous measurement in real time of heart rate, physical activity and stress levels. This helps in the early detection of heart health problems and allows for faster and more effective treatment. Early warnings such as notifications can also be provided by technology if the elderly experience an abnormal situation in their heart health.

Data analytics technology where mobile applications are able to analyze heart health data can help seniors and doctors understand the heart health of seniors and make the best decisions for treatment purposes. Mobile heart monitoring applications make it very easy for the elderly to monitor their heart conditions anywhere and anytime. Continuous self-monitoring using technology helps seniors feel calmer and more comfortable about their heart health. Seniors can also reduce visits to the clinic or hospital to see their doctor, and can make better use of that time. Accordingly, the quality of life of the elderly who suffer from chronic diseases such as heart disease will increase.

This paper aims to review the various technologies that can be used to monitor the heart health of the elderly and challenges pertaining to the usability and affordances of the mobile applications and relevant technology. This paper begins with a brief discussion of issues of heart disease. It continues with a review of the various technologies and challenges of the technology to use monitoring the heart health of the elderly. The paper wraps with a brief conclusion and salient points for further research.

2. Review of Various Heart Health Monitoring Technologies

In this section, we will review some selected technologies that can potentially be used by the elderly to monitor their heart health. Today, there are a variety of heart health monitoring technologies that can be used by elderly. Among those technologies are (i) wearable devices, (ii) ECG mobile devices, (iii) mobile application devices, (iv) pacemaker implant, and (v) IoT sensors.
2.1 Wearable Device

Wearable devices, which can monitor heart rate and physical activity in real time, are known as online heart rate and physical activity monitors. There are several examples of wearable devices that can usually be obtained by the elderly and other users, including (a) Apple Watch, (b) Fitbit Charge, (c) Samsung Galaxy Watch, and (d) Garmin Smartwatches. The Apple Watch Series is one of the popular examples of wearable devices in the form of smart watches produced by the giant technology company, Apple. This smart watch has an integrated heart monitor and can monitor the heart rate in real time and report the data to a smartphone, especially the Apple iPhone. The 8th generation Apple Watch is the latest series launched in September 2022.

The smartwatch features a built-in app that can record and display a single-lead ECG, allowing it to be used independently without having to be paired with an iPhone. Apple's watch uses light sensor technology, can measure blood flow at certain time intervals using the principle of photoplethysmography, and to detect changes in heart rate regulation. ECG recording technology on the Apple Watch has received U.S. clearance from their Food and Drug Administration (US FDA) for the early detection of atrial fibrillation (AF) which shows that the Apple Watch has a high level of accuracy in AF detection, with a diagnostic value almost comparable to 12-lead.

Seniors are recommended to consult their doctor about the best wearable technology for them in addition to what is affordable for them, as the price of these smart watches is typically higher than RM1,000 especially for those with different brands and features. However, basic smartwatches with a heart rate sensor can be purchased for less than RM1,000 according to brands and features such as FitBit Luxe, Fossil Gen 5, Xiaomi Mi Watch, OnePlus Watch, and many more. Figure 1 shows the Apple Watch technology used to record the heartbeat.

![Fig. 1. Apple Watch Technology](image)

2.2 ECG Mobile Devices

A portable ECG device can perform an online heart examination and monitor the heart rate in real-time. ECG stands for Electrocardiogram which is a simple test that can be used to check the heart rhythm and electrical activity of the heart. Sensors attached to the skin are used to detect the electrical signals produced by the heart each time it beats. These signals are recorded by a machine and checked by a doctor to see if they are abnormal or normal. An ECG test can be carried out by a specially trained healthcare professional in a hospital or clinic. However, there are also portable ECGs that can be used by the elderly.

Examples of portable ECG devices are AliveCorKardiaMobile, Withings BPM Core, iHealth ECG Monitor, and Omron EVOLV. All of these portable ECG devices are capable of monitoring the heart rate of seniors and reporting the data to their smartphones. Seniors are advised to talk to their doctor about a suitable portable ECG device so that their heart health can be monitored more effectively[8]. Figure 2 shows AliveCord paired with KardiaMobile.
Mobile applications are software developed for use in mobile devices such as smartphones and tablets. The application installed in this smartphone is given the affordances for heart patients to perform self-monitoring of their heart health condition easily due to the small size of the smartphone device and easy to carry anywhere, and can be used at any time. Among the features that must be present in a heart health monitoring application are: (i) providing information and data about heart health in real time, (ii) helping the elderly to monitor and monitor their heart health easily, (iii) making it easier for the elderly to talk and communicate with their doctors quickly, (iv) help make diagnosis and treatment faster and more accurate, and (v) improve the quality of life of the elderly by enabling them to control and care for their heart health more effectively[8, 9].

Examples of heart health monitoring mobile apps include Cardiogram, MyFitnessPal, Heart Rate Plus, HeartMapp, and HeartM. Cardiograms for example are used to monitor heart rate and understand their heart health history [11]. Research at the Institute of Visual Informatics, Universiti Kebangsaan Malaysia (IVI, UKM) has developed a mobile heart health application that has technological affordances, medical affordances and social affordances called HeartM. For now, it is being used on a trial basis among elderly heart patients and their doctors at several hospitals in Palembang, Indonesia.

HeartM was developed with the ability for heart patients to record their heartbeat using a smartphone camera, record physical activity such as walking with a specific goal such as 1,000 steps a day, record medication intake and reminders, and communicate with doctors directly through the HeartM application. More interestingly, HeartM is designed with interface display settings in Bahasa Indonesia for the needs of elderly people who have difficulty understanding English as in other commercial heart health mobile applications which mostly provided in English. It is also provided for free making HeartM accessible to everyone[12]. Figure 3 shows some selected interfaces of HeartM.
2.4 Pacemaker Implant

Pacemaker implant is a small device that is placed in the heart patient's body either permanently or temporarily. A pacemaker aims to correct heart rhythm problems such as a heartbeat that is too slow or too fast. There are several types of pacemakers, including: single chamber pacemaker; double chamber pacemaker; and biventricular pacemaker[13]. In the context of monitoring the heart health of the elderly, implanting can mean implanting a pacemaker or heart sensor. This implant can monitor the heartbeat and give signals when there are problems such as arrhythmia.

However, the installation of the implant requires surgical treatment and can carry the risk of side effects such as infection near the site where the device is implanted in the heart; swelling, bruising or bleeding at the pacemaker site; and damage to blood vessels or nerves near the pacemaker[14]. Elderly people who wear a pacemaker usually need regular check-ups by a doctor to ensure that the device is working properly and to monitor their heart health more effectively. Figure 4 shows an example of a pacemaker.

2.5 IoT Sensors

For most of the technologies discussed above, especially for wearable devices, mobile ECG devices and mobile applications require the support of other technologies called sensors. When these sensors have the ability to connect with other sensors or to transfer data to other devices via the Internet, it is called the Internet of Things, or IoT. The data collected by the sensors is stored in the device itself or in cloud storage, and can be analyzed to determine risk and monitor the development of heart health. These IoT sensors help doctors diagnose and treat patients more quickly and accurately. A heart rate sensor is an ECG, especially a portable ECG.
Wearable devices such as smart watches have many embedded sensors including an ECG sensor, an oximeter sensor to measure oxygen saturation in the blood, a body temperature sensor, a heart rate monitor sensor, and an electrodermal activity sensor to measure the electrical impedance of the skin that can be used to detect sweat glands. This information can detect whether the elderly suffer from injury or pain. The smart watch also has a pedometer sensor that detects vibrations due to the user's feet which is then converted into an electrical signal. This signal tracks and records the steps taken by the user and this data can be used to calculate distance and total steps traveled and calories burned.

A study by[15] proposed the application of mobile IoT technology for early monitoring and detection of heart failure for health services widely, especially for heart health. This application system monitors and detects clinical and psychological signs such as ECG, tests heart failure symptoms, and implements a heart disease-related questionnaire system so that relevant factors can be used as supportive indicators of definite or uncertain heart disease. Figure5 shows example of IoT sensors for monitoring heart condition.

![Fig. 5 Example of IoT Sensors](image)

### 3 Challenges and Research Directions

In order to increase the use of technology to monitor the heart health of the elderly, there are several challenges that need to be overcome and future research needs to have a clear direction towards the usability and capability of the technology. Usability (usability) is the quality of the application that determines how easy or difficult it is for users to use and interact with the application or technology. In the context of cardiac health monitoring applications for the elderly, usability is important because the application needs to be easy to understand and use by elderly people with different experiences and skills in technology. Affordance refers to a person's ability to use an application or technology efficiently, effectively and satisfactorily[16–19].

To improve the usability of heart health monitoring technology, technology and application developers need to ensure that user studies such as user-centered design approaches are used[20], testing is done repeatedly with users to ensure that the application works as expected, and training and technical support is provided to users so that they understand and use the application correctly[21].

Additionally, in order to improve usability, the following steps should also be taken into account, namely (i) ensuring an intuitive, simple and user-friendly interface, (ii) the ability to measure and monitor blood pressure, heart rate and so on, (iii) the ability to save historical data and display long-term heart health trends, (iv) the ability to make heart health notes and reports to discuss with the doctor, (v) the ability to create and give reminders and take action to ensure good heart health, (vi) the ability to discuss and connect with the doctor easily, (vii)
the ability to save and download heart health data, (viii) the ability to synchronize the smartphone with other heart health monitoring equipment such as a portable ECG, (ix) the ability to record and warn the intake of scheduled medication, and (x) the ability to measure and monitor physical activity [18–21].

There are also other challenges such as accuracy and reliability of data where accurate and reliable data is very important to ensure the effectiveness of the technology used. In addition, the accessibility of the use of heart health monitoring equipment and technology by the elderly who may be less educated, less skilled in using technology or lack digital literacy. The cost and price aspect of the technology is also a challenge, especially for devices that are expensive and difficult to obtain in the local market.

4. Conclusion

In conclusion, there are many technologies that can be used by seniors with heart-related diseases to monitor their health independently. Some of the following steps can be taken to increase the acceptance of the elderly towards heart health monitoring technologies such as (i) an easy-to-understand explanation of the benefits and advantages of the application and heart health monitoring technology by health experts, (ii) training and assistance for the elderly to use the application, (iii) the addition of features that facilitate and meet special needs or can be customized according to individual needs, and (iv) guarantee the privacy and security of health data. With this high level of acceptance, the role and potential of technology in monitoring the heart health of the elderly can be realized in order to ensure better health for the elderly by ensuring their welfare is maintained while they continue to be able to contribute towards a more compassionate and civilized society.

Acknowledgements

The main researcher thanked Universitas Bina Darma for providing grant funding to conduct this research.

References


M. Clinic, “Pacemaker,” https://www.mayoclinic.org/testsprocedures/pacemaker/about/pac-20384689 (2023)
