ResearchGate

See discussions, stats, and author profiles for this publication at: https://www.researchgate.net/publication/349367479

IoT Based Risk Level Prediction Model For Maternal Health Care In The Context Of Bangladesh

Conference Paper · February 2021

DOI: 10.1109/STI50764.2020.9350320

CITATIONS
0

READS
238

2 authors, including:

Marzia Ahmed
Universiti Malaysia Pahang
4 PUBLICATIONS **10** CITATIONS

SEE PROFILE

Some of the authors of this publication are also working on these related projects:

Review and Analysis of Risk Factor of Maternal Health in Remote Area using Internet of Things (IOT) View project

CVD Prediction View project

All content following this page was uploaded by Marzia Ahmed on 22 July 2021.

The user has requested enhancement of the downloaded file.

2020 2nd International Conference on Sustainable Technologies for Industry 4.0 (STI), 19-20 December, Dhaka

IoT Based Risk Level Prediction Model For Maternal Health Care In The Context Of Bangladesh

Marzia Ahmed[1,2], and Mohammod Abul Kashem[2]
[1]Department of Software Engineering, Daffodil International University, Dhaka, Bangladesh.
[2]Department of Computer Science and Engineering, Dhaka University of Science and Technology, Gazipur, Bangladesh.
Email: ahmed.marzia32@gmail.com

Abstract—
Internet of Things(IoT), a new paradigm has the extensive applicability including healthcare and numerous areas. In this research, a system has been developed for effective monitoring and predicting risk level of a pregnant women, in the context of Bangladesh. This system will analyzed the health data and risk factors of pregnant women to identify the risk intensity level. The United Nations goal is primarily concern about improving maternal health, reducing maternal and child mortality by 2030; however the rate is not declining up to the indication. This research intended to use respective analytical tools and machine learning algorithms for discovering the risk level on the basis of risk factors in pregnancy. In this research, a maternal health data set has been prepared from different sources (IoT device, Web portal, Hospitals in Bangladesh). This data set been also stored in the local server and as usual as in the cloud server as CSV(comma-separated value). For the analysis of risk factors, categorize and classifying approaches has been used according to the intensity of risk. After comparing among some groups of the machine learning algorithm, in case of classification and prediction of the risk level shows that Modified Decision Tree Algorithm gives the highest accuracy and the numeric value of this accuracy is 97%. A web application has also been developed as a crowdsourced platform to get feedback on different important suggestions and recommendations from corresponding stakeholders, which can also create as test data for further use.

Keywords— Maternal Health, Maternal Health Dataset, Risk Factor, Internet of Things, Industry 4.0, Machine Learning.

I. INTRODUCTION

Many pregnant women die from complications of pregnancy because of not having enough information about maternal health care during pregnancy and post-pregnancy. It especially occurs in rural areas and in the low middle-class family of a developing country [1].

Every moment should be monitored during pregnancy for the healthy development of fetal and for making sure of the harmless delivery. Huge traffic jams, bad weather, pollution, etc. are big problems for the continuous checkup in the hospital. Most maternal health-related difficulties can be reduce by identifying the root causes, is very important for any indications at the beginning[2]. An alternative care for pregnant women has ben ensured in this research especially those who are living in rural areas. Iot based smart health monitoring system can be supportive for them. Internet of things(IoT) is highly capable to communicate with machine to machine and human to human which is one of the essential in health care industry to get monitoring 24/7 [3].

Considering maternal health as a physical entity for connecting with modern technology such as Cyber-Physical System (CPS). The implication of CPS, one of the core technology of Industry 4.0, is communicating, computing and controlling the different statuses of a physical entity. Therefore, the main objectives of Industry 4.0 are the uses of modern technologies e.g. IoT, Big data, Blockchain, Hadoop, etc. to solve or improve existing complexities in real life.

This system is to solve the maternal healthcare problem, mainly for the rural areas of a developing country. This system will help to reduce the problems of pregnant women as well as a newborn baby. Therefore, among the three parts, first one is data collection through iot enabled sensors, next one is data processing and third one is to transferring the data to the cloud for further analysis. Thus, this process will increase the safety of maternal health as well as the unborn baby.

Additionally, the system will interact in real-time due to the smart technology of Industry 4.0. Considering the miniaturaization in hardware layer, one of the challenge is to connect with body area network through sensors. Electromagnatic spectrum and bandwidth is another concern to connecting all the devices together in a single network. However, one of the solution for this consequences is IoT enabled devices which helps the health industry to tackle challenges and transfer data in effectively and efficien manner.

978-0-7381-4246-3/20/$31.00 ©2020 IEEE

During Pregnancy there are plenty of risk factors to measure. They are- Age, Body Mass Index(BMI), Blood Oxygen(BO), Blood Pressure(BP) [4], Body temperature, Physical Activity. Maternal ECG, Vaginal dis-charge at the first trimester, Nausea with the first trimester, The contraction in the third trimester, Fetal Heart Rate(FHR), Abnormal Fetal Protein(AFP), Electrical Uterine Activity (EUA), Fetal Movement Activity & so on. We have to consider the threshold values or measurement units of these factors[5].

Timely diagnosis with proper medication is the primary concern for maintaining the good health during pregnancy. Proper care and diagnosis at the beginning of pregnancy can help to reduce the preventable death of pregnant women and neonatal especially in rural areas [6].

The importance of Internat of things in mission critical like healthcare industry is one of the blessing from Industry 4.0 technology. The hardware layer is responsible for health/medical data transferring [7], also capable and interconnecting the physical devices through the iot enabled technology where the main challenge is to keep the device small and organized. In communication layer, bandwidth can be a challenge as well as electromagnetic spectrum because multiple devices are connected in a single network, which can affect data transferring smoothly in an efficient manner [8].

Wearable sensors such as temperature sensors, heart rate sensors can be controlled by an Arduino controller, that analyzed the data come from the sensors. Inter-networking between different physical devices, the Arduino controller simulates the results. The Internet of Things (IoT) is a compact system of computing devices that are interrelated, digital, and mechanical machines, objects, animals, or people all are provided with unique identifiers and this system is capable to transfer data over a network without requiring the interaction of human-to-human or human-to-computer. This technology is able to transfer the data for long distances [9].

II. Review of machine learning related research work

A comparative analysis takes place on both data mining and statistical approaches. The whole analysis was done by using data mining tools Weka. In recent years, this type of risk prediction analysis has been done by both data mining [10-13].
Risk analysis, risk prediction, and implementing devices/tools to diagnosis the disease have a common trend nowadays [14-15]. A smartphone-based risk prediction tool by research was done on Heart Attack risk prediction in [16] drawn the attraction of diagnosis and prognosis have been done by analyzing risk factors in recent research on medical science. According to WHO and Unicef, many pregnant women die due to preventable diseases. Machine learning technologies is been focused to handle these kinds of critical situations recommended by the new researchers [17]. High-risk prediction and classification of the unknown level can be done by machine learning algorithms. Decision Tree is the most advantageous in case of accuracy and prediction rather than the regression model among all other algorithms in the health domain with the less mean absolute error [18]. Data mining and machine learning have the greatest and fastest-growing features of knowledge- discovery from a dataset in big data science, and this advantage is broadly used for predicting risk following different steps of mining such as classification, pattern prediction, clustering, attribute selection etc [19].
In this paper detailed analysis of a few risk factors of maternal mortality has been done and shown. Risk factors mean those reasons, which increase the chance of getting a disease. The classification and prediction of risk intensity during pregnancy is a multilayered problem. The risk parameter collected and shown here is highly significant. Few approaches have been designed to classify, analyze, and predict the risk level of maternal and neonatal health. Furthermore, more than 60 research papers been gone through in Google scholar, IEEE, Science Direct, Research gate for the analysis and the status of the existing works.

III. Proposed Methodology

This paper proposes a maternal healthcare model for observing a pregnant woman and fetal health. Data has been collected and transmitted in the cloud as well as in local servers for analyzing the medical data and predicting risk level, in IoT environments. The proposed model composes of four continuous processes: (1) The patient's health data is collected through wearable sensing devices. (2) Collected data has been stored in the local server and cloud server as well. (3) Stored data has been classified and predicted using a machine learning algorithm according to the trained data (4) The predicted result has been sent at both the source's (hospital and other emergency services related with) and the destination's (patient's) sides.

The proposed methodology describes that data has been merged from different sources. Merged data has been used to prepare a medical data set for further analysis and prediction using machine learning algorithms using both weka and python. When the prediction accuracy is poor then hyperparameter tuning has been performed using machine learning classifiers in both cases and comparing the accuracy best prediction model has been selected to perform further analysis and implementations.

As shown in Fig:1, three steps are required to be accomplished in order to predict decisions: dataset collection, training of machine learning classifiers, and evaluation of machine learning classifiers.

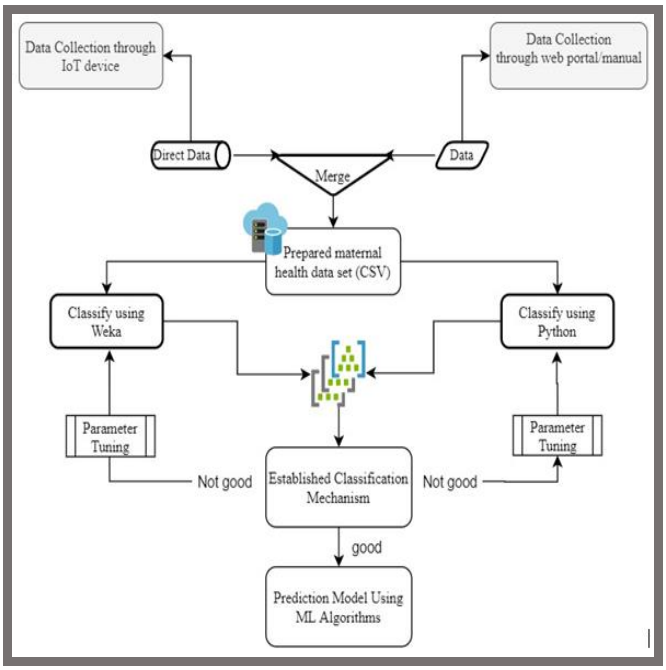

Fig: 1 A methodology of decision-making system

IV. Experimental Setup and Data Collection

Maternal Mortality is now a concerning factor that is increasing at an alarming rate in low incoming countries like Bangladesh. In order to solve this life critical issues, we designed an IoT based maternal health care system to detect the symptoms as well as a maternal health risk factor and these data have been saved in an excel file in the local server. Fig: 2 illustrates our designed model that has been integrated with all of the above sensors to detect the risk factor of maternal health.

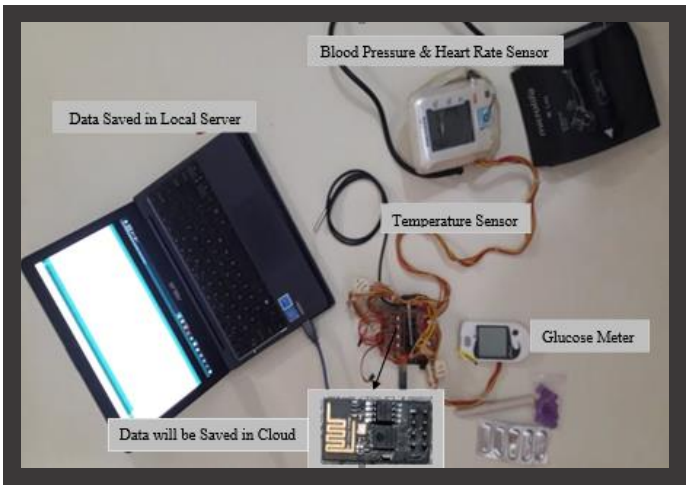

Fig: 2 Wearable sensing devices to detect health risk during pregnancy

V. Data Collection through other sources

Data collection is a crucial factor in any survey-based research. In this research, data were collected by a questioner. The questioner was designed by the study of numerous research papers [20-25] and by discussing with medical persons. Maternal health is supposed to be at risk due to age hence at the time of data collection age was accounted for. Table-1 shows the list of all hospitals in Dhaka and another maternity clinic in Khulna from where we have collected all the health information.

Table-1: List of Maternity Clinic for collected data

SN#	Hospital Name	Address and Contact	Date
1.	Maternity Clinic	Chuadanga, Khulna, Bangladesh	26.01.2018 27.01.2018 03.04.2020
2.	Kurmitola General Hospital	Tongi Diversion Rd, Dhaka 1206	11-02-2019 12-02-2019
3.	Aichi medical college & hospital	Plot- 35 & 37, Sector-08, Abdullahpur Mohasorok, Dhaka 1230	12-02-2019 14-02-2019
4.	Uttara Adhunik Medical College Hospital(BMSRI)	H.No 34, Road No.4 Janapath Sonargaon, Road, Dhaka 1230	18-02-2019
5.	East-West Medical College & Hospital	Aichi Nagar, JBCS Sarani P.O- Khayertek, Horirampur, Dhaka 1711	18-06-2019 12-02-2020
6.	CARe Medical College & Hospital,	Dhaka, Bangladesh	18-06-2020

VI. Classifying the Collected Data

Maternal risk factor data were collected from different hospitals and maternity clinics from Dhaka, Bangladesh. The data collection was done by following a questioner that has been formed by previous research studies and discussion with medical persons. Three categorial risks have been considered and collected as low risk, mid risk, and high risk. The total data size is 1014 where 406 was classified as low-risk level, 336 in mid and 272 was in high-risk level.

VII. Proposed Algorithm

Groups of machine learning algorithms have been implemented in both weka and using python, therefore, the decision tree gives the highest accuracy of 97%. The classifier has been tuned using GridSearchCV, a hyperparameter tuning method to get the best parameters. Moreover, to find significant factors Chi-square test, Info gain, Gain ratio etc. few data mining and statistical approaches have been done. Algorithms have been shown below-

***Inputs**: medical data of pregnant women*
***Output**: Data stored in server and notify the health status*
Begin
Read the health data row by row
Loop
1. *Choose attributes from dataset*
2. *Calculate significance for each factor/attribute with respect to the accuracy and error.*
3. *Implement data mining and statistical approaches to calculate the best value of best attribute.*
4. *For other combination of attributes go to step-1*

End Loop
Compare with trained data stored in the server
Classify and Predict the risk level
Prepare msg = ""
END

Decision tree classifiers can be varied according to the different values of the tree depth to reach the best prediction. Furthermore, accuracy has been shown with respect to the changes of maximum depth of the tree and observe that depth 8 given the highest accuracy. Fig: 3 shows that accuracy has been changed with maximum depth.

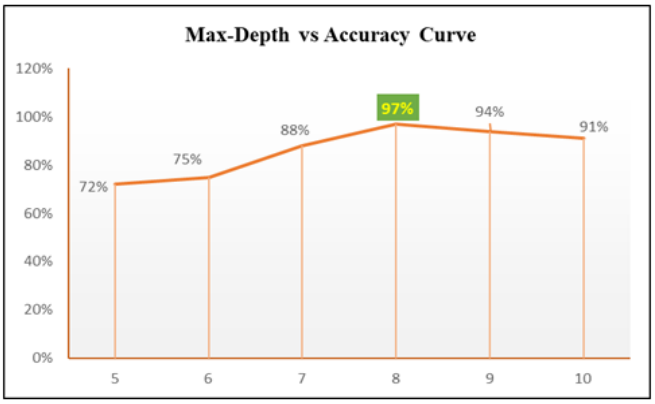

Fig: 3 Best accuracy selection according to max-depth

VIII. Attribute Selection

Data would be analyzed by a ranking system where highly affected factors are ranking first and normally affected attributes are sequentially lower ranking. Info gains the context of decision trees, used synonymously with mutual information, which is expected the value of the entropy of a random variable. If the number is high then it has a high-risk factor and the number is low it has a lower risk factor. Information gain is usually a good measure for deciding the relevance of an attribute. The gain ratio also providing comparing value. It calculates inaccuracy more than the relevant value, which means comparing two values and finally finding to value accuracy. The factor (χ2- Test) is very important in the data analysis term. (χ2- Test) carry out a number sequentially. Highly number is indicated for high-risk factor and the lower number is indicated for the low risk factor. From the Fig: 4 we realized that the most probability risk factor is BS(Blood Sugar) in pregnancy. Especially the mother affected by diabetes is considerably more responsible about three times higher than Blood Pressure and other factors. Then blood pressure also a responsible risk factor in sequential probability time.

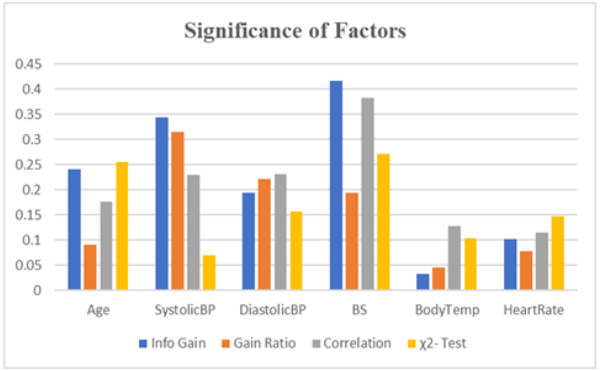

Fig: 4 Significant risk factors during pregnancy

IX. Comparison among machine learning algorithms

After preprocessing all the risk factor has been encoded in an object type array by implementing sklearn and select the risk level as the class to predict. Then the whole data set has been splitting as 70% training and 30% test data.

Fig:5 describes the accuracy of the following machine learning algorithms to determine the best performed algorithm.

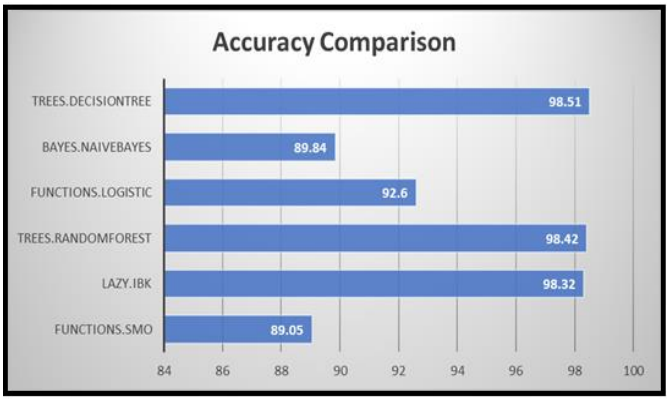

Fig:5 Comparison among machine learning algorithms

A detailed classification report of the Decision Tree classifier for categorized data has been shown in Fig: 6. From the above figure, it has been examined that decision tree classifier has given the highest accuracy for categorized dataset among all groups of machine learning algorithms.

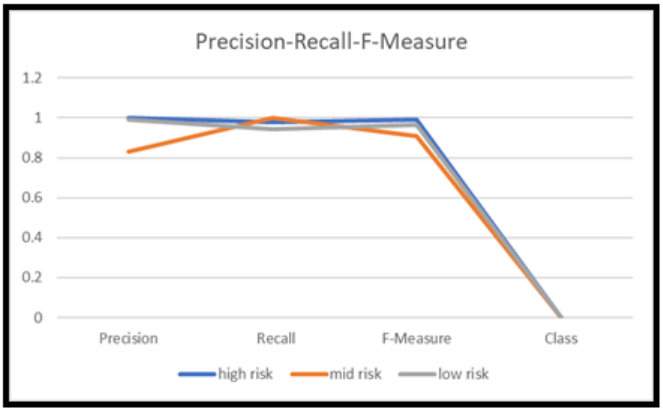

Fig: 6 Precision Recall curve of proposed prediction model

Therefore, the model will be trained by the decision tree classifier to measure accuracy. Un-processed and not categorized data given the highest accuracy using decision tree algorithm with 15 cross-fold validation. Following figures shows 96% accuracy; by criterion: entropy (information gain) with 15 cross-fold validation.

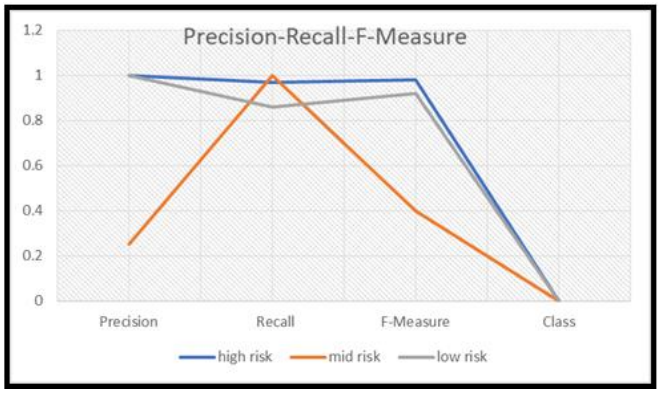

Fig: 7(a) Shows 96% accuracy; criterion: entropy (information gain)

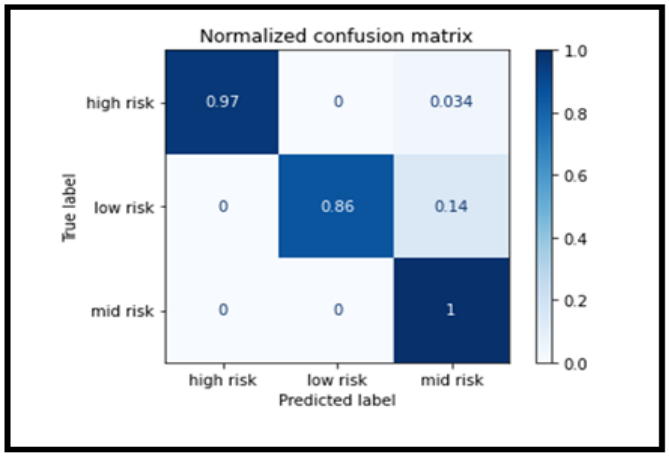

Fig:7(b) Confusion matrix; criterion: entropy (information gain)

	Actual	Predicted
0	low risk	low risk
1	low risk	low risk
2	low risk	low risk
3	low risk	low risk
4	low risk	low risk
...	...	...
62	high risk	high risk
63	high risk	high risk
64	high risk	high risk
65	high risk	high risk
66	mid risk	mid risk

Fig: 8 Risk prediction result of proposed model

Pregnancy related medical data has been received through IoT enabled devices. With the help of medical experts, and from the literature review, the risk level is determined that whether it is high, mid, or low. The above results show the accuracy of correct identification of risk level in pregnancy for the given dataset of risk parameters. Among the entire machine learning algorithm, Decision Tree provides the highest accuracy for correct classification in both training set data and 15 cross folding validations. Factors like Blood Pressure, Blood Sugar, and Age are key factors for high risk. All the data and Tables from the dataset, the final decision tree can be formed. By the decision tree, we can easily describe whether the pregnant women are at risk or not and if at risk that what is the risk intensity. All data are processing in the tree that means data are analyzing for decision finally a result.

Table:2 Overall Comparison of Accuracy among Machine Learning Algorithms

Classifier (15 cross validation)	Accuracy			
	Categorized & Processed Dataset		Un-Categorized Dataset	
	Weka	*Python*	*Weka*	*Python*
Decision Tree	96.75	**98.51**	73.47	**97**
Random Forest	**98.42**	97.83	**85.7**	81.95
Support Vector Machine	N/A	96.67	N/A	81.12
Sequential Minimal Optimization	89.05	N/A	64.1	N/A
Logistic Regression	92.6	80.67	61.83	60.66
Naïve Bayes	89.84	N/A	59.47	N/A
Ibk	98.32	N/A	84.62	N/A
Logistic Model Tree	97.73	N/A	81.65	N/A

A website has been designed to generate the test data as well as a virtual platform to reach the doctor easily in this pandemic situation. The system can also solve the problem to find a doctor for the specific symptoms at very ease. Patients can also give their feedback for the doctor and directly communicate with the doctor though during pregnancy it is highly required. the objectives are given below-

a. To create a virtual communication system between doctors and patients.

b. Admin has the privilege to approve both patient and doctor like a clinic.
c. To recommend a doctor according to the symptom
d. The patient can chat and see the doctor's feedback.
e. To recommend a healthy diet according to the health parameter value (if needed and change unstably from the standard range)

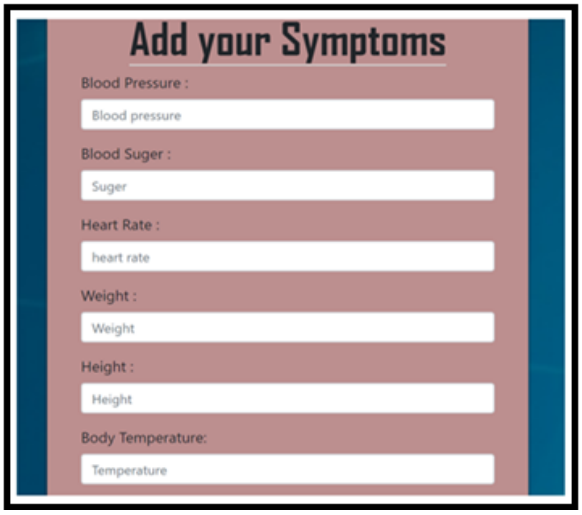

Fig:9 Patient can share her current symptoms manually

X. Conclusion and Future Work

Pregnant women's data was collected from different sources. The analysis takes place with both data mining and machine learning algorithms with a statistical approach. A website has been demonstrated along with the prediction model which works as a backend risk factor analyzer. A different approach has been done to find out the significant risk factor the analyzing, classifying and predicting the intensity of risk.

In the future, We will add more attributes (Risk Factors) to make the vast analysis as well as research on maternal and fetal health and immunology. We will try to analyze big data, which creates a hybrid algorithm or a new algorithm that will be able to provide the best result.

References

[1] Ahmed, M., Kashem, M.A., Rahman, M. and Khatun, S., 2020. Review and Analysis of Risk Factor of Maternal Health in Remote Area Using the Internet of Things (IoT). In InECCE2019 (pp. 357-365). Springer, Singapore.

[2] Say, L., Chou, D., Gemmill, A., Tunçalp, Ö., Moller, A.B., Daniels, J., Gülmezoglu, A.M., Temmerman, M. and Alkema, L., 2014. Global causes of maternal death: a WHO systematic analysis. *The Lancet Global Health*, *2*(6), pp.e323-e333.

[3] Talpur, M.S.H., Shaikh, M.H., Buriro, R.A., Talpur, H.S., Talpur, F., Shafi, H. and Shaikh, M.A., 2014. Internet of Things as Intimating for Pregnant Women's Healthcare: An Impending Privacy Issues. *Indonesian Journal of Electrical Engineering and Computer Science*, *12*(6), pp.4337-4344.

[4] Mustafa, Reem, Sana Ahmed, Anu Gupta, and Rocco C. Venuto. "A comprehensive review of hypertension in pregnancy." *Journal of pregnancy* 2012 (2012).

[5] Storm, Frederikke, Suneth Agampodi, Michael Eddleston, Jane Brandt Sørensen, Flemming Konradsen, and Thilde Rheinländer. "Indirect causes of maternal death." *Lancet Glob Health* 2, no. 10 (2014): e556.

[6] Santhi, V., K. Ramya, A. P. J. Tarana, and G. Vinitha. "IOT based wearable health monitoring system for pregnant ladies using cc3200." *International Journal of Advanced Research Methodology in Engineering & Technology* 1, no. 3 (2017): 56-60.

[7] Lyu, P., Peng, M., Lyu, Y., Chen, Y. and Yang, J., 2013, October. A multi-communication-fusion based mobile monitoring system for maternal and fetal information. In *e-Health Networking, Applications & Services (Healthcom), 2013 IEEE 15th International Conference on* (pp. 559-563). IEEE.

[8] Megalingam, R.K., Pocklassery, G., Thulasi, A.A., Jayakrishnan, V., Mourya, G. and Nair, M.S., 2015. Integrated embedded system for pre-natal health care. *Procedia Computer Science*, *57*, pp.313-322.

[9] Amala, S. Shiny, and S. Mythili. "IoT Based Health Care Monitoring System For Rural Pregnant Women." *International Journal of Pure and Applied Mathematics* 119, no. 15 (2018): 837-843.

[10] Ahmed, Kawsar, and Tasnuba Jesmin. "Comparative Analysis of Data Mining Classification Algorithms in Type-2 Diabetes Prediction Data Using WEKA Approach." International Journal of Science and Engineering 7, no. 2 (2014): 155-160.

[11] Ahmed, Kawsar, Tasnuba Jesmin, and Md Zamilur Rahman. "Early prevention and detection of skin cancer risk using data mining." International Journal of Computer Applications 62, no. 4 (2013).

[12] Islam, Md Shariful, Sharmin Akhter, Md Salahuddin, Jay Prakash Sah, Md Ramim Tanver Rahman, Sayed Asaduzzaman, Kawsar Ahmed, A. K. M. Mohiuddin, and Abu Zaffar Shibly. "Early Prevention and Detection of Cancer Risk for Low Income Country using Data Mining Technology: Bangladesh Perspective." Biochem Physiol 5 (2016): e155.

[13] Ahmed, Kawsar, Md Ahsan Habib, Tasnuba Jesmin, Md Zamilur Rahman, and Md Badrul Alam Miah. "Prediction of breast cancer risk level with risk factors in perspective to bangladeshi women using data Mining." International Journal of Computer Applications 82, no. 4 (2013).

[14] Thomas, Grégoire, Louise C. Kenny, Philip N. Baker, and Robin Tuytten. "A novel method for interrogating receiver operating characteristic curves for assessing prognostic tests." Diagnostic and prognostic research 1, no. 1 (2017): 1-9.

[15] van Doorn, Sander, Timo B. Brakenhoff, Karel GM Moons, Frans H. Rutten, Arno W. Hoes, Rolf HH Groenwold, and Geert Jan Geersing. "The effects of misclassification in routine healthcare databases on the accuracy of prognostic prediction models: a case study of the CHA2DS2-VASc score in atrial fibrillation." Diagnostic and prognostic research 1, no. 1 (2017): 18.

[16] Raihan, M., Saikat Mondal, Arun More, Md Omar Faruqe Sagor, Gopal Sikder, Mahbub Arab

Majumder, Mohammad Abdullah Al Manjur, and Kushal Ghosh. "Smartphone based ischemic heart disease (heart attack) risk prediction using clinical data and data mining approaches, a prototype design." In 2016 19th International Conference on Computer and Information Technology (ICCIT), pp. 299-303. IEEE, 2016.

[17] Du, Xin, Weijie Zeng, Chengwei Li, Junwei Xue, Xiuyong Wu, Yinjia Liu, Yuxin Wan et al. "A Maternal Health Care System Based on Mobile Health Care." Sheng wu yi xue gong cheng xue za zhi= Journal of biomedical engineering= Shengwu yixue gongchengxue zazhi 33, no. 1 (2016): 2-7.

[18] Mehta, Rutvij, Nikita Bhatt, and Amit Ganatra. "A survey on data mining technologies for decision support system of maternal care domain." International Journal of Computers and Applications 138, no. 10 (2016): 20-4.

[19] Abegaz, Kedir Hussein, and Ephrem Mannekulih Habtewold. "Trend and barriers of antenatal care utilization from 2000 to 2016 Ethiopian DHS: a data mining approach." Scientific African 3 (2019): e00063.

[20] Bauserman, M., Lokangaka, A., Thorsten, V., Tshefu, A., Goudar, S.S., Esamai, F., Garces, A., Saleem, S., Pasha, O., Patel, A. and Manasyan, A., 2015. Risk factors for maternal death and trends in maternal mortality in low-and-middle-income countries: a prospective longitudinal cohort analysis. *Reproductive health*, *12*(2), p.S5.

[21] Sato, Hiroyuki, Kazuhiro Yoshimura, Hiroyuki Nakamoto, Daijiro Ishibashi, Yoshihiro Nakata, Yoshinori Yaginuma, and Shoichi Masui. "19.2 cm 3 flexible fetal heart rate sensor for improved quality of pregnancy life." In *2016 IEEE Biomedical Circuits and Systems Conference (BioCAS)*, pp. 140-143. IEEE, 2016.

[22] Gomez, Jorge, Byron Oviedo, and Emilio Zhuma. "Patient monitoring system based on internet of things." *Procedia Computer Science* 83 (2016): 90-97.

[23] Mangesi, Lindeka, G. Justus Hofmeyr, Valerie Smith, and Rebecca MD Smyth. "Fetal movement counting for assessment of fetal wellbeing." *Cochrane Database of Systematic Reviews* 10 (2015).

[24] Louise C. Kenny 1 , Tina Lavender 2 , Roseanne McNamee 3 , Sine´ad M. O'Neill 4 , Tracey Mills 2 ,Ali S. Khashan 1,5 *, February 20, 2013, *Advanced Maternal Age and Adverse Pregnancy Outcome: Evidence from a Large Contemporary Cohort*, DOI:10.1371/journal.pone.0056583.

[25] Sarah Ali, Anne Dornhorst, *Diabetes in pregnancy: health risks and management*, *Postgrad Med* J2011;87:417e427.doi:10.1136/pgmj.2010.10915.

View publication stats