Management of Artificial Intelligence Enabled Smart Wearable Devices for Early Diagnosis and Continuous Monitoring of CVDS

Mounir M. El Khatib, Gouher Ahmed

Abstract; Cardiovascular diseases are often sudden and deadly. Every year, world over, there are millions of CVD deaths, not due to timely detection and treatment and continuous monitoring of patient situations. In the medical field, Artificial intelligence enabled/driven wearable devices are a new, and welcome development. This study is addressed to the cure and management of CVDs for timely diagnosis detection, treatment and monitoring CVDs. It is found that the wearable devices are effective means of meeting the challenges of CVDs. However, it is a just picking up technology, which needs to be generally known and cost effective, for which certain suggestions are made such as solar powered batteries in the device for their ever fully working capability.

Keywords: Pervasive health, wearable devices, health informatics

I. INTRODUCTION

Cardiovascular diseases (CVD), which are heart diseases, are among the deadly diseases. For example, in 2016, 17.9 million deaths representing 31% of all the global deaths were found due to CVDs (WHO, 2017). Medical science is making rapid and advances to meet these problem, such as computer aided diagnosis, early detection and treatment of acute Chronic Neuro-Immune Diseases (CNDs), associated with loose joints, deformity chest unusual facial appearance, and depression and mental disorders or ill-health. Artificial Intelligence (AI) and wearable medical (CVDs) devices are significant (AI) advances in the diseases treatment field.

It would be an interesting exercise to examine the use of Artificial Intelligence and CVDs in the timely detection and treatment of the CVDs, nearly costing so many human lives, globally, especially the underdeveloped and developing countries like the UAE, which is a medical hub of the Middle East and even North Africa (MENA), (Alzoubi & Ahmed, 2019); Amponsah & Ahmed, (2017), El Khatib, Al-Nakeeb, & Ahmed (2019), Ahmed (2018). The state is up-to-date in the use of new medical technologies and devices **(**Ahmed, Al Amiri & Khan, 2018). And, as far as CVDs? CNDs are concerned, they strike at any time and place quite un-anonymous and any warning signals. So, first, to the study's Aim and Objectives.

A. Aims and Objectives

The overall aim of the study is to examine the impact of smart wearable devices in early diagnosis, as well as continuous monitoring of the cardiovascular diseases (CVDs), with the following objectives.

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(1) to analyze the effects of adopting the wearable devices technology on the patient's health with heart diseases and their impacts on the lifestyle of the patients is (2) to gain an understanding on the influence of wearable devices technology on cardiovascular diseases patients (3) to analyze the effect of advanced methods of artificial intelligence in enhancing the speed and accuracy of the wearable devices, (4) to address the challenges of smart wearable devices in the future that needs to be tackled.

II. LITERATURE REVIEW

A. Effects of wearable devices in monitoring cardiovascular diseases

Two (2) persons in every 6 people above the age of 60 are found to be the victims of cardiovascular diseases (Castelli, 1984). In 2010, CAD (Coronary Artery Disease) was held as the major cause for the increase in death rates in Europe and the rest of the world, and CAD accounted for 64% of all cardiovascular deaths (Tardif, 2010). In the USA, i.e. one in every nine deaths is due to CAD (Otoom *et al.* 2015). According to Boursalie, Samavi & Doyle (2015), general death rate has increased through the occurrence of various diseases, such as CVD, and CVD directly linked to the aging population and obesity. The death rates are also increasing owing to the inefficiency of the health system as well as the lack of awareness of health and illness among the populace.

However, according to Appelboom et al. (2014), among others the wearable devices help the doctors on being better informed and take decisions wisely when it comes to treat hypertension, the root cause of the CVDs. Through the use of smart devices, doctors can diagnose the elements of the diseases, if needed. Most importantly, it can be possible for doctors to provide better care and conduct the needed tests through improved diagnostics. Doctors can demonstrate faster reactions to diseases through using wearable devices. They are used for identifying causes of diseases and most importantly, they can help in fixing up health issues. Also, with the wearable technology, same self-monitoring of CVDs conditions is possible, which greatly cases tensions of CVDs and greatly facilities their treatment.

B. Influence of wearable devices

In the context of cardiovascular diseases, the latest technology has introduced wearable devices to detect the level of the disease. Kakria, Tripathi & Kitipawang (2015) state that wearable devices are capable of monitoring as well as recording real-time information about the motion activities.

The technology used in wearable devices hold sensor based health-monitoring system that includes different flexible sensors. Theses sensors have the capability to measure physiological signs such as heart rate, electrocardiogram, body temperature, blood pressure, arterial oxygen saturation, and respiration rate. As a result, the wearable devices create impact on the cardiovascular diseases patient by reducing the chances of readmitting to the hospitals with congestive failure of heart as well as lower down the mortality of patients with the help of implanted cardiac rhythm devices. In this context, it is pointed out that a man had been able to save his life by using features of the Apple Watch. This device has been proved as utilitarian in providing alerts to the man in case his heart rose to an unusual level (Shortsleeve, 2018). As opined by Otoom *et al.* (2015), wearable sensor mobile technologies and machine learning techniques can be ensuring effective diagnosis and at the same time, heart disease can be monitored in an effective and efficient manner. In the developing continents like Africa, wearable devices are used for remote monitoring and real time identification of instability in heart. In rural areas, the use of these devices is useful in terms of continuous remote monitoring and initial analysis and identification of heart disease. Based on identification, it is possible to take primitive measures for reducing the intensity of diseases.

Older people in Canada are accepting wearable health devices and they are using them for monitoring physical activities. In this way, they support their healthy lifestyle. The Canadian are said to be enriched with a high level of experience through smart wearable devices (Puri, 2017). As per Weng (2016), wearable devices match the desire of consumers and expectations. In addition, they cast influence upon behavioral intention for using wearable devices. Perceived ease of use and perceived usefulness influences the use of behavioral intention, which can lead to actual use.

C. Impact of artificial intelligence upon the wearable devices

In this age of artificial intelligence, according to Andreu-Perez et al. (2015), AI technology has designed these wearable devices as fitness bands as well as intelligence platforms to track down the motion activities, pulse rates, and heart rate. The impact of artificial intelligence on wearable devices brings out the fact that smart technology is installed to design the devices that detect intelligence to body language as well as movements. The speed and accuracy levels of the devices are set to give the perfect measurements of physical reaction, heart rates, and energy level to detect cardiovascular diseases. As opined by Boursalie, Samavi & Doyle (2015), the speed and accuracy of wearable devices have contributed to maintaining efficiency in the health service delivery system. Through the monitoring technology, it has come possible to record large amounts of physiological data. Mobile phones are shown to have computational power so that MLAs (Machine Learning Algorithms) can be supported. Machine Learning Algorithms are used for analyzing psychological data for monitoring CVDs (Boursalie, Samavi & Doyle, 2015). HeartToGo device is used for data acquisition and classification of ECG signals. HeartToGo is a mobile phone that plays a vital role in performing the process of data acquisition along with extraction and classification of ECG signals (Oresko *et al.* 2010). CVD monitoring system has been improved through amplifying monitored input data. Smartest and AMON are used as wearable devices for signal and data acquisition. As far as accuracy and speed of Smartest is concerned, it can be said that it is solely an acquisition device. On the other hand, AMON has gone beyond the acquisition of data, as it has been playing an important role in providing assistance to physicians through the display of abnormal recordings (Chan *et al.* 2012). AMON displays limited data interpretation too but it is not considered effective in psychological readings and it does not focus upon the integration of clinical database information. According to Miyashita & Brady (2019), the biggest promise of artificial intelligence is to find the accurate predictions at near-zero marginal cost—has rightly generated substantial interest in applying AI to nearly every area of healthcare.

D. Challenges and improvements

Battery technologies and energy scavenging: In the case of wearable devices, the most common challenge witnessed is the battery and energy drainage due to constant use. Therefore, it is a serious concern to improve the reliability, security, and efficiency of the wearable devices through energy scavenging (Tuna & Gungor, 2015). A suggestion is adopting solar energy or kinetic energy or wind energy to easily and efficiency power the smart devices. As a result, these energies generating methods aim to extend the battery lifetime of the nodes instead of replacing them. There are various examples of clean energy that can be used, such as solar energy, geothermal energy and hydropower. Wearable technology is used in the healthcare sector under different forms, such as small banks, which are used for recording and monitoring physical activities. However, over-use of these technologies can create issues with respect to the reduction of battery life, which in turn can affect efficiency of smart wearable devices. Runtastic, Wahoo and Fitness are regarded as the examples of smart bank applications in healthcare (Otoom *et al.* 2015).

Security of private information: In recent time, wearable devices have experienced security and privacy risks, which aim to hack the hospital network as well as patient's health records to use for illegal purposes. So, it is recommended that the wearable manufacturer to pay attention to the management of the devices' design with a trusted supply chain (Tunnell et al. 2017). It is also advised that the patients should not reveal the data to any service provider.

However, privacy is given attention for setting up devices and applications (Weng, 2016; Golembiewski, 2019) have proposed an encryption technique for the ECG segments that are transmitted to the cardiologist and the hospital database from the patient wearable device in order to avoid this confidential information according to the wrong hands. The proposed system is considered strong and computationally less expensive compared to other algorithms like permutation cipher (Sufi et al., 2011).

The concerned challenges affect the efficiency of wearable devices. Through constant use of battery, efficiency of wearable devices is decreased. On the other hand, security and privacy related issues can result in leaking of confidential information. It is therefore essential to choose features on the basis of requirements related to

wearable biosensor systems. It is important to ensure reasonable consumption of energy and multiple parameters are to be measured for creating efficiency in the system. In addition, intelligent algorithms are needed to be incorporated for featuring extraction and decision support (Pantelopoulos & Bourbakis, 2010).

It is, therefore intended in this study to practically test efficiency of Artificial Intelligence empowered CVDs in the timely diagnosis, detection treatment and its monitoring of CVDs with the help of live data.

III. METHODOLOGY

The purpose of the study brings finding the efficacy and effect of AI enabled wearable device in the timely diagnosis, detection and treatment of the cardiovascular diseases, recourse was taken to finding information on this from CVD patients and Doctors, the two most authentic sources of information.

From the respondent doctors (5) who had a long-standing experience in the field of CVDs and had their CVDs data was collected concerning on the subject of the study the method of interview was adopted to elicit information on various aspects, of CVDs. The Doctors are of very knowledgeable and reliable sources in the case. The other party or patrons to the problem are patients, who need to have the satisfaction of the CVD wearable devices (WDs). Interview method was adopted to get data on the various wearable devices.

The data collected focused on finding responses to the research questions highlighted in this research, in terms of the effect of wearable devices for early diagnosis and continuous monitoring of cardiovascular diseases devices in monitoring cardiovascular diseases, influence of wearable devices technology on cardiovascular disease patients, impact of artificial intelligence on the wearable devices' speed and accuracy as well as the challenges and improvement opportunities in areas like, battery technologies and energy scavenging and security of private information. Also, with Cardiologists who were selected based on certain criteria, like knowledge and experience of using the devices on patients, the number of patients who have had experience with the devices, the challenges faced by both parties-patients and the Cardiologists/Internists.

Direct questions and answers or interview method was adopted by the researchers to get hold of the relevant data from the respondent doctors. Moreover, researchers ensured that relevant questions were addressed to interviewees to understand the wearable devices, their application, and the level of patient acceptance / rejection towards the devices, and any challenges and experiences they have faced with the devices. This approach is adopted more in healthcare research topics in order to help define areas that need further exploration; similarly, consist of key questions that allow both the interviewer and interviewee – to convey ideas/ responses thoroughly.

IV. DATA ANALYSIS AND FINDINGS

It is yet a catching up technology among the doctors and patients, the economics of which needs to be favorable to both doctors and patients. The economics of the Artificial Intelligence- wearable devices technology is not clear (Kalautari, 2017).

Technology: The interviews revealed that technology could provide the doctors with the necessary data all the time about the condition of their patients which will result in providing the needed care at the right time. As a result, saving lives of people by tracking their condition and knowing their location by using this technology is one of the main advantages of wearable devices. This is done by sending an alert in case of any risky situation. However, there is some concern regarding the cost, security and whether it will integrate with the health reports of the patients.

Prior Experience: In addition to having knowledge on the wearable devices concept, one of the cardiologists uses wearable devices in reading and monitoring the life of people. Across their field of work, many devices were established to monitor cardiac reading and each year an increase in the progress of accuracy of the reading is shown. But, even then, patients should visit the clinic to do other tests that will confirm their situation.

Ease of use: Using wearable devices helps patients in giving the necessary care at home by tracking their health and give the doctors a better understanding about the patients' status. However, any device has some limitations, especially in the acceptance of patients in using these devices which may result in stressing them and getting many emotional thoughts.

Accuracy & speed: The interviewee (s) commented on the accuracy and the speed of wearable devices and stated that they have been enhanced and improved upon due to the improvements in the existing sensors that help in giving an accurate reading.

Privacy concern: Privacy concern is a challenge in using wearable devices because the gathered data is stored locally at the hospital server which are provided by the company. As patients integrate more of their lives into the digital space with new intelligence-amplifying devices, there is a need to consider and address issues of data transparency, privacy, and autonomy. Furthermore, more security measures should be established to avoid revealing of confidential information to the wrong party.

Battery & energy: The doctors revealed that battery life affects the result of the reading and proper maintenance steps should be adopted. However, not all the patients are aware of doing this which places a big challenge on the vendors to improve this issue in the future by, as, for example, making these devices work with the solar energy system.

Future improvement: Introducing artificial intelligence algorithms and technology helps in predicting the diagnosis of patients if they face any emotional status. Furthermore, this will add value to these devices.

V. DISCUSSION

Medical wearable devices establish a quantitative way of assessing patient's health by tracking their status while they are away from the hospital. Gathering such data may reduce the percentage of mortality of people. Moreover, it may reduce the duration of the treatment required in the therapy, which will result in improving the quality of a patient's life. The doctors revealed their positive practice results upon using wearable devices by encouraging patients to use these devices. Moreover,

using wearable devices will move the patients into a more preventative healthcare model that will give the public the capability to play a more energetic role in personal health management by shifting healthcare from the hospitals to the homes.

The analysis shows several interesting findings regarding further improvement in wearable devices. An area of growing interest has been indicated in the field of wearable technology by introducing artificial intelligence. For, artificial intelligence play's a critical role in developing these devices and make them effective and efficient by adding wearable sensors and systems to achieve early detection of change in a patient's situation, which may require clinical intervention, especially with cardiovascular disease which require tracking the hearts rate of the patients all the time to prevent any risk that may happen to them. Furthermore, establishing artificial intelligence will create smart wearable devices that will make the device favorable and acceptable to be used by a different slice of people.

Although wearable devices show effective work, several limitations and challenges are presented. The first challenge is the acceptance of all the prospective users such as patients, researchers and doctors. Young person's show more acceptances to use wearable devices than old people. Also, doctors show an interest of using those devices on their patients and they are trusting the data gathered by them. Another challenge is faced by the battery life of the devices, which need to be maintained from time to time. This can be improved in further research by applying long-term sustainable energy such as solar energy, which will solve this problem and may lower the consumption cost. Another challenge is related to the security and the privacy of using wearable devices which should be managed carefully to avoid any spread of data. This can be done by assuring privacy and confidentiality for the patients, so they can stay confortable while using wearable devices.

Overall, wearable devices are becoming popular in various fields due to their positive impact in long-term health monitoring. However, no efficient solutions have been proposed for the challenges faced by these technological devices, which might be realized in further research.

VI. CONCLUSION

The study was intended to find out the efficacy of smart wearable devices in the timely diagnosis, detailed, treatment and monitoring of cardiovascular diseases, causing millions of yearly deaths in the world, with the help of expert doctors in the field. It is found out that was in CVDs are picking up due to their proven efficacy. They, however, need to become a general knowledge, their economics need to be worked out, and also their effective management. There are challenging or problems associated with the devices, such as costs, general acceptance, effective management, privacy, etc. which are to be effectively met with.

In sum, the study finds a new and effective medical hope in wearable Cardio Vascular devices for the present and prospective patients of CVDs and on exciting developments in the medical field.

Limitations: It is mostly a doctor-side study of the problem, with no patient representation. But, it is the patients who should find satisfaction with the new cardio vascular technology. In future and further research of the problem, both doctor and patient's sides should be taken into account. The study is with reference to the UAE wherein too different segments of the population, and public and private hospitals need to be considered.

REFERENCES

1. Ahmed, G., Al Amiri, N. Khan, W. (2018) "Outward Medical Tourism: A Case of UAE", *Theoretical Economics Letters*, 8 (7) 1368-1390.
2. Ahmed, G. (2018) "Transforming the UAE from Desert to Developed Economy" *Forbes Middle East*, April, No. 70, p.29.
3. Alzoubi, H. & Ahmed, G. (2019) "Do TQM Practices Improve Organisational Success? A Case Study of Electronics Industry in the UAE" *International Journal of Economics and Business Research*, 17 (4), 459-472.
4. Amponsah, C. & Ahmed, G. (2018) "New Global Dimensions of Business Excellence" *International Journal of Business Excellence*, 13 (1), 60-78.
5. Andreu-Perez, J., Leff, D. R., Ip, H. M., & Yang, G-Z. (2015). "From wearable sensors to smart implants--towards pervasive and personalized healthcare". *IEEE Transactions on Biomedical Engineering*, *62*(12), 2750-2762.
6. Appelboom, G., Camacho, E., Abraham, M. E., Bruce, S. S., Dumont, E. L., Zacharia, B. E., ... & Connolly Jr, E. S. (2014). "Smart wearable body sensors for patient self-assessment and monitoring". *Archives of Public Health*, 72 (28) 1-9.
7. https://doi.org/10.1186/2049-3258-72-28
8. Boursalie, O., Samavi, R., & Doyle, T. E. (2015). "M4CVD: Mobile machine learning model for monitoring cardiovascular disease". *Procedia Computer Science*, 63, 384-391.
9. Castelli, W. P. (1984). Epidemiology of coronary heart disease: the Framingham study. *The American Journal of Medicine*, *76*(2), 4-12.
10. Chan, M., Estève, D., Fourniols, J. Y., Escriba, C., & Campo, E. (2012). Smart wearable systems: Current status and future challenges. *Artificial intelligence in medicine*, *56*(3), 137-156. doi: 10.1016/j.artmed.2012.09.003
11. El Khatib, M. Al-Nakeeb, A. & Ahmed, G. (2019) "Integration of Cloud Computing with Artificial Intelligence and Its Impact on Telecom Sector-A Case Study" *iBusiness* 11 (1), 1-10.
12. Golembiewski, L. (2019) How Wearable AI Will Amplify Human Intelligence, *Harvard Business Review*, April 30, 1-5.
13. Kakria, P., Tripathi, N. K., & Kitipawang, P. (2015). A real-time health monitoring system for remote cardiac patients using smartphone and wearable sensors. *International journal of telemedicine and applications*, Vol. 2015 (Article ID 373474), pp. 1-11. http://dx.doi.org/10.1155/2015/373474
14. Miyashita, M. & Brady, M. (2019) "The Health Care Benefits of Combining Wearables and AI" *Harvard Business Review*, May 29, 1-5.
15. Oresko, J. J., Jin, Z., Cheng, J., Huang, S., Sun, Y., Duschl, H., & Cheng, A. C. (2010). A wearable smartphone-based platform for real-time cardiovascular disease detection via electrocardiogram processing. *IEEE Transactions on Information Technology in Biomedicine*, 14(3), 734-740.
16. Otoom, A. F., Abdallah, E. E., Kilani, Y., Kefaye, A., & Ashour, M. (2015). Effective diagnosis and monitoring of heart disease. *heart*, *International Journal of Software Engineering* 9(1), 143-156.
17. Pantelopoulos, A., & Bourbakis, N. G. (2010). A survey on wearable sensor-based systems for health monitoring and prognosis. *IEEE Transactions on Systems, Man, and Cybernetics, Part C (Applications and Reviews)*, 40(1), 1-12. DOI: 10.1109/TSMCC.2009.2032660
18. Puri, A. (2017). *Acceptance and Usage of Smart Wearable Devices in Canadian Older Adults* (Master's thesis, University of Waterloo). Retrieved on 31 August, 2019 from https://uwspace.uwaterloo.ca/handle/10012/11861

19. Shortsleeve, C. (2018). This Apple Watch Feature Helped Save a Man's Life. Men's Journal. Retrieved 31 August, 2019 from https://www.mensjournal.com/health-fitness/how-this-apple-watch-feature-saved-a-mans-life/
20. Sufi, F., Han, F., Khalil, I. and Hu, J., (2011). "A chaos-based encryption technique to protect ECG packets for time critical telecardiology applications". *Security and Communication Networks*, 4(5), pp.515-524. **https://doi.org/10.1002/sec.226**
21. Tuna, G., & Gungor, V. C. (2015) "Energy harvesting and battery technologies for powering wireless sensor networks". In *Industrial Wireless Sensor Networks* Budampati, R. & Kolavennu, S. (eds.) Woodhead Publishing Series in Electronics & Optical Materials, pp. 25-38. DOI: 10.1016/B978-1-78242-230-3.00002-7
22. Tunnell, C. D., Mitchell, J., Pereira, G., & Zurasky, J. (2017). *U.S. Patent Application No. 15/252,468*. Retrieved from https://patentimages.storage.googleapis.com/f2/74/67/9b364b493448d7/US20170132613A1.pdf
23. Weng, M. (2016). "The acceptance of wearable devices for personal healthcare in China", *Master's Thesis* Submitted to University of Oulu, Finland.
24. World Health Organization (WHO) (2017). *Cardiovascular diseases (CVDs)*, World Health Organization. Retrieved on 31 August 2019 from https://www.who.int/en/news-room/fact-sheets/detail/cardiovascular-diseases-(cvds)

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