A Review on Internet of Medical Things (IoMT): A Case Study for Preeclampsia

Hadiyanto, Sukamto, Suryono, Kurnianingsih

Abstract. Preeclampsia detection research has started exploring some methods to diagnose and predict preeclampsia. Machine learning (ML) methods and the Internet of Things (IoT) have been successfully implemented in medical research to improve the diagnosis and prevention of complex diseases and syndromes. The goal of this work is to undertake a review of the most recent work on preeclampsia detection. The research focused on articles related to the keywords 'machine learning, 'Internet of Things, 'IoT', 'medical', and preeclampsia in five main databases, namely IEEEXplore, ScienceDirect, SpringerLink, ResearchGate, and ACM Digital Library, etc. We selected and reviewed 90 articles in the end. The final discussion highlights research gaps that remain to be investigated in the cognitive approach to IoT. The study found that preeclampsia detection based on the Internet of Medical things (IoMT) was not found, so it became a big opportunity to develop this research in the future.

1 Introduction

Preeclampsia, classically defined as proteinuric gestational hypertension [1], is characterized by hypertension and organ disorders caused by pregnancy or affected by the current pregnancy. However, preeclampsia can occur even without symptoms of high blood pressure and the presence of protein in the urine, hypertension is the main cause of maternal death [2]. When the disorder advances cause seizures, which is a condition known as eclampsia [3]. Until now, preeclampsia is to be one of the leading causes of maternal death, so professionals must know how to deal with and take action [4].

Based on a survey by the National Health Portal of India, almost 8-10% of pregnant women have preeclampsia [5]. Preeclampsia is a leading cause of maternal death [6], the second leading cause of maternal death in the UK [7], in Europe [8], in several developing countries [8], and the main contributors to maternal mortality in the world [9], and also responsible for 75,000 maternal deaths worldwide each year [10]. Globally, 10–15% of all...
2 Internet of Medical Things (IoMT)

- The prediction of preeclampsia and its disorders has received much attention during the last two decades. Several factors that cause preeclampsia such as first pregnancies, twins, and teenage pregnancies occur more frequently in developing countries. These diseases are important not only for healthcare professionals but also for patients.

- Early detection and management of hypertension in pregnancy is required. The prediction of preeclampsia disease mortality has been done and validated in several studies. In this scenario, advanced computing research such as Internet of Things (IoT) and machine learning have been used to support the doctor in the prevention of preeclampsia. Machine learning algorithms have been applied in several approaches that include risk factors and prevent the occurrence of diseases.

- The prevention of complex diseases and syndromes is important not only for healthcare professionals but also for patients. The prediction of high blood pressure can reduce maternal morbidity and consequently mortality. These diagnoses can be improved with the use of e-health technologies. This diagnosis can be improved with the use of e-health technologies.

- These techniques have been successfully implemented in several countries. The focus of this systematic review is to investigate the effectiveness of these techniques in the prevention of complex diseases and syndromes. The goals of this systematic review are to:
  - Understand the current state of e-health research
  - Analyze the effectiveness of e-health technologies in preventing complex diseases
  - Identify gaps in the literature

- In this digital computing technology era, the recent developments in IoT are combined with several technologies such as artificial intelligence, machine learning, and cloud computing. These technologies have been proven to provide effective services. To sum up, the following are the primary outcomes of this systematic review:

- Several countries have implemented e-health technologies to support medical decisions. Health technology in developing countries to support medical decisions has been investigated. This diagnosis can be improved with the use of e-health technologies. IoT has been proven to provide effective services.

- In this international issue, now, the medical personnel and researchers are looking for to use e-health technologies to improve the diagnosis and treatment of complex diseases. IoT has been proven to provide effective services. To sum up, the following are the primary outcomes of this systematic review:

- Several countries have implemented e-health technologies to support medical decisions. Health technology in developing countries to support medical decisions has been investigated. This diagnosis can be improved with the use of e-health technologies. IoT has been proven to provide effective services.

- In this digital computing technology era, the recent developments in IoT are combined with several technologies such as artificial intelligence, machine learning, and cloud computing. These technologies have been proven to provide effective services. To sum up, the following are the primary outcomes of this systematic review:

- Several countries have implemented e-health technologies to support medical decisions. Health technology in developing countries to support medical decisions has been investigated. This diagnosis can be improved with the use of e-health technologies. IoT has been proven to provide effective services.

- In this international issue, now, the medical personnel and researchers are looking for to use e-health technologies to improve the diagnosis and treatment of complex diseases. IoT has been proven to provide effective services. To sum up, the following are the primary outcomes of this systematic review:
A complex system that includes microelectronics, medicine and health systems, computer science, and more [53]. Wireless sensor network (BASN) under the IoT framework has been widely applied for ubiquitous applications and services has a big impact, especially eHealth [31]. Nowadays, recent advances of several technologies such as mobile, wearable, and IoT allow new opportunities to interact, communicate, collect and exchange data [33]. Several research related with IoT and health care and medical analysis have done to address several issues. Meanwhile, benefits of receiving quality healthcare can be increased by using the IoT to transfer patient data over networks without demanding human to computer interaction [56]. This a new paradigm, named Internet of Medical Things (IoMT) [41].

Things (CIoT), to empower the current IoT with a ‘brain’ for high level intelligence which is well developed in the field of Machine Learning [54]. Internet of Medical Things (IoMT) enables continuous, remote and real time patient monitoring [37], in hospitals and, most importantly, at home [38]. The aim of IoMT and health sector is proving to be one of the most attractive fields for IoT applications. Recently, a large amount of data is produced by IoT application required for intelligent data processing. Health monitoring system is one of the popular IoT applications and plays a significant contribution in healthcare and medicine [40].

2.1 Internet of Medical Things (IoMT) and Machine Learning

A large amount of data is the key to developing smart IoT [24]. Machine learning using Big Data is widely used in several domains to address several issues. It allows things to learn, think, and understand both physical and social contexts [55]. This a new paradigm, name IoT for health. IoT integrated with health care can enable medical professionals to remotely monitor and make quick decisions in critical situations (i.e., blood pressure monitoring, heart rate monitoring, glucometer, etc.) [47]. This is especially useful for the elderly population with chronic disease on the modern health care system. For example, a vital signs based medical device for collecting patients’ heart details before and after surgery has been developed [57].

2.1.1 Internet of Medical Things (IoMT) for Health Monitoring

The IoMT is mainly used to collect the remote data for patient through wearable enabled devices such as fitness bands, smart watch, and other wireless sensors/devices [45]. These wearable devices can improve patients’ health [40].

As several research works related with IoT and health care and medical analysis have done to address several issues, recently, the IoMT has been extensively adopted to improve patients’ health [40]. The IoMT and enables the collection of vital medical data from their homes [40]. The IoMT develops the interconnection of communication enabled systems. Internet of Medical Things (IoMT) enables continuous, remote and real time patient monitoring [37], in hospitals and, most importantly, at home [38]. The aim of IoMT and health sector is proving to be one of the most attractive fields for IoT applications. Recently, a large amount of data is produced by IoT application required for intelligent data processing. Health monitoring system is one of the popular IoT applications and plays a significant contribution in healthcare and medicine [40].

2.1 Internet of Medical Things (IoMT) and Machine Learning
Smart wearable devices are one of the major types of IoT services that can be used for patients who need to collect data about their health status such as heartbeat, blood pressure, and glucose level through sensors on wearable technologies, which are sent to smartphones. The health status of patients can be monitored in real-time. The industry of wearable devices for pregnancies has been developing rapidly. The monitoring and management of maternal health indicators in the home for pregnant women and obstetricians used several factors such as fetal heart rate, blood glucose, and blood pressure.

We have summarized the results of analyzing IoT for medical analysis in Table 1.

<table>
<thead>
<tr>
<th>Author</th>
<th>Function</th>
<th>Technology</th>
<th>Object</th>
</tr>
</thead>
<tbody>
<tr>
<td>Singh et al.</td>
<td>Identify thyroid patients</td>
<td>Fog computing</td>
<td>Thyroid patients</td>
</tr>
<tr>
<td>Guan et al.</td>
<td>Home care monitoring system</td>
<td>IoT</td>
<td>Elderly patients</td>
</tr>
<tr>
<td>Li et al.</td>
<td>The monitoring and management of maternal health</td>
<td>IoT</td>
<td>Pregnant women and obstetricians</td>
</tr>
<tr>
<td>T. Zhang et al.</td>
<td>The cardiac image processing of remote elderly patients.</td>
<td>A Joint DL and IoT platform (Deep-IoMT)</td>
<td>Elderly patients</td>
</tr>
<tr>
<td>N. Jin et al.</td>
<td>A real-time detection framework for analysing the level of stress</td>
<td>IoT, cloud &amp; Amazon Web Services (AWS)</td>
<td>COVID-19 patients</td>
</tr>
<tr>
<td>Gupta et al.; Iyda et al.</td>
<td>Early warning architecture for remote monitoring in wards and at home</td>
<td>IoT, cloud &amp; Amazon Web Services (AWS)</td>
<td>Chronic disease patients</td>
</tr>
<tr>
<td>Qin et al.</td>
<td>Prediction of the health status of the elderly</td>
<td>Machine learning</td>
<td>Elderly patients</td>
</tr>
<tr>
<td>Bao et al.</td>
<td>Predicting HIV and the diagnosis of sexually transmitted infections (STIs)</td>
<td>Machine learning</td>
<td>HIV patients</td>
</tr>
</tbody>
</table>

2.2 Internet of Medical Things (IoMT) for Pregnancy

Several studies related to the detection of preeclampsia using different methods have been carried out, ranging from simple methods to methods using machine learning. The prediction model using an elastic net.
The detection system for patients with preeclampsia uses a fuzzy decision tree. The fuzzy linguistic model uses two main steps. First, a linguistic transformation to improve interpretability and flexibility in the analysis of preeclampsia was applied to the data sets. Second, knowledge extraction to classify data sets is done by inferring the decision tree rules. The linguistic rules obtained provide an understandable monitoring of preeclampsia based on application [71].

Prediction of preeclampsia using maternal medical record data at the beginning of the second trimester at the hospital for the prevention of preeclampsia using machine learning based on pattern recognition and cluster analysis. The prediction model using logistic regression, decision tree model, naïve bayes classification, support vector machine, random forest algorithm, and stochastic gradient boosting were used to build the prediction model. Statistics C was used to assess the performance of each model. Features of systolic blood pressure, serum blood urea nitrogen and creatinine levels, platelet counts, serum potassium level, white blood cell, serum calcium, and urinary protein were the most influential variables included in the prediction model. Machine learning algorithms can be used to effectively predict preeclampsia using a combination of maternal factors and laboratory data from the beginning of the second trimester to the beginning of the third trimester [16].

Prediction of preeclampsia using the BP JS Health dataset with a machine learning model. The number of datasets used is 95 features consisting of demographic variables and medical history was processed first using a nested case control design into preeclampsia/eclampsia (n = 3318) and normotensive pregnant women (n = 19,883) of all pregnant women. The best model consists of 17 predictors extracted by the random forest algorithm [8].

3 Research Methods

3.1 The primary databases utilized in the search for papers were the eight listed below:

1. IEEEXplore, the Institute of Electrical and Electronics Engineers' (IEEE) database that houses technical literature in the fields of electrical engineering, electronics, computer science, and other related disciplines
2. ScienceDirect, which offers access to journals and technical and scientific articles published by Elsevier
3. SpringerLink, which provides access to scholarly articles published by the Springer Nature editorial team
4. The ACM Digital Library, a collection of published resources in the computing field maintained by the Association for Computing Machinery.
5. The National Library of Medicine is a leader in research in biomedical informatics and data science and the world's largest biomedical library
6. Elsevier is a Netherlands-based academic publishing company specializing in scientific, technical, and medical content.
7. ResearchGate is a popular online hub for disseminating academic publications, as well as a social networking and academic profile site.
Table 2.

<table>
<thead>
<tr>
<th>No.</th>
<th>Criteria</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Studies that are included in a journal’s print or online edition.</td>
<td>IC</td>
</tr>
<tr>
<td>2</td>
<td>Studies will be published between 2015 and 2022.</td>
<td>IC</td>
</tr>
<tr>
<td>3</td>
<td>There has been a review of the literature.</td>
<td>EC</td>
</tr>
<tr>
<td>4</td>
<td>IoT, AI, Cognitive are used in the inquiry.</td>
<td>EC</td>
</tr>
</tbody>
</table>

3.2 Search process and filtering criteria

![Diagram of the search process and filtering criteria](image)

Fig 1.

4 Result and Discussion

...
Several methods and contributions provided in this review evaluation were highly accurate shown the importance of adding inception layers to networks in order to improve performance. Summarize all the articles cited above, lists the ML method, performance, and the IoMT architecture model it can be seen in Table 3.

<table>
<thead>
<tr>
<th>Author</th>
<th>ML</th>
<th>Performance</th>
<th>IoMT</th>
<th>Object</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sufriyana et al. [8]</td>
<td>Logistic Regression, Decision Tree,</td>
<td>AUROC</td>
<td></td>
<td>Preeclampsia</td>
</tr>
<tr>
<td></td>
<td>Artificial Neural Network, Random</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Forest, Support Vector Machine, &amp;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ensemble Algorithm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marić et al. [70]</td>
<td>Gradient Boosting, Elastic Net &amp; Logistic Regression</td>
<td>AUROC</td>
<td></td>
<td>Preeclampsia</td>
</tr>
<tr>
<td>Jhee et al. [16]</td>
<td>Stochastic Gradient Boosting Method,</td>
<td>t-score &amp; accuracy</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Random Forest Algorithm, Decision Tree</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Model, Naïve Bayes Classification,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Support Vector Machine, &amp; Logistic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Regression</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Martinez-velasco &amp;</td>
<td>Random Forest</td>
<td>Accuracy &amp; F1-score</td>
<td></td>
<td>Preeclampsia</td>
</tr>
<tr>
<td>Miralles [13]</td>
<td>Decision Tree</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simbolon [81]</td>
<td>Soft Voting-Based Ensemble Method, K</td>
<td>Accuracy &amp; F1-score</td>
<td></td>
<td>Preeclampsia</td>
</tr>
<tr>
<td></td>
<td>Nearest Neighbors, Linear Support</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vector Machine, RBF Support Vector</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Machine, Gaussian Process, Multi-layer</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3.
5 Challenges & Implication

Today, the world faces serious challenges in tackling various problems related to human health and well-being, such as a rapidly increasing aging population, chronic diseases, child mortality, and poverty due to an increasing population. On the other hand, the health service model is still carried out traditionally by visiting health service centers such as hospitals or clinics for examinations. This of course will be an obstacle. Several of the challenges and obstacles of the problem:

- **Data processing in intelligent algorithms need more sufficient and big training data** [73].
- **Feature extraction and classification in intelligent algorithms require computational time** [74].
- **Accuracy and performance** [75].
- **Data loss is a common problem in this system, long-term monitoring can cause data acquisition to be interrupted, data is inconsistent and incomplete. Therefore, a holistic approach to match missing data in real-time health monitoring systems is needed** [76].
- **WSN is vulnerable to several types of attack** [77] due to sensor.
- **Node is part of a bidirectional sensor network as discussed in** [78] describes several...
possible attacks which include Jamming, tampering, Sybil, Flooding.

Cloud computing is this shared resource can face many security threats like Man-in-the-middle attacks (MITM), Phishing etc. [79].

Some of the possible insider threats include data loss, account hijacking, and massive use of shared computers, etc. [80].

Primary Health Care Becoming More Accessible [90]

Technology That Is Accessible and Easy to Use [89]

As shown in Table 2 and 3, the research about preeclampsia states has always been restricted to studying only the ML. Whereas, in fact, where people have more complex. This will motivate future researchers to work on IoMT architectures for preeclampsia.

Protection and testing mechanisms are critical in the implementation of any IoT program [88].

6 Conclusion

This paper provides a review of recent research on IoMT on maternal objects using ML and IoT. The goal is that we can know the latest developments in this field and as an insight in considering analytical methods for preeclampsia.

We have provided a brief description of the various IoT & ML model architectures in maternal health care proposed by the most cited researchers. We have described the research methods we adopted in detail, we have described the results of a systematic review according to three main classifications reflecting the research question. Recent discussions have shed light on the many issues that are still open in our chosen topic, which proves that further research efforts are needed, in the near future, to make the use of machine learning a part of IoT.

References


J. A. L. Marques et al., IoT-Based Smart Health System for Ambulatory Maternal and Fetal Monitoring, IEEE Internet Things J., 8, 23, 16814–16824 (2021)

F. Sarhaddi et al., Long-term iot-based maternal monitoring: System design and evaluation, Sensors, 21, 7 (2021)


