_____

Role of a 24-hour Ambulatory Internet of Things System in Preeclampsia Monitoring: Technologies, Challenges, and Future Path Survey

Faith Mueni Musyoka
Department of Computing and Information Technology
University of Embu
Embu, Kenya
mueni.faith@embuni.ac.ke

Abstract—The Internet of Things (IoT) is a technology that integrates different sensor actuators, working together for data management towards efficient communication within the digital world. IoT has been applied in many sectors to achieve sustainable development goals. Massive devices and a huge amount of data have been the major components of the technology, which has presented new challenges. IoT has been applied in healthcare to improve several ways of managing health, including antenatal care. Worldwide, the cost of having preeclampsia monitoring has been a major concern. A 24-hour ambulatory IoT system, an integration of a smartwatch, a mobile device, and a cloud-based application, is one of the technologies used to help in preeclampsia monitoring. IoT and its functionalities have been evaluated in previous studies and assessments. However, they concentrated on its application in other areas, such as animal husbandry, and little on ambulatory care. The impact of a real-time ambulatory IoT system on preeclampsia monitoring are comprehensively and methodically examined in this paper, focusing on three categories: the challenges and its benefits in ambulatory care. The application's effects, performance, and safety have been thoroughly described. Generally, this paper explores potential initiatives of the IoT system to address existing ambulatory care issues.

Keywords-Internet of Things; ambulatory care; preeclampsia; applications of IoT; Future trends.

I. INTRODUCTION

Technological development has recently created a noticeable change in health care. Technology has been integrated into different ways to help physicians treat and diagnose illnesses. According to [1], the transformation of how health services are delivered as a result of communication, telecommunications, and informatics technology growth and development is extraordinary.

The Internet of Things (IoT) technology has recently been embraced in health care due to its wings to provide many solutions in the sector. The health IoT is a complex system involving fields such as; microelectronics systems, medical and health, and computer science, among others. It is key in illuminating people's health levels, thus improving life's worth [2]. According to [3], Three layers make up a modern IoT system: the physical layer, which gathers data, the edge computing layer, which processes the data and gets it ready to send to the cloud servers; and the application layer, which is made up of applications that use the data to offer insightful information.

With IoT, patients can be monitored from home, as several studies have proven the concept. One of the key merits of adopting this technology is its efficiency and cost-effectiveness in patient care. Through remote healthcare monitoring, patients are helped to continue living at home rather than in expensive, crowded hospitals [4]. With fewer staff members, at a lower cost, and with real-time service delivery, ambulatory care monitoring devices enable doctors to monitor crucial physiological indications.

Despite being a rewarding experience in society, being a mother is associated with poor health in particular women. Preventing and managing preeclampsia has become a top priority due to the disease's widespread prevalence [5]. Preeclampsia is one of the main factors that discreetly endangers the expectant mother's health. It is described as a condition associated with elevated blood pressure and protein in the urine that often manifests after the mother's twentieth week of pregnancy. [6]. This disorder can also affect the mother's placenta, kidney, liver, and brain. As the disease progresses, it can cause a multifactorial eclampsia state, resulting in various pathologies such as cerebral ischemia, vasogenic edema, cerebral vasoconstriction, or vasogenic edema. [7].

According to studies, blood pressure is a significant, preventable risk factor for cardiovascular disease and early mortality on a global scale. Significant decreases in mortality, morbidity rate, and healthcare expenses have been confirmed

221

due to its early detection and efficient therapy. [8]. Although curable, it remains the world's top cause of death. [9].

The contributions of this paper include a detailed review of current and recent Internet of Things-based systems on preeclampsia monitoring to show that IoT is part of ambulatory care in preeclampsia monitoring and other important physiological signs. The study is conducted to improve responsible IT practices and the benefits of the economy and SDGs. In addition, the paper examines how the IoT study has been used recently, and outlines some of the early research related to this field.

Section 2 provides a summary of some IoT ambulatory systems in preeclampsia monitoring. Section 3 discusses the IoT ambulatory systems' challenges and performance factors and addresses the implementation benefits in Section 4. The future work of IoT in ambulatory care is discussed in Section 5, and Section 6 outlines the study's conclusion.

II. IOT AMBULATORY CARE SYSTEM

Globally, every healthy child is necessary for a healthy mother; thus, maternal health care is vital. Studies have shown that at least 20% of under-five-year-old children's disease is related to maternal pregnancy complications. Moreover, [10], Infants who lost their moms while young had a tenfold increased risk of dying within two years after the mother's death.

The leading causes of maternal health conditions and mortality are hemorrhage, high blood pressure, unsafe abortions, and obstructed labor [11]. Factors such as unreachable, inaccessible, high-priced, or poor-quality care are predominantly accountable for the same.

The Ambulatory Blood Pressure Monitoring technique was initially based on semi-automated blood pressure measurements when Kain and colleagues first reported it in the 1960s [12], [13]. The newly invented devices were considered cumbersome, but as time went by with technology, they became more readily available, more compact, lighter, and less loud, and the majority were automated. The devices became more reliable than the traditional ones and could monitor for 24 hours while patients attended their usual daily activities [14].

According to [15], the Ambulatory Blood Pressure Monitoring System is vital during pregnancy for detecting white coat hypertension. Gestational hypertension can occur in 40% of pregnancies, and ABPM has been shown to more accurately predict the likelihood of proteinuric hypertension [16]. The study reported that people with preeclampsia are more likely to experience nocturnal hypertension than those with gestational hypertension.

The Internet of Things (IoT) designates a variety of technologies and research areas that enable universal connectivity through the world's physical objects [17]. Several objects have been widely applied in technology, such as RFID, sensor networks, biometrics, and nanotechnologies [18]. Based on data usage and routing capabilities, the infrastructure links and disregards the distance between virtual and physical items. These objects have enabled IoT technology to be applied in different areas, such as e-health, smart agriculture, intelligent transport, and smart home. The IoT environment is developed in tiny spaces, like our homes or offices, and bigger spaces, such as cities, university campuses, and gated communities [3]. The health sector has embraced technology as well.

According to studies, cardiovascular diseases constitute the primary cause of death for a significant portion of the global population [5], [19]; thus, the affected would require effective instruments and an intelligent platform to perform a self-assessment. It has been proven several platforms, and framework implementations have been used to monitor diseases when patients are in remote areas at their convenience. According to [19], an Arduino-Bluetooth-based system was developed, an electrocardiogram (ECG) monitoring device able to send data over Bluetooth through an Android application. The authors went further to conduct experiments to test the system's performance. With the promising results, in the next stage of their investigation, the authors suggested using the technology to study ambulatory monitoring and future personnel healthcare for Thai citizens.

The Nations' Sustainable Development Goal (SDG) aspires to lower maternal death rates worldwide to fewer than 70 per 100,000 live births. In a study [5], ambulatory blood pressure monitoring was used to manage preeclampsia around the clock. As seen in figure 1 below, the monitoring system combined a smartwatch, a smart mobile device, and a cloud-based application. An alert is sent to the doctor to initiate quick action in an emergency. Given its ease of use and low cost, the study indicated a tremendous potential for actual implementation in healthcare systems in developing nations.

In a study [20], a health application for the Internet of Things called oxygen saturation monitoring continually and non-invasively monitors a patient's blood oxygen saturation to give medical professionals information about the patient's oxygen saturation and heart rate. The human body is connected to the Internet of Things sensor, which senses and tracks the patient's heart rate and oxygen levels. From the hospital, the healthcare professional monitors the patient's data remotely. Finally, healthcare app solutions assist the medical professionals in accessing appointments, communications, and health information to make an accurate decision based on the analysis results.

_____

Moreover, [21] thoroughly assessed IoT application areas in healthcare and discovered the following. First, IoT for Rural Healthcare Monitoring and Control system uses RFID sensors to collect patient data and send it to healthcare providers via SMS to keep track of patients' progress in rural areas. Secondly, the Customized Service Model allows patients to share medical devices like IoT-based glucose meters. Thirdly, the Proteus Digital Health-created ingestible sensor uses high-volume semiconductor and pharmaceutical components to track if the patient has taken their medications according to the doctor's instructions. Lastly, the IoT-based Hearing Aids is a wearable earing device for communication and fitness management and delivers biometric data. Doppler Lab designed these hearing aids using EQ and audio effects to generate a sense for the listener.

The study utilized the EcoHealth scenario to integrate cardiovascular-focused devices, assess variables at runtime, and trigger alert messages in the event of abnormal situations [22]. The study used an oscillometric blood pressure monitor and an ECG sensor with electrodes on the patient's chest. The integration of numerous biometric sensors allowed for the connection of the sensors with the Arduino Uno open platform, and after that, the data was provided to EcoHealth. The EcoHealth web application could process the sensor data and effectively communicate it to healthcare professionals. Utilizing a mobile phone as a necessary tool means that mobile health applications still face difficulties.

A mobile-based information technology paradigm called MAMICare was developed. It is a model created in response to the shockingly high incidence of maternity and baby mortality in rural parts of Mexico, mostly caused by insufficient monitoring of pregnancy progress and a lack of a suitable alerting mechanism in case of aberrant gestation progress. [23]. MamiCare systems include mobile devices and health sensors like blood-glucose meters, stethoscopes, pulse oximeters, and ECGs (electrocardiograms) to automatically gather valid health information for monitoring pregnant women.

The following were components of the architecture's functionality: a device that enables timely, thorough input from a remote doctor while also enabling a healthcare practitioner to check on the patient; Data is shared to a centralized database in the community center for analysis while also being locally kept and used to follow up on the patient's record correctly; A risk-condition assessment tool for healthcare worker to spot circumstances that require attention. The study reported challenges of communication issues and technologies. It was concluded that the state and federal health agencies' approval determines whether the MAMICare model is adopted or rejected. Figure 2, shown below, depicts the MamiCare architecture.

Pregnant women's heart rates, blood sugar levels, oxygen levels, and fluid movement are measured based on the architecture and then locally saved in a social worker's tablet. Other doctors can access the data that the social worker shares in a central location. It implies that the social worker's data collection is defective because it needs to be locally accessible before being consolidated.
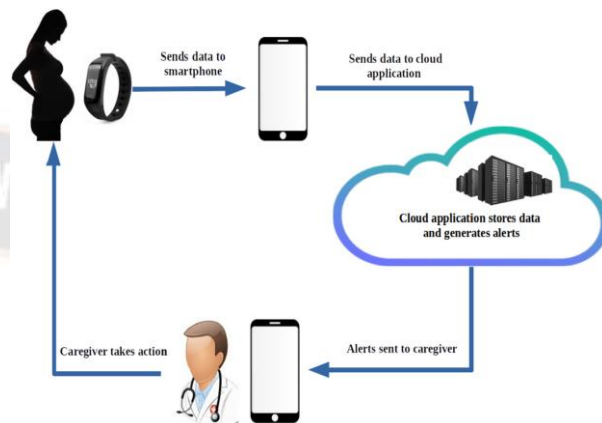

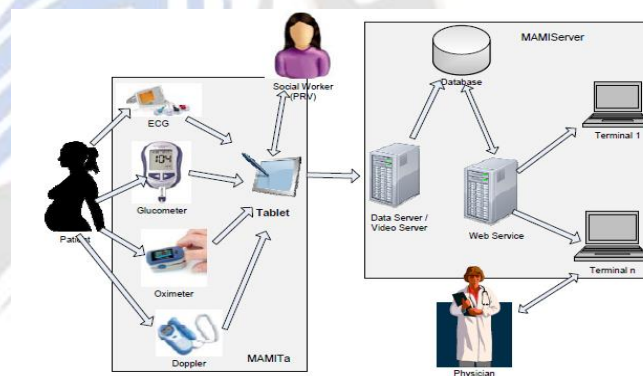Fig. 1: An Architecture for the Internet of Things-based preeclampsia management system

Figure 2: MAMICare Overall Architecture Source: [23]

III. PERFORMANCE FACTORS AND CHALLENGES OF IOT AMBULATORY CARE SYSTEM

Before becoming widely used and accepted by the public, wearable technology faced numerous difficulties, including battery life, display, privacy, and other issues [24]. While some of these difficulties disappear over time as technology advances, new issues occasionally appear. According to Joseph Dvorak, who has over ten years of expertise in the field, wearability, ease of use, attractive design, functionality, and price are the five primary factors that impact whether wearable technology is accepted by the general public [24].

A strong communication network is required since many healthcare services attempt to provide direct involvement at the point of care from a distance [25]. Another significant issue with wearable body sensors is compatibility across numerous heterogeneous devices from different vendors [26].

223

Existing wearable technologies might not be sufficient to: influence target populations' behavior and enhance data collecting for research in low-resource environments [27]. Motivation, abilities and knowledge, the environment, and a lack of social support are some of the hurdles to behavior change. In addition, the difficulty of gathering research data frequently leads to incomplete or erroneous data, leaving out women and new-borns who cannot attend facilities and data that may not accurately reflect population reality. To prevent pregnancy issues like preeclampsia, it demonstrates the necessity of focusing on the function of wearable technology.

Another study [6] on armband blood pressure device in expectant moms suggested that ongoing research on patient monitoring systems should concentrate on making systems more portable and easily accessible at reasonable costs. Moreover, innovative systems' performance might be improved by new technology. It has been established that little work has been done on wearable gadget acceptance because of compatibility and cost concerns.

Technological enhancements, such as wireless communications, low-power processors, and electronic devices, have recently made IoT a certainty. All objects globally can be identified, controllable, measurable, and analyzed over the Internet with the visualization of IoT [28]. The IoT paradigm has been widely adopted in applications from various real-world domains, including domotics, ambient assisted living, energy, transportation, and environmental and urban monitoring, revealing its potential to significantly impact people's daily lives [26]. Due to the heterogeneous devices from different manufacturers, interoperability is a big barrier when using a wearable body sensor to communicate over the internet. Using linked body sensors to connect doctors and patients, EcoHealth (Ecosystem of Health Care Devices) is a Web middleware platform that enables better patient health assessment [22].

The effectiveness of the IoT-based model for preeclampsia monitoring was assessed in a study [29]. System integration, Internet of Things, smart bands, and mobile apps were assessed. The five performance criteria used were consistency, response rate, accuracy, dependability, and output. The outcomes of the system integration were reliable, and the gadget responded quickly and accurately. The smart armband was also trustworthy, with a 5.5% minimum error rate. According to the performance metrics, the smart wristband could be utilized in hospitals without problems related to proximity or data loss/delay.

According to [26], e-health is one application domain that can be gained from IoT technology. E-health is the healthcare practice backed up by information and communications technologies for electronic medical records, prescription medicines, remote monitoring, and health knowledge transfer.

IV. BENEFITS OF IOT AMBULATORY CARE SYSTEM IN PREECLAMPSIA MONITORING

A variety of industries and businesses are adopting IoT due to its multiple benefits in its adoption. According to a study [30], ambulatory blood pressure monitoring is the best technique for determining blood pressure and ensuring the appropriate administration of antihypertensive medications. They claimed that for measuring blood pressure, the ambulatory approach is economical. It would mainly lower healthcare expenses by not treating white-coat hypertensive patients with antihypertensive medications [15].

In addition, the wearable BP monitoring device is considered comfortable for patients since it is cuffless [30]. The study reported that the device would pose a validation challenge; thus, a standardized validation protocol is needed. The IoT-based system is also beneficial because it offers reliable hand-held devices, thus facilitating communication between patients, medical devices, and doctors [31].

The ambulatory blood pressure monitoring devices provide several benefits, as adapted from [32]. The benefits include a large number of readings, reproductive 24-h, identification of white coat and masked hypertension occurrences in untreated and treated individuals, profile provision of BP behaviour in the individual's usual daily environment, assessment of BP variability over the 24-h period, and effectiveness of the antihypertensive medication. Most hospitals use inadequate and infrequently available infrastructure. Few people who live in rural areas can afford to travel there. While some conditions (such as blood pressure) necessitate round-the-clock supervision, most technology is insufficient for patient demands [33].

Continuous monitoring is also a benefit of having IoT based system. Integrating health monitoring with ubiquitous IoT-based systems could enable patients to be monitored continuously in hospitals, at home, and work [34] [33]. Wearable devices that make wireless sensor networks help give continuous BP measurements, which then send the data to a cloud-based back end for analysis by healthcare providers [35].

According to a study by [36], the Internet of Things is applied in various aspects of health care. Blood pressure is one of the most crucial physiological aspects of the human body, and IoT is being applied and connected with sensors and healthcare systems to enable safe communication between patients, physicians, and healthcare professionals. It assists in gathering real-time patient BP data for analysis by the doctor. The Rehabilitation System, which boosts functional capacities and raises the quality of life for people with disabilities, is the other area that has been reported. It lessens the issues they experience and helps older individuals who are neglected because there aren't enough health professionals. An ontology-based automated design method is connected with an IoT-based smart rehabilitation system [37]. In addition, [38] noted that one of the most beneficial industries for IoT application is healthcare, as it is used to monitor and make timely choices in life-or-death circumstances.

V. FUTURE WORK OF IOT AMBULATORY SYSTEM IN PREECLAMPSIA MONITORING

With the recently made significant strides in Internet of Things (IoT) technologies, it is promising that the technology will bring a great fourth industrial revolution and have huge benefits in the future of the digital world. According to [39], existing research is geared toward smart health tools integration in healthcare provision to establish new solutions for patients and create efficient communications between the patient and healthcare providers. With IoT in the health sector, there will be exceptional opportunities to improve treatment quality and productivity, patient well-being, and government funding [38].

Data gathering and analysis are revolutionizing personal care services as a result of the Internet of Things revolution and wearable devices in the healthcare industry, providing a new opportunity to create smart sensors [40]. The use of smart sensors for medication and treatment purposes is growing in popularity. The sensors' advantages of being non-invasive, real-time monitoring, simple to use, and point-of-care applications make them extremely important. In the future, IoT in the healthcare sector will explore new ways to manage diseases. Integrating big data analytics with IoT will lead to modern medical telematics and informatics development. More disease diagnoses, real-time health monitoring, and medical emergency services will be discovered.

VI. CONCLUSION

The Internet of Things has transformed people in the way they explore healthcare systems and services. Its adoption will improve service delivery and bring a long-term effect to the healthcare sector. IoT has greatly benefited the health sector, more so in monitoring disease 24/7. Studying the role of IoT in preeclampsia monitoring is essential. Preeclampsia being a major concern in maternal health, the expectant mothers would therefore require a 24-hour ambulatory IoT system for blood pressure monitoring. The paper discussed the technologies, challenges, and benefits of the 24-hour ambulatory IoT system in disease monitoring. This paper also addressed the future of IoT in the healthcare sector. However, there are still some challenges to the field, for instance, ensuring security and privacy in future healthcare systems. Cyber risk is a major challenge to the broad adoption of the IoT in healthcare. Other challenges include interoperability and standardization of IoT, which would form a relevant research field for future study.

REFERENCES

[1] G. Deimazar, M. Kahouei, Zamani, and Z. Ganji, 'Health information technology in ambulatory care in a developing country', Electron. Physician, vol. 10, no. 2, 2018.

[2] M. M. Dhanvijay and S. C. Patil, 'Internet of Things: A survey of enabling technologies in healthcare and its applications', Comput. Netw., vol. 153, pp. 113–131, 2019.

[3] Techahead, 'Evolution of Internet of Things (IoT): Past, present and future', 2022. https://www.techaheadcorp.com/knowledge-center/evolution-of-iot/#:~:text=The%20evolution%20of%20IoT%20started,internet%20of%20things%20was%20paved. (accessed Jul. 20, 2022).

[4] M. J. Deen, 'Information and communications technologies for elderly ubiquitous healthcare in a smart home', Pers. Ubiquitous Comput., vol. 19, no. 3, pp. 573–599, 2015.

[5] F. M. Musyoka, M. Thiga, and G. M. Muketha, 'A 24-hour ambulatory blood pressure monitoring system for preeclampsia management in antenatal care', Inform. Med. Unlocked, vol. 16, no. 100199, 2019.

[6] V. S., B. N. ., Kumar Bhagat, A. ., C., C. ., Sulaiman Alfurhood, B. ., Pratap Singh, A. ., & T. R., M. . (2023). Blockchain Based De-Duplication Analysis of Cloud Data with Data Integrity using Policy Based Encryption Technique in Cloud Storage. International Journal of Intelligent Systems and Applications in Engineering, 11(3s), 161–164. Retrieved from https://ijisae.org/index.php/IJISAE/article/view/2555

[7] H. Suhasini and V. Sudarshini, 'ARM Based Wearable Device for Blood Pressure,Weight and Temperature Measurement in Pregnant Woman', Int. J. Mag. Eng. Technol. Manag. Res., vol. 2, no. 6, pp. 231–239, 2015.

[8] M. Koofreh, M. Ekott, and D. Ekpoudom, 'The prevalence of pre-eclampsia among pregnant women in the University of Calabar Teaching Hospital', Saudi J. Health Sci., vol. 3, no. 3, pp. 133–136, 2014.

[9] R. Severin, A. Sabbahi, A. Albarrati, S. A. Phillips, and S. Arena, 'Blood pressure screening by outpatient physical therapists: a call to action and clinical recommendations', Phys. Ther., vol. 100, no. 6, pp. 1008–1019, 2020.

[10] M. H. Forouzanfar et al., 'Global burden of hypertension and systolic blood pressure of at least 110 to 115 mm Hg, 1990-2015', Jama, vol. 317, no. 2, pp. 165–182, 2017.

[11] UNICEF, 'Maternal and NewBorn Health'. UNICEF, 2016. [Online]. Available: https://www.unicef.org/health/index_maternalhealth.html

225

[12] WHO, 'Maternal Health. Wolrd Health Organization', WHO, 2017. [Online]. Available: http://who.int/maternal-health/en/

[13] H. K. Kain, A. T. Hinman, and M. Sokolow, 'Arterial blood pressure measurements with a portable recorder in hypertensive patients: I. Variability and correlation with" casual" pressures', Circulation, vol. 30, no. 6, pp. 882–892, 1964.

[14] M. Sokolow, D. Werdegar, H. K. Kain, and A. T. Hinman, 'Relationship between level of blood pressure measured casually and by portable recorders and severity of complications in essential hypertension.', Circulation, vol. 34, no. 2, pp. 279–298, 1966.

[15] T. G. Pickering, D. Shimbo, and D. Haas, 'Ambulatory blood-pressure monitoring', N. Engl. J. Med., vol. 354, no. 22, pp. 2368–2374, 2006.

[16] R. A. Sanchez, J. Boggia, E. Penaherrera, W. S. Barroso, R. Villar, and G. Parati, 'Ambulatory blood pressure monitoring over 24 h: A Latin American Society of Hypertension position paper—accessibility, clinical use and cost effectiveness of ABPM in Latin America in year 2020', J. Clin. Hypertens., vol. 22, no. 4, pp. 527–543, 2020.

[17] W. Rojo-Contreras et al., 'Circadian rhythm of blood pressure in patients with chronic hypertension and pregnancy', Ginecol. Obstet. México, vol. 82, no. 9, pp. 604–612, 2014.

[18] F. Al-Turjman, A. Kamal, Husain Rehmani, M. Radwan, A. Radwan, and A. S. Khan Pathan, 'The green internet of things (g-iot)', Wirel. Commun. Mob. Comput., 2019, [Online]. Available: doi:doi.org/ 10.1155/2019/6059343

[19] S. Park, 'A development of UHF RFID device for mobile IoT service', 2016 IEEE 7th Annu. Ubiquitous Comput. Electron. Mob. Commun. Conf. UEMCON, pp. 1–7, 2016, doi: 10.1109/UEMCON. 2016.7777830.

[20] A. Thongklang, P. Thongnawakun, T. Chanwimalueang, N. Rattanajaruskul, and D. Sueaseenak, 'An ArduinoBLE based Digital Holter for Thai Ambulatory and Personal Healthcare', 2021 IEEE 3rd Glob. Conf. Life Sci. Technol. LifeTech, pp. 522–526, Mar. 2021.

[21] L. J. R. Lopez, G. P. Aponte, and A. R. Garcia, 'Internet of things applied in healthcare based on open hardware with low-energy consumption.', Healthc. Inform. Res., vol. 25, no. 3, pp. 230–235, 2019.

[22] B. Singh, S. Bhattacharya, C. L. Chowdhary, and D. S. Jat, 'A review on internet of things and its applications in healthcare.', J. Chem. Pharm. Sci., vol. 10, no. 1, pp. 447–452, 2017.

[23] P. Maia et al., 'A Web platform for interconnecting body sensors and improving health care', Procedia Comput. Sci., vol. 40, pp. 135–142, 2014.

[24] J. Lavariega, G. Cordova, L. Gomez, and A. Avila, 'Monitoring and Assisting Maternity-Infant Care in Rural Areas (Mamicare)', Mexico, 2013, vol. 2, pp. 174–184.

[25] A. Adapa, 'Factors influencing the adoption of smart wearable devices', Missouri University of Science and Technology., 2016.

[26] A. Maitra and N. Kuntagod, 'A Novel Mobile Application to Assist Maternal Health Workers in Rural India', IEEE, vol. 5, no. 13, pp. 75–78, 2013.

[27] P. Maia et al., 'A Web platform for interconnecting body sensors and improving health care', Procedia Comput. Sci., vol. 40, pp. 135–142, 2014.

[28] Bill & Melinda Gates Foundation, 'Wearables and Technology for Maternal, Neonatal and Child Health Behavior Change (Round 19). Global Grand Challenges.', 2017. [Online]. Available:
https://gcgh.grandchallenges.org/challenge/wearables-and-technology-maternal-neonatal-and-child-health-behavior-change-round-19

[29] F. M. Musyoka, M. Thiga, and G. Muketha, 'A 24-hour ambulatory blood pressure monitoring system for preeclampsia management in antenatal care', Inform. Med. Unlocked, vol. 16, 2019, doi: 10.1016/j.imu.2019.100199.

[30] F. M. Musyoka, 'Performance Evaluation of Internet of Things Prototype for Preeclampsia Monitoring in Antenatal Care', Int. J. Eng. Adv. Technol., vol. 10, no. 2, pp. 112–115, Dec. 2020.

[31] Q. F. Huang et al., 'Ambulatory blood pressure monitoring to diagnose and manage hypertension', Hypertension, vol. 77, no. 2, pp. 254–264, 2021.

[32] Y. I. N. Yuehong, Y. Zeng, X. Chen, and Y. Fan, 'The internet of things in healthcare: An overview', J. Ind. Inf. Integr., vol. 1, pp. 3–13, 2016.

[33] G. Parati et al., 'European Society of Hypertension practice guidelines for ambulatory blood pressure monitoring', J. Hypertens., vol. 32, no. 7, pp. 1359–1366, 2014.

[34] C. Comito, D. Falcone, and A. Forestiero, 'Current trends and practices in smart health monitoring and clinical decision support.', 2020 IEEE Int. Conf. Bioinforma. Biomed. BIBM, pp. 2577–2584, Dec. 2020.

[35] A. Anzanpour et al., 'Self-awareness in remote health monitoring systems using wearable electronics', Des. Autom. Test Eur. Conf. Exhib. DATE IEEE, pp. 1056–1061, 2017.

[36] V. B. Shalini, 'Smart Health Care Monitoring System based on Internet of Things (IOT).', 2021 Int. Conf. Artif. Intell. Smart Syst. ICAIS, pp. 1449–1453, Mar. 2021.

[37] S. Neelam, 'Internet of Things in Health Care', Master of Science in Electrical Engineering: Telecommunication Systems, Blekinge Institute of Technology, Sweden, 2017.

[38] S. Islam, D. Kwak, and M. Hossain, 'The Internet of Things for Health Care: A Comprehensive Survey', IEEE, vol. 3, pp. 678–708, Jun. 2015.

[39] Z. N. Aghdam, A. M. Rahmani, and M. Hosseinzadeh, 'The role of the Internet of Things in healthcare: Future trends and challenges.', Comput. Methods Programs Biomed., vol. 199, no. 105903, 2021.

[40] H. Ahmadi, G. Arji, L. Shahmoradi, R. Safdari, M. Nilashi, and M. Alizadeh, 'The application of Internet of Things in healthcare: a systematic literature review and classification.', Univers. Access Inf. Soc., vol. 18, pp. 837–69, 2019.

[41] N. D. Hoa, 'Smart Sensors for Health Care Application: Challenges and Opportunities: Keynote Talk# 1.', in In 2020 4th International Conference on Recent Advances in Signal Processing, Telecommunications & Computing (SigTelCom), Aug. 2020.