Wireless Personal Communications
https://doi.org/10.1007/s11277-021-08249-x

Remote Monitoring System for the Detection of Prenatal Risk in a Pregnant Woman

S. Veena[1] · **D. John Aravindhar**[2]

Accepted: 4 February 2021

Abstract
The survey given by the World Health Organization (WHO), says that most of the women who are pregnant die every day related to issues during pregnancy and childbirth such as still birth/pre-term/miscarriage etc., which are preventable at an earlier stage. The women need support and access to care by the skilled nurse at the appropriate time during the period of pregnancy. But due to the factors such as lack of awareness, delays, lack of information, poverty, few skilled health professionals, and less adequate health care services, pregnant women do not receive proper care during pregnancy. In poor and rural areas, the ratio of maternal mortality is high, as these areas are too remote to have an access to immediate medical attention. Timely monitoring of vital parameters during pregnancy can help in identification and diagnosis of such pregnancy related risks. The proposed remote pregnancy risk monitoring (RPRM) system is a non-invasive and real-time system which uses a combination of wireless sensors and the internet to measure the risk status of such pregnant women. The proposed remote pregnancy risk monitoring (RPRM) system provides healthcare services, which can be used by pregnant women in the comfort of the home,. It allows connecting these pregnant women to their healthcare providers thus allowing remote supervision and consultation in time of need. In addition, the proposed system also provides an effective data visualization mechanism for the health care provider to view and monitor the status of their patients remotely overcoming the barriers of distance.

Keywords Bioinformatics · Data analysis · Gesture recognition · Healthcare · Machine learning · Sensors

✉ S. Veena
djohnveena@gmail.com

D. John Aravindhar
jaravindhar@gmail.com

[1] S.A.Engineering College, Chennai, India

[2] Hindustan Institute of Technology and Science, Chennai, India

Published online: 26 February 2021

1 Introduction

Timely monitoring of the vital parameters helps in identification and diagnosis of pregnancy related risks at an early stage of pregnancy. Monitoring of high risk pregnancies to identify pregnancy related problems helps to prevent the complications such as still birth/pre-term/miscarriage etc. All pregnant women need access to quality care services on time and also to have communication links effectively with healthcare providers. Nowadays, the sensors and smart phone devices play a vital role in providing various services to the pregnant women in a very quick and efficient means and thus preventing the complications during the pregnancy time. The pregnant women who very rarely care about monitoring and preventing such risks are responsible for risking their lives as well as the lives of their babies.

Using wireless sensors and mobile phones, the proposed (Remote Pregnancy Risk Monitoring) system provides healthcare services to pregnant women in the comfort of the home. Also, the proposed system uses the power of the internet to connect these pregnant women to their healthcare providers thus allowing remote supervision and consultation to patients in time of need. In addition, the proposed system also provides an effective data visualization mechanism for the health care provider to view and monitor the status of their patients remotely overcoming the barriers of distance. This remote pregnancy risk monitoring (RPRM) system is a non invasive and real-time system and it is well suited for home-based health monitoring of pregnant women living in remote and underprivileged parts of India.

2 Literature Review

Diamer et al. [1] discuss using wearable devices for pregnant women to monitor hypertension and to control them. Hypertension leads to pregnancy complications such as preeclampsia which presents the risk to both the baby and the mother. The risk of Preeclampsia are stillbirth, preterm birth, miscarriage and low birth weight. The approach proposed by the authors provides the patients with a healthier behaviour, by giving an awareness about their health condition and also reduces the risks such as direct and indirect for child health and maternal health problems.

Endo et al. [2] explore the Internet of Things(IoT), which can be used to monitor the patient using modern technologies and also ensures the safety of the baby and the pregnant women. The smart phones used in modern days especially in developing areas are extremely pervasive. The smart phones are associated with the hardware, for monitoring the patients by supporting biometric for all the patients. The proposed device has a sensor, biomedical signal acquisition device in the smartphone, it can extract the vital information like health status of the pregnant women. The system assists the healthcare providers, by sending the acquired data, which are then processed using signal processing equipment and then finally analysed using analysis tools to evaluate the status of the pregnant women from a remote place.

Tumpa et al. [3] discuss a new framework, which is smart to guide the pregnant women and assist them during the crucial situations and also during sensitive periods. The framework provides necessary advice to the pregnant women during each stage and accordingly gives dietary guidelines to the pregnant women. Thus, it uses its

intelligence at an advanced level to guide pregnant women. The assistant uses a cloud for all the communication between the health care providers and the pregnant women. The main objective of the Smart care framework is to reduce the stress of the pregnant women and to guide them to be healthy in each stage of the maternity period.

Oleh Viunytsky and Vyacheslav Shulgin [4] proposes a new methodology, which includes the software, algorithms and hardware prototypes for processing the signals in the abdomen. This method aims in monitoring the heart activity of the fetal in a non-invasive manner. The author discusses a new technique, Abdominal Fetal Electrocardiogram Monitoring system, which is used to monitor the fetal during pregnancy and gives the information about the fetus after analyzing the electric signals from multiple channels kept on the body surface of the mother. The approach used to measure the two parameters for fetal distress like shape of the fetal and heart rate of the fetal.

Moreira1 et al. [5] proposes one of the machine learning algorithms, which is a support vector machine, for the recognition of patterns in a pregnancy database. This approach has outperformed other ML methods, representing a valuable tool for smart decision support systems (DSSs) and mobile health (m-health) applications. This approach has outperformed other ML methods, representing a valuable tool for smart decision support systems (DSSs) and mobile health (m-health) applications. This research provides a comprehensive inference mechanism for mobile DSSs capable of enhancing the care provided to the pregnant women who have several problems during pregnancy. Thus, this work can contribute to improve the maternal and fetal health conditions, predicting preterm birth risk early.

Shulgin et al. [6] propose a technique to prevent premature birth by using Electrohysterography signals, which processes in a spatio-temporal manner using multiple channels in the abdomen. Premature birth is one of the major problems during pregnancy. It leads to the major cause of neonatal deaths and baby's morbidity. The existing methods for predicting preterm delivery uses devices and instruments, which are not accurate, uncomfortable and can be used in hospitals and clinics. The Electrohysterography signals are analyzed by observing on the body surface in the abdomen of the pregnant women and predicts the preterm delivery. The sensitive parameter of the Electrohysterography signal is the Conduction Velocity, which may burst sometimes during the contraction of the uterus.

Allahem et al. [7] proposes a safe, simple and low-cost system to monitor pregnant women who are at high risk of premature labor. Premature birth is the leading cause of death in children under 5 years. Furthermore, surviving children can have a lifetime of disability such as hearing and vision loss or learning difficulties. Research suggests that monitoring uterine contractions can help in evaluating the health and progress of pregnancy, and also determine if the pregnant woman is in labor, and consequently mitigate the effects of premature labor. The proposed system consists of a wireless body sensor network to non-invasively monitor the uterine contractions and trigger a warning via a smartphone if the readings are outside the normal thresholds.

Zhivolupova et al. [8] proposes the concept of a system for remote monitoring of pregnant women's health status for home use. The system is built on the basis of existing diagnostic methods, but takes into account features of use without direct medical involvement. Accumulation of data about cases of functional changes, processing of these data, analysis and systematization is a source of valuable diagnostic information. Only monitoring the patient's condition in the dynamics and monitoring the continuum of patient health with consideration of the patient living environment, makes it possible to increase probability of pathologies early diagnosis and allows to carry out preventive measures to stop pathology development.

Poorejbari et al. [9] discuss how the healthcare system is important due to its focus on human care and its interference with human lives. In recent years, a rapid rise in e-healthcare technologies such as Electronic Health Records (EHRs) and the importance of emergency detection and response were witnessed. Cloud computing is one of the new approaches that can handle some of the challenges of smart healthcare in terms of security, sharing, integration and management. In this study, the significance and opportunities of using cloud computing in pervasive healthcare, and the current as well as the future challenges it faces were analyzed.

Aparicio et al. [10] discussed the importance of Data Visualization over a period of years. The authors had described the importance of statistics used for hunting by ancient Humans. The authors had also specified the various types of visualization used in B.C like pictographic images used in Egyptian and Maya Civilization, maps to show the richness of the Kingdom. In 1970s, infographics are used and they also collected the statistical information in real life to represent the data graphically in different ways.

Berman et al. [11] proposed the model for patients who demand the service virtually and the system was applied to a telemedicine used in rural Alaska. The authors have considered the ENT clinic patients and identified the provider imposed delays and cost of the patients are highly significant. The authors also highlighted that the telemedicine has a good impact in the survey results, which specifies that the loss of the patient is reduced by 20% and the benefit of the patient has been increased by $40 per visit.

Sannino et al. [12] have proposed a multi sensor system to detect the dangerous heart rate variability of the patients with respect to the context. The system also detects the patient falls in a context. The proposed system uses a rule based DSS to analyse the data and showed that the accuracy have been increased compared to the system which does not implement DSS or does not use context awareness.

Yang et al. [13] discuss the importance of Open Body Sensor Network with various challenges and application scenarios. The author have analysed the various applications of Body sensor networks and wireless sensor networks and found that there are several factors to have a few limitations in the Body sensor networks. The author have also discussed that by using Open Body sensor networks, it can improve the various factors like system interoperability, energy efficiency, privacy, scalability and usability.

Gravina et al. [14] discusses the fusion of Body sensor networks data with relevant directions and future challenges on multi sensor fusion in Body sensor Network. The paper has a survey on various methodologies used for fusion of multiple sensor data and mainly discuss on physical activity recognition. The author has compared the unique features of muti sensor data fusion and parameters affecting the data fusion design. The paper mainly focuses data fusion in emotion recognition and general health domain.

Serhani et al. [15] proposed three algorithms to process and analyze specifically electroencephalography data. The input to the first algorithm is the European Data Format (EDF) which converts into Javascript Object Notation and compresses for increasing the transfer rate in the network, which is then forwarded to the second algorithm which collects all the compressed files and decompress the data for analysing by the third algorithm. The third algorithm provides the real time interaction with the signal data and finally visualize the signals on a mobile smart phone.

Liu et al. [16] proposed a novel visualization method for supporting heterogeneous data. The paper shows that the visualization can be improved by dynamically changing the visual structure as per the user requirements. The author describes the method used to improve querying the database for any size of the data set. The author also considered the software engineering data to depict the relationship among the data. The results in this

paper proves that the relationship between the data can be explored visually even for a little or no understanding of the data by the users.

Frink et al. [17] discusses on the visualization tool for analysing the multidimensional clinical data which can be used in web and mobile platform. The paper presents the design architecture of a new tool for visualization of the data in the clinical environment. The paper illustrates the four diagram view of the patient data in chronological order and presented in pie charts for continuous calendars and days.

3 Existing System

The current paradigm of prenatal care includes frequent face to face interaction with the providers which is quite difficult for the pregnant women as they progress throughout the gestational period because of the distance to be travelled by the patient to visit their doctor. Existing systems for the monitoring of pregnant women are focused on measuring a specific problem such as uterine contractions/ElectroHysteroGraphy (EHG) signals/ultrasound (US). Also the information collected is very technical and can only be viewed and understood by the healthcare providers such as doctors or hospitals.

The drawback of the existing system is that it does not provide a holistic monitoring solution of all pregnancy related risks, it does not handle different types of risk and are too specialized, they are not cost effective and hence not accessible to all, and finally, data collected from the existing systems can only be interpreted by medical professionals and cannot be understood by layman. The existing systems require face to face interaction between the patients/health care providers which is impractical as the gestational period progresses.

4 System Model

4.1 Remote Pregnancy Risk Monitoring System (RPMS)

The main objective of the proposed system is to provide an effective mechanism to collect health related data about the pregnant ladies using wireless sensors, to continuously monitor the health of their pregnant patients by Doctors using effective data visualization throughout the gestational period which previously used to be difficult due to distance or number of patients, the Pregnant patients gets urgent attention in situations such as preterm labor because of lack of awareness of contractions or absence of support nearby, and the Family members of the pregnant patients are to be intimated of such situations when they are not present with the patient, enables to attend emergency patients immediately by alerting Hospitals/Ambulances/Nurses in order to provide the pregnant women with immediate attentions.

The scope of the proposed system is to build an end to end solution to collect health related parameters of pregnant ladies using sensors and to be able to analyze this data to determine any pregnancy related risks such as preterm/stillbirth and to be able to visually intimate the same to the healthcare providers of the patients such as doctors, relatives, hospitals so that necessary actions can be taken in emergency situations.

To develop a low cost, efficient system to improve the ability of prenatal health care providers to monitor the health and well-being of pregnant women, while helping the pregnant women and their close ones to monitor the health and make informed decisions during

emergencies remotely through the use of body sensors to measure the parameters like blood pressure, temperature and heart rate, which are critical.

The advantages of the proposed system are it enables the healthcare professionals to monitor multiple patients health status using simple data visualization tool, it enables faster informed decisions during emergencies which can save valuable time, it prevent risks such as still birth / pre term / miscarriage etc. and finally the data collected are easily understandable by not only healthcare professionals but also by any family member.

4.2 System Architecture

All pregnant women need quick access to the personalized information, quality care services on time and effective communication with the health care providers. The pregnancy related complications can be prevented by using Sensors, Smartphone devices, communication systems, Data visualization tools and the internet communication, which play a major role in monitoring the pregnant women in a quick and efficient way. The proposed system developed uses Sensors, data analysis techniques and visualization tools for the effective communication between the healthcare providers and the pregnant women during the pregnancy to improve the quality of care.

Figure 1 shows the Architecture of Remote Pregnancy Risk Monitoring System to detect the prenatal risk in Pregnant woman.

Algorithm The steps of Remote Pregnancy Risk Monitoring System are:

i. Pregnant Women should wear sensor devices / wearable / Smart Watch with Heart Rate Sensor/ECG to monitor heart rate/BP etc.
ii. The Registration of various users like Patient, Doctor, Family member and Hospital of the proposed system are performed.
iii. Collection of Data like health parameters from the pregnant women are performed
iv. Store the data collected in a database and then Compare these data with the historical data of the patients by analyzing them using Machine Learning techniques and then determine the health status of the patients
v. Predict any possibility of risks such as PreTerm Labor / StillBirth based on the above analysis

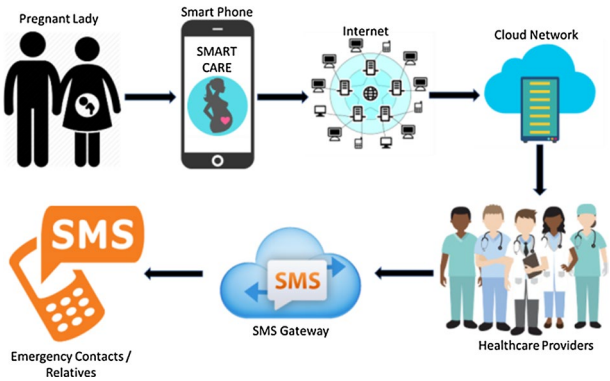


Fig. 1 Architecture of remote pregnancy risk monitoring system

vi. Display Patient status to doctors/family members using Map based data visualization with color coding
- Red-Need Critical Attention
- Yellow-Not critical, require immediate analysis (Hyper)
- Green-Healthy

vii. Intimate Doctors/Hospitals/Family members to enable immediate attention to be given to patients, if required.

4.2.1 Registration

Registration of the Patient, Doctor, Family member and Hospital are processed to enable tracking of the health parameters of the Pregnant women and thereby reporting the status to Doctors, Family members and Hospital from a remote place.

4.2.2 Data Collection

The Pregnancy Risk Monitoring system uses the following sensors to collect the data from the Pregnant women. It also allows manual entry of the data. The various sensors used to collect the health parameters of the Pregnant Women are.

4.2.2.1 Heart Rate Sensor The Heart Rate sensor is one of the important sensors used in the proposed system and follows the principle of photoplethysmography. This sensor is used to measure the change in the volume of the body through any body organ, which in turn causes a change in the intensity of the light through the same organ, a vascular region. The heart beat sensor consists of two devices namely a Light Emitting Diode and a Photodiode, which is a light detecting resistor. The heartbeat pulses cause a variation in the flow of blood to different regions of the body. When the light is emitted by a Light Emitting Diode or when the tissue is illuminated with the source of light, it either transmits the light, earlobe or it reflects a finger tissue. Some quantity of the light is absorbed by the blood and the rest is transmitted, which is received by the light detector. The amount of the absorbed light depends on the volume of the blood in the tissue. The detector outputs the electric signal, which is proportional to the rate of the heart beat.

4.2.2.2 Blood Glucose Sensor A Blood Glucose sensor is used to measure the sugar level or glucose level by using the sweat produced from the skin. This sensor is used to send the measured glucose level to the compatible smart device or the receiver, to track the rise and fall of blood sugar at regular intervals so that a decision can be taken and accordingly informed to the patient. This is the automated system for measuring the Blood glucose and it is also a very common method to measure since it is simple and non-invasive.

4.2.2.3 Temperature Sensor The Temperature sensor is silicon based and it is an integrated circuit, which includes signal processing circuitry. The Digital output sensor consists of an Analog to Digital converter, Temperature sensor registers, which is used for controlling the operation of the Integrated Circuit and a two wire digital interface. The temperature sensor

is used to measure the temperature in a continuous manner and it can be read at any time. If the user desires, the host system or processor can monitor the temperature and can give instructions to the sensor to take an output pin low or high, if the temperature exceeds a threshold limit. This temperature sensor is a digital output sensor, which can be used to monitor the temperature in a microprocessor based system.

4.2.2.4 Uterine Contraction Sensor A uterine contraction sensor device for non-invasively monitoring uterine contractions passing through an abdomen includes a base including a top wall, a bottom wall and a perimeter wall extending between the bottom wall and the top wall to define an interior space. The base is positional on the abdomen.

4.2.3 Data Analysis

The patient data is collected and then analysed using Super Vector Machine, which is a machine Learning algorithm, with the historical data to determine the current state. This Super vector machine is a supervised learning model, which consists of learning algorithms, which performs the regression analysis and classification. The Super vector machine is used to build a model that inputs a set of training examples and outputs it to one of many categories. A Super vector machine is used to widen the gap between the two categories in a space of points. Based on the data points mapped onto the same space, they are categorized as the same category and others as different categories. The main drawback of the Super Vector Machine is that it requires the input data to be labelled, un calibrated class membership probabilities, and it can be applied only for categorizing the data in two categories, which makes the parameters of the model to interpret easily.

4.2.4 Data Visualization

The proposed system provides a visual representation of the health status of multiple patients in a chart. It also enables the doctor to view the status of all of his patients in one consolidated chart.

4.2.5 Risk Notification

The proposed system monitors the health state of the patient continuously and notify through Email to the healthcare provider/family members informing them of any critical changes in the health status of the patient. It also enables the Doctor / family members to take immediate steps in case of any risks.

4.2.6 Advantages of Remote Pregnancy Risk Monitoring System

The Remote Pregnancy Risk Monitoring system bears the following advantages that are as follows:

- Data collected are easily understandable not by just healthcare professionals but also by any family member

- Enables healthcare professionals to monitor the health status of multiple patients using a simple data visualization tool.
- Enables faster informed decisions during emergencies which can save valuable time.
- Prevent risks such as still birth / pre term / miscarriage etc.

5 Results and Discussions

The proposed system has been developed, tested and executed using Java to prevent the risk of the Pregnant women by monitoring the health status continuously and reporting to the Doctor and Family member during emergency.

The Remote Pregnancy Risk Monitoring system provides an interface for patients, healthcare professionals or family members to register the patient to the network to enable tracking their parameters and health status remotely.

5.1 Doctor Registration

Hospital Doctors/Consultant Doctors/Doctors running their own clinic can register themselves and their patients whose status they want to continuously monitor.

5.2 Patient Registration

Patients can register and add themselves to their doctors list of patients to be monitored. Figure 2 specifies the information of the Patient provided at the time of Registration.

5.3 Hospital/Ambulance/Nurse Registration

Healthcare providers can register themselves, the doctors who work with them and their patients so that they can be intimated in case urgent attention is required where the nearest hospital / ambulance needs to be available based on the location of the patient.

5.4 Family Member Registration

Family members can register themselves and the patient they want to monitor so that they can be intimated / alerted in case of any urgent medical need.

The sample data of the proposed system is given in Table 1.

The developed system is finally analyzed for all patients using three parameters namely Blood Glucose, Heart rate and Temperature. The Overall Pregnancy risk status of 100 patients is provided as a report to the Doctor.

Figure 3 shows the Blood Glucose Report which specifies the Glucose level measured for 100 patients using Blood Glucose Sensor.

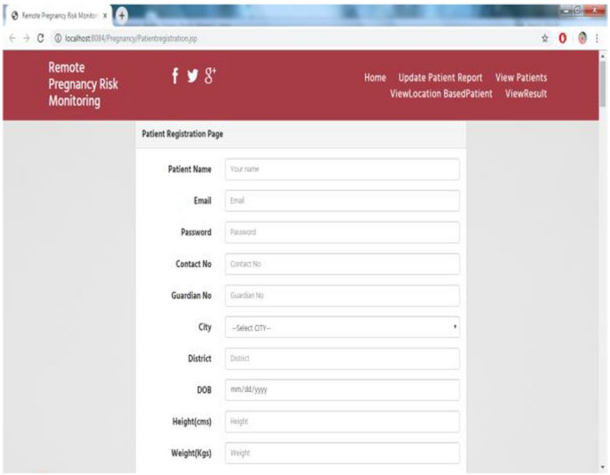


Fig. 2 Patient registration

Table 1 Parameters and values of a patient

Parameter	Sample data
Maternal age	32
Gestational age	8th Month
Patient weight	70 kg
Patient height	172 cm
Maternal blood pressure	120
Maternal body temperature	97
Maternal heart rate	80 beats per minute
Uterine contraction	2–4 contractions per min
Blood glucose	100

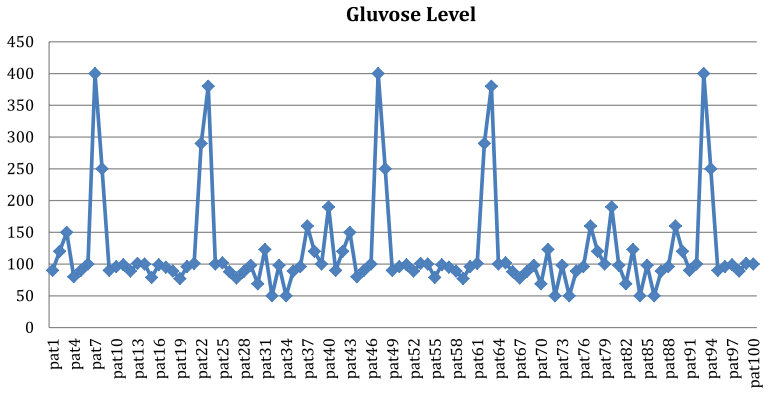


Fig. 3 Blood glucose report

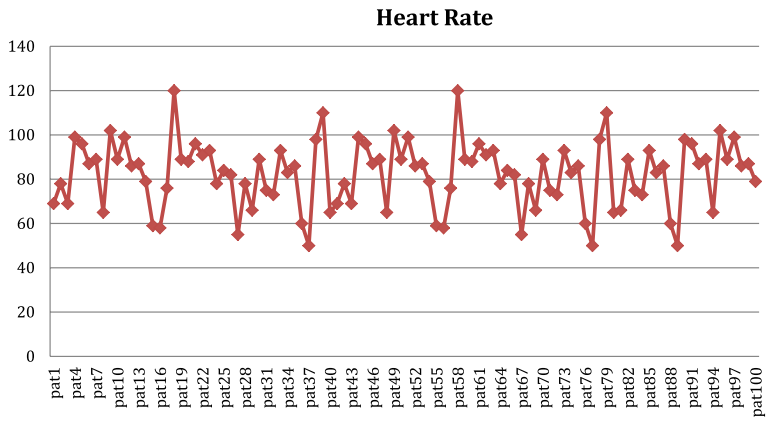


Fig. 4 Heart rate report

Figure 4 shows the Heart Rate Report which specifies the Heart Rate measured for 100 patients using Heart Rate Sensor.

Figure 5 shows the Temperature Report which specifies the Temperature measured for 100 patients using Temperature Sensor.

The various parameters like Maternal age, Gestational Age, Patient weight, Patient Height, Maternal Blood Pressure, Maternal Body Temperature, Maternal heart Rate, Uterine Contraction and Blood Glucose are considered for detecting the risk of a Pregnant Woman and to determine whether the status is normal / abnormal. Figure 6 specifies the status report of Pregnant women after analysis and the Result of the patient in the Fig. 6 indicates whether the patient is under Normal or Low Risk or High Risk.

Figure 7 specifies the Overall Pregnancy Risk status of 100 patients. The Pregnancy Risk Monitoring system detects the Prenatal risk of 100 pregnant women and the Figure shows that 55% of the patients are under High Risk, 12% of the patients are under Low Risk and 33% of the patients are Normal.

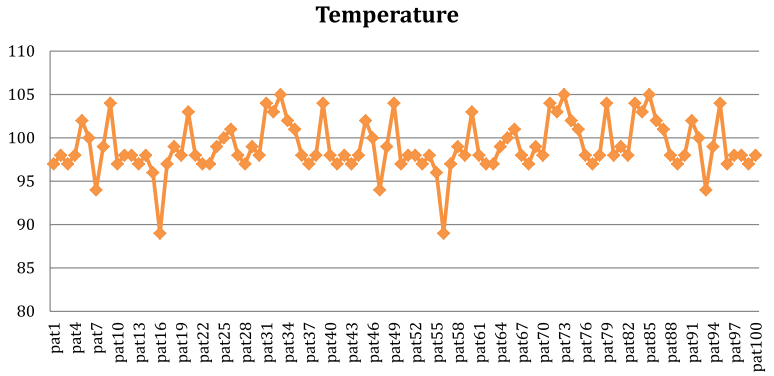


Fig. 5 Temperature report

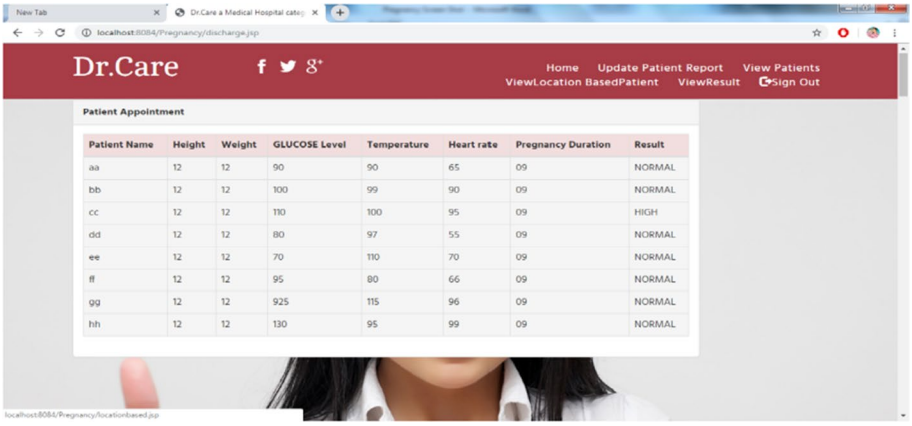
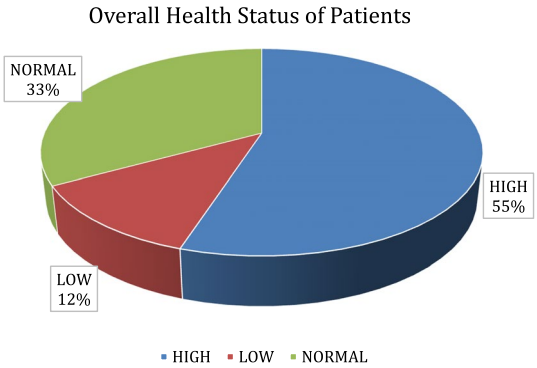


Fig. 6 Status report of the patient

Fig. 7 Overall pregnancy risk status of patients



6 Conclusion and Future Enhancement

The remote pregnancy risk monitoring system (RPRM) is thus providing an efficient and novel means of being able to remotely monitor the health status of a pregnant woman and to monitor the same and intimate to the Doctors, Hospital and Family members when there is any abnormality detected.

The proposed system can be enhanced to use a more efficient Machine Learning (ML) algorithm to analyze the data collected from the sensors to determine the other risk status of a Pregnant woman, to create more ways of visualizing the data over more dimensions such as Continuous Month View and Continuous Day View. Also, it can be enhanced by using GPS sensors to monitor multiple patients in a particular area by having a capability to draw a polygon or select an area on a map and to have the list of all patients along with their status displayed on the map. Thus it helps in detecting the status and locating the patients quickly.

Acknowledgements S.Veena, is a member of ACM and Life member of ISTE. She has published and presented a total of 40 papers in Conferences and Journals and she has also published 1 Book. Her areas of interest are Data Mining, Network Security and Cloud Computing. I would like to thank the Management, Advisor and Principal for their motivation and support given to carry out research activities in our college.

D.John Aravindhar, is a member of ACM Professional Society. He has published and presented a total of 40 papers in Conferences and Journals and he has also published 1 Book. His areas of interest are Cloud Computing, Data Mining and Data Science. I would like to thank the Management, Director, Dean for their motivation and support given to carry out research activities in our college.

References

1. Lopez, B. D. B., Aguirre, J. A. A., Coronado, D. A. R., & Gonzalez, P. A. (2018). Wearable technology model to control and monitor hypertension during pregnancy. In: *2018 13th Iberian Conference on Information Systems and Technologies (CISTI)*, Caceres, (pp. 1-6), doi: https://doi.org/10.23919/CISTI.2018.8399200.
2. Endo, G. K., Oluwayomi, I., Alexandra, V., Athavale, Y., & Krishnan, S. (2017). Technology for continuous long-term monitoring of pregnant women for safe childbirth. In: *2017 IEEE Canada International Humanitarian Technology Conference (IHTC)* (pp. 6-10), doi: https://doi.org/10.1109/IHTC.2017.8058200.
3. Tumpa, S. N., Islam A. B., & Ankon, M. T. M. (2017). Smart care: An intelligent assistant for pregnant mothers. In: *2017 4th International Conference on Advances in Electrical Engineering (ICAEE)*, Dhaka, 2017, (pp. 754-759), doi: https://doi.org/10.1109/ICAEE.2017.8255455.
4. Viunytskyi, O., & Shulgin, V. (2017). Fetal ECG and heart rhythm analyzing using BabyCard. In: 2017 Signal Processing Symposium (SPSympo), Jachranka, (pp. 1–4), doi: https://doi.org/10.1109/SPS.2017.8053640.
5. Moreira, M. W. L., Rodrigues, J. J. P. C., Marcondes, G. A. B., Neto, A. J. V. Kumar N. & De La Torre Diez, I. (2018). A preterm birth risk prediction system for mobile health applications based on the support vector machine algorithm. In: *2018 IEEE International Conference on Communications (ICC)*, Kansas City, MO, 2018, (pp. 1–5), doi: https://doi.org/10.1109/ICC.2018.8422616.
6. Shulgin, V., & Viunytskyi, O. (2018). Spatio-temporal signal processing for fetus and mother state monitoring during pregnancy. In: *2018 IEEE 9th International Conference on Dependable Systems, Services and Technologies (DESSERT)*, Kiev, 2018, (pp. 641–644), doi: https://doi.org/10.1109/DESSERT.2018.8409210.
7. Allahem H., & Sampalli, S. (2017). Framework to monitor pregnant women with a high risk of premature labour using sensor networks. In: *2017 IFIP/IEEE Symposium on Integrated Network and Service Management (IM)*, Lisbon, (pp. 1178-1181), doi: https://doi.org/10.23919/INM.2017.7987458.
8. Zhivolupova Y. A., & Bobrova, Y. O. (2017). The concept of the fetal remote monitoring system development. In: *2017 IEEE II International Conference on Control in Technical Systems (CTS)*, St. Petersburg, 2017, (pp. 360–362), doi: https://doi.org/10.1109/CTSYS.2017.8109567.
9. Poorejbari, S., & Vahdat-Nejad, H. (2015). An introduction to cloud-based pervasive healthcare systems. In: *2015 3rd International Conference on Context-Aware Systems and Applications*, ACM, Doi: https://doi.org/10.4108/icst.iccasa.2014.257442
10. Aparicio, M., & Costa, C. J. (2015). Data visualization. *Communication Design Quarterly Review, 3*(1), 7–11. https://doi.org/10.1145/2721882.2721883.
11. Berman, M., & Fenaughty, A. (2005). Technology and managed care: patient benefits of telemedicine in a rural health care network. *Health Economics, 14*(6), 559–573. https://doi.org/10.1002/hec.952.
12. Sannino, G., & Pietro, G. D. (2014). A mobile system for real-time context-aware monitoring of patients; health and fainting. *International Journal of Data Mining and Bioinformatics, 10*(4), 407–423. https://doi.org/10.1504/IJDMB.2014.064891.
13. Yang, N., Wang, Z., Gravina, R., & Fortino, G. (2017). A survey of open body sensor networks: Applications and challenges. In: *2017 14th IEEE Annual Consumer Communications & Networking Conference (CCNC)*, Las Vegas, NV, (pp. 65-70), doi: https://doi.org/10.1109/CCNC.2017.7983083.
14. Gravina, R., Alinia, P., Ghasemzadeh, H., & Fortino, G. (2017). Multi-sensor fusion in body sensor networks: State of- the-art and research challenges. *Information Fusion, 35,* 68–80. https://doi.org/10.1016/j.inffus.2016.09.005.
15. Serhani, M. A., Menshawy, M. E., Benharref, A., Harous, S., & Navaz, A. N. (2017). New algorithms for processing time-series big EEG data within mobile health monitoring systems. *Computer Methods and Programs in Biomedicine, 149,* 79–94. https://doi.org/10.1016/j.cmpb.2017.07.007.
16. Liu, Q., Guo, X., Fan, H., & Zhu, H., (2017). A novel data visualization approach and scheme for supporting heterogeneous data. In: *2017 IEEE 2nd Information Technology, Networking, Electronic*

and Automation Control Conference (ITNEC), Chengdu, (pp. 1259-1263), doi: https://doi.org/10.1109/ITNEC.2017.8284978.

17. Frink, T. M., Gyllinsky, J. V., & Mankodiya, K. (2017). Visualization of multidimensional clinical data from wearables on the web and on apps. In: *2017 IEEE MIT Undergraduate Research Technology Conference (URTC)*, Cambridge, MA, (pp. 1-4), doi: https://doi.org/10.1109/URTC.2017.8284217.

S. Veena is working in S.A.Engineering College. She has a total teaching experience of 18.6 years. She is a Life member of ISTE. She has published and presented a total of 40 papers in Conferences and Journals and she has also published 1 Book. Her areas of interest are Data Analysis, Artificial Intelligence, Data Mining, Bioinformatics, Network Security and Cloud Computing. She and her Colleague have received a Workshop Grant from DST-SERB,FDTP approved by Anna University and Seminar grant from ISTE.

D. John Aravindhar is working in Hindustan Institute of Technology and Science. He has a total teaching experience of 19.6 years. He is a member of ACM Professional Society. He has published and presented a total of 40 papers in Conferences and Journals and he has also published 1 Book. His areas of interest are Cloud Computing, Data Mining and Data Science. He and his Colleague have received a grant from TNSCST for organizing International Conference in the year 2018.