Tanzania Journal of Engineering and Technology 2023, **42**(4):46-55
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Websites: https://ajol.org/tjet; https://tjet.udsm.ac.tz

ISSN 1821-536X (**print**); ISSN 2619-8789 (**electronic**)
https://doi.org/10.52339/tjet.v42i4.866

Review Manuscript

An Overview of Maternity healthcare Monitoring in Developing Nations

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ABSTRACT

A healthcare monitoring arrangement is essential for frequently monitoring a patient's health status. Specifically, maternal healthcare systems for tracking are utilized to evaluate the clinical status and monitor any abnormal condition changes during all three trimesters. This paper's objective is to conduct an extensive literature review and acknowledge earlier initiatives and studies conducted previously in maternal health care monitoring. This review focuses on accumulating information from earlier work and presents a general overview of previous studies concerning maternal health care monitoring (MHCM). The paper focuses on the maternal healthcare systems in developing countries accessed by pregnant women during the antenatal period. Furthermore, this paper highlights the challenges in the maternal health sector that include inadequate work conditions for health workers, home-based birth practices, long distances to healthcare facilities, and long waiting times in health facilities. The paper indicates the potential opportunities to strengthen maternal healthcare services and allow effective access to maternal healthcare facilities by pregnant women.

ARTICLE INFO

Submitted: **Jan. 10, 2023**

Revised: **Dec. 27, 2023**

Accepted: **Jan. 15, 2024**

Published: **Feb., 2024**

Keywords: *Maternity, Health Services, Hospitalization, patients, prenatal care, Care during pregnant*

INTRODUCTION

The field of health is one of the most crucial fields for saving lives in any nation. Worldwide most hospitals strive to improve their services, including treatment service, delivery systems and environment, to meet patients' expectations. As part of the service improvement initiatives, computers create and maintain access to patients' medical records.

In the healthcare field, the World Health Organization (WHO) endorse access to services for maternal healthcare, family planning and delivery services (Organization, 2005). or. Yet, to target efficient MHCM, important areas need appropriate management and quality evaluation. For example, the time it takes pregnant women to walk into a hospital and attend is the most critical factor that needs proper handling (Shija *et al*., 2011).

In Tanzania, MHCM is conducted manually, requiring pregnant women to visit the health centre monthly physically. The pregnancy health status is recorded

manually in clinic cards and scheduled for the next visit. Furthermore, it is reported that slots of time available for MHCM are not unionized in the way pregnant women can reschedule some other day if missed a clinical appointment checkup or need an urgent clinical appointment.

Moreover, when pregnant women visit the hospital, they are not assured of being seen by doctors when they are in bench queues. On a day, those doctors attend a massive number of pregnant women, as the designation is based on a day, not a time slot. When pregnant women postpone their clinical appointment, there is no mechanism for doctors to notice that patients won't show up for clinical maternal checkups.

Monitoring maternal health care was selected since it encourages distinguishing proof of information gaps and the chance that exists due to emerging technology (Mtei *et al*., 2014). It is important to follow up on maternal health (Pembe *et al*., 2010). Currently, the methodology used in maternal healthcare monitoring is manual, allowing pregnant women to attend healthcare facilities physically. Maternal healthcare monitoring for pregnancy is conducted on monthly visits to a health facility until the last trimester, where maternal monitoring is on weekly basis. During the first maternal visit, a pregnant woman is required to fill in a personal clinic card with her personal details.

This literature explores the information about diverse technology mechanisms for monitoring maternal health found from several sources. This paper discusses the finding based on 345 reviewed articles from three databases; Web of Science, PubMed/Medline, WHO Global Health Library, Popline and Google Scholar. The literature review is focused on maternal health care monitoring in Tanzania. The information collected from this literature review will be applied to design a technological solution for MHCM.

The technological solution can help maternal health care improve (Bhat *et al*., 2011). It will promote better health sector services to patients and doctors by knowing when to attend to the patient and who is responsible at what time. (Mey & Sankaranarayanan, 2013) Show that service waiting time will decrease if technology is applied to health services.

Therefore, the challenge of MHCM application of Information and Communication Technology (ICT) is inevitable. ICT is used in symptom diagnosis and offers efficiency in obtaining results quicker. ICT presently has made tremendous innovation and become accessible both in organizations and healthcare industries.

METHODS AND MATERIALS

This segment briefly clarifies the method followed for identifying related and suitable literature articles for the research work. The first part explains the aim of this literature review; the second part narrates the search process for the literature review, including database selection and search query. The final part defines the study selection procedure.

Goal of the Research

Examining the available research is the goal of the literature review, acknowledging earlier research and researching maternal health care monitoring in underdeveloped nations. The literature review focus on compiling the information obtained from previous work and presents a comprehensive overview of information attained from previous studies concerning MHCM.

Search Process

A literature review was steered in four databases. The literature search was conducted on Web of Science, WHO Global Health Library, PubMed/Medline, Popline and Google Scholar for peer-reviewed articles published up to June 31, 2022, using search terms as shown in Table 1. The search was restricted to review

papers focusing only on monitoring maternal health to meet the criteria. Review articles concentrating on manual monitoring systems were also included to comprehend the current monitoring of maternal health care services.

Table 1. Searched terms

SN	KEYWORDS	SEARCHED ITEM
1	Maternal care Health	Monitoring, Machine Learning, ICT, Patient Monitoring, Medical Sensor, Internet of Things, Remote Monitoring, Artificial Intelligence, Wearable tech Antenatal care, Prenatal care
2	Developing countries	Sub-Saharan countries, middle-income countries, lower-income countries

RESULTS AND DISCUSSION

Data search process

After literature searches in the databases, reviewed articles were further extracted into their title and abstract if they were related, and related articles were fully reviewed. Figure 2 represents the data search process. A total of 345 reviewed articles in all databases were screened. After screening for title-related, 125 articles were eliminated, 220 articles were evaluated based on their abstract-related, 98 articles were eliminated, and 77 articles could not be accessed. The final identified reviewed articles that met the criteria were 77. Key issues recognized from the reviewed articles were the information on the sensors used in the devices for capturing data and monitoring symptoms and the analyzed data was utilized to predict by machine learning techniques.

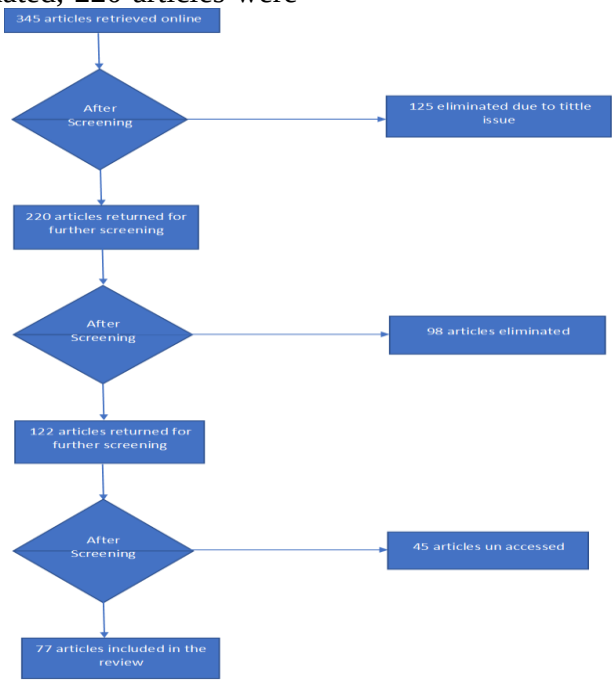

Figure 2: Data search process.

Description of sensors used in the devices for capturing data

The literature review revealed different types of sensors used to find symptoms or health data for numerous diseases. These sensors include heart rate, temperature, ECG, EEG, gyroscopes, and accelerometers. Information obtained from (Site *et al*., 2021) accelerometer sensors have been used in more than 23% of studies, gyroscopes sensors have been used in more than 10% of studies, Magnetometer

sensors have been used in more than 5% of studies, Blood glucose meter, Gait sensors have been used more than 3% of the studies, moreover pulse oximeter, temperature sensor, heart rate sensor, humidity sensor and pacemakers have been used more than 1% of the studies. Furthermore, the reviewed article proves that even smartwatches/wearables devices with built-in sensors have been used in more than 14% of the studies.

Zhao *et al*., 2019 presented an accessory system for automatically tracking of speedometers and methods for learning from machines to monitor activities of the fetus.. Ullah *et al*., 2021 propose a system for recognizing and tracking physical activity that employs embedded detectors to detect and monitor a vigorous workout throughout pregnancy. The effects of exercising during pregnancy can differ based on the level of exertion, which might whether exacerbate or alleviate health issues.

Musyoka et al., 2019, implemented an ambulating cardiovascular health for an entire day. This system comprises a timepiece featuring hosted on the internet and smartphone functions applications. When the expectant mother's blood pressure is measured, a notification is delivered to the designated caregiver to take immediate action.

Ullah e*t al*., 2021, In the context of pregnancy, provide a wearable sensor-based system for recognizing and tracking physical activity. A body-worn component, as per the advised structure, consists of sensors for temperature, an accelerometer with three axes and a three-axis gyroscope. Raspberry PI historical information is transmitted via Bluetooth Low Energy (BLE) sensors.

Roham *et al*., 2011 suggest a wireless, portable technology for non-invasively monitoring uterine contractions and fetal heart rate at the same time. A mobile cellular gateway for wide-area connectivity makes up the entire system, a wearable front-end for Doppler ultrasound and pressure sensors with short-range radio, for remote monitoring and diagnostics, a web server and browser-based user interface are required.

They provide a vital mobile a multi-communication fusion and Android OS-based indications monitoring system that enables expectant mothers to track fetal and maternal data from any location. Moreover, by sending information to the server for processing and remote diagnostics, patients have access to comprehensive care. (Lyu et al., 2013)

Tsai *et al*., 2006 proposes a tracking the fetal heart rate (FHR) and prenatal recognition of distress portable equipment. The suggested method uses machine vision techniques to gather FHR values and the use of pattern matching to analyze them. once a mobile GSM network detects fetal distress, a medical alarm will instantly alert medical professionals. A pregnant woman can monitor her baby's health state using the suggested approach, and medical professionals can promptly provide resources for treatment.

Queyam *et al*., 2018, Present a reliable bio tele monitoring of pregnant women using an intra-probe, multiple-parameter system to enable comprehensive the collection of personally identifiable information to track their health throughout pregnancy and labour. Zhang *et al*., 2018, suggest home-based fetal heartbeat monitoring and identification throughout pregnancy.

(Subalakshmi *et al*., 2018) Outlines a framework for monitoring physical variations in pregnant women. This framework can spot unforeseen events and alert the patient and doctor. The controller node (CN) is physically connected to the patient in the proposed design to collect all uterine contraction signals, and Monitoring devices sensors are tracked and sent to the access point. A network of wireless body sensors (WBSN) has sensors linked to the patient's body frame that may assess things like blood pressure, pulse rate, and uterine tightness.

Allahem & Sampalli, 2017, Propose a framework for employing sensor networks to monitor pregnant women at risk for early labour. The proposed approach tracks uterine contractions non-invasively using body-worn wireless sensor network and notifies a smartphone if the results are above or below the normal limit.

Chourasia & Tiwari, 2012 Propose a fetal tracker for electronic health utilizing smart mobile devices and wearable network to deliver cutting-edge healthcare in a home setting.

Nitulescu *et al*., 2015, Presents a framework for employing sensor networks to monitor pregnant women at risk for early labour. The suggested method uses a body-worn wireless sensor network to track uterine contractions non-invasively and alert a smartphone if the readings are above or below typical limits.

Aravind *et al*., 2017 provided a health monitoring system powered by the Internet of Things (IoT) that continuously detects body pressure with the use of a pressure measurement kit and measures a pregnant woman's heartbeat using a heartbeat sensor. Every time there are variations from the specific number, it sends the information to her doctor through a mobile.

Predictive algorithms using machine learning

Numerous automated learning techniques have been used to predict maternal health status. Supervised and unsupervised learning algorithms are examples of classification of machine learning algorithms. In reviewed articles, both supervising and unstructured, both of which have been employed for various arrangement and regression tasks.

According to Site *et al*., 2021, a supervised machine-learning algorithm, which supports vector machines, has been used in more than 43 studies to analyze various features. Neural networking has been used 41 times to analyze information extracted from different features.

Mehbodniya *et al*., 2022 used machine learning (ML) techniques that classify the medical condition as normal, needs guarantee, or pathology to forecast the maternal wellbeing from the cardiotocographic (CTG) information. Using algorithms like support vector machines and random forests, this study determines how several CTG-measured parameters affect the forecasting of the fetus's health. Yakong *et al*., 2010, K-nearest neighbours and multi-layer perceptron. Furthermore, regression analysis Additionally, the correlation and regression analyses showed how the variables affected fetal health.

Marin *et al*., 2019 employed a machine learning strategy for early preeclampsia identification and the Viterbi algorithm to identify preeclampsia.

Sharma & Sharma, 2022 suggested employing a novel upgraded binary bat algorithm to assess the health of a fetus. The suggested EBBA can be utilized to classify cardiotocography datasets into normal, suspicious, and pathologic fetal states when using the random forest classification algorithm from machine learning, and it has an efficiency of 96.21%.

Ahmed & Kashem, 2020, employed a modified decision tree algorithm for classification and risk level prediction to create great monitoring and insight into the risk a pregnant woman faces. (Hoffman *et al*., 2021) propose the development of machine learning and validate in the context of neonatal hospitalization of mothers attributed explicitly to difficulties arising from pregnancy-related hypertension issues.

Challenges of maternal healthcare service in developing countries

Maternal healthcare services have been fundamental objective of The WHO introduced the Millennium Development Objectives (MDGs) and the

Sustainable Development Goals (SDGs) main concerns, (Sachs, 2012).

The difficult working condition of health workers, especially in rural areas, affects their main responsibility of providing good care services for maternal health. Bureaucracy facilitates the unavailability of a specific strategy for health workers' development to enhance the expertise of health professionals in maternal health care issues (Mkoka *et al*., 2015).

Home-based neonatal care practised by many societies facilitates the challenge of attending maternal healthcare monitoring during pregnancy. Research conducted in the Lindi region reveals that some society allows pregnant women to move to their parents during their last trimester to deliver (Mrisho *et al*., 2008).

Long distance to maternal health facilities hinders entry to maternal services for health care, particularly in remote locations. Some pregnant women attend only the final trimester due to the distance to a health facility. According to various research, armed conflicts make maternity healthcare services less accessible and raise the rate of maternal mortality (Chukwuma & Ekhator-Mobayode, 2019). Long waiting time to be attended at a maternal health facility is a big challenge for pregnant women. Pregnant women are expected not to consume more time attending the maternal health facility. Inadequate scheduling during maternal healthcare visiting. Normally, scheduling is provided in a range of groups of time and not a slot of time for individual pregnant women.

Some pregnant women are unsatisfied with maternal healthcare services when attending clinical checkups, hence attending maternal healthcare monitoring only during the last trimesters and the first two trimesters remained unmonitored. Only pregnant women with obstetric and required emergency care are attending all three trimesters for maternal healthcare monitoring.

Opportunities to improve maternal healthcare services

Primary healthcare providers are struggling to quicken improvement towards attaining Millennium Development goals on how easily pregnant women can access maternal healthcare services during pregnancy without any difficulties (Basinga et al., 2011). Maternal healthcare service in Tanzania is free in all public health facilities, including antenatal, delivery, and family planning (Magoma *et al*., 2010; Mpembeni et al., 2007). Even pregnant women from low families access maternal healthcare monitoring for all trimesters for free in any public facility. The presence of private health institutions, which annually produce health professionals, alleviates the scarcity of healthcare personnel in the commercial and public sectors, particularly in maternal healthcare (White *et al*., 2013). Currently, the Tanzanian government has built health facilities with emergency care in practically every district to facilitate frequent visits and access to maternal healthcare services for expectant women often then get maternal healthcare services. It makes it easier for people to travel large distances to medical facilities, especially in rural areas where pregnant women with obstetric difficulties must receive specialized care in urban healthcare centres, (Ramsey *et al*., 2013).

'Men's participation in reproductive health is inevitable (Amoo et al., 2017). Suppose men are well involved during the pregnancy period. In that case, all complications that pregnant women are expected to face can be reduced as knowledge of reproductive are on both sides of the community (Vermeulen *et al*., 2016). Men are regarded as financial backers and those who make decisions about when and where women can get maternal health care and services. Pregnancy-related difficulties are seen as a woman's responsibility throughout all trimesters (August *et al*., 2016). Participation of community people in

reproductive health will make maternal health services more easily accessible (Kilonzo *et al*., 2001).

Discussion

The literature review examined the process of monitoring maternal health care in developing countries using 77 studies attained over a succession of stages. This study revealed different types of sensors that can be used to obtain health data. This review discovered that different signals could be collected from sensors, including gyroscopes, EEG/ECG, and wearables like smartwatches. The study also identified several traits that can be drawn from those signals.

The article investigates how more studies have utilized supervised and unsupervised machine learning methods for data analysis. The greatest studies use machine learning algorithms to achieve classification and prediction tasks. The study employed multiple machine learning techniques to analyze those characteristics. Several different kinds of tree-based and neural networking algorithms were used to analyze feature vectors. The outcomes attained from this literature review- and the information and knowledge gained from earlier studies will be used for emerging computerized real-time systems monitoring maternal health care. Furthermore, the review was more attentive to features like wearable/sensors essential in designing real-time monitoring systems for maternal health care.

CONCLUSION AND RECOMMENDATION

A review of previously published research revealed a critical need to enhance maternal healthcare monitoring. Some obstacles make it more difficult for pregnant women to get maternal health treatments, such as when they are women with impairments who lack adequate transportation (Ganle *et al., 2016)*. Most of them are expected to have lower access to education and social and economic issues than those without disabilities (Hosseinpoor *et al*., 2013). Moreover, during the covid 19, there were movement restrictions and accessing maternal health services was difficult and very challenging (Nguyen *et al*., 2022; Pant *et al*., 2020)

All women should have equal access to maternal health services, yet there are differences between rural and urban women in terms of attending and using these services (Yakong *et al*., 2010). Other articles advise that maternal health services need to be increased in areas where maternal services are limited and accessibility is difficult (Elmusharaf et al., 2015). When better services are provided, the focus is on how satisfied women are with their capacity to access maternity care. (Srivastava *et al*., 2015). The attitude and behaviour of caregivers during pregnancy can be taken concerning women when the accessibility of maternal care services is conducted smoothly and appreciated by women who attend the services (Ajayi, 2019). It can be used to evaluate how satisfied pregnant women are with the treatment they receive from maternal health care providers. (Camacho et al., 2012); in turn, will assist hospital administrators in stepping up efforts to provide maternal healthcare services, especially to pregnant women who need special care throughout pregnancy (Özkan *et al*., 2020). The continuum of care enables women and maternal health care professionals to interact more effectively. (Macpherson *et al*., 2016).

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