Content lists available at Pubmedia

International Journal of Health and Information System (IJHIS)

journal homepage : https://ijhis.pubmedia.id/index.php/ijhis

Article

Implementation of Risk Factor Detection System Using k-NN Method to Reduce Maternal Mortality Rate at Sumbersari Primary Health Centre

Bakhtiyar Hadi Prakoso [1*], Muhammad Yunus [2], Angga Rahagiyanto [3,4], Veronika Vestine [5], Gandu Eko Julianto Suyoso [6], Atma Deharja [7]

[1] Jurusan Kesehatan, Politeknik Negeri Jember; bakhtiyar.hp@polije.ac.id
[2] Jurusan Kesehatan, Politeknik Negeri Jember; m.yunus@polije.ac.id
[3] Jurusan Kesehatan, Politeknik Negeri Jember; rahagiyanto@polije.ac.id
[4] Graduate School of Information Science Engineering, Ritsumeikan University; gr0734xe@ed.ritsumei.ac.jp
[5] Jurusan Kesehatan, Politeknik Negeri Jember; veronikavestine@polije.ac.id
[6] Jurusan Kesehatan, Politeknik Negeri Jember; gandu.eko.js@polije.ac.id
[7] Jurusan Kesehatan, Politeknik Negeri Jember; atma_deharja@polije.ac.id

* Correspondence: bakhtiyar.hp@polije.co.id; Tel.: +6282257197272

Abstract: The Maternal Mortality Rate has become a major issue for the Indonesian government as it can be used to measure the reproductive health level of a country. In 2023, the maternal mortality rate in Jember Regency was recorded at 150 per 100,000 live births. Sumbersari Primary Heath Centre is one of Primary Health in Jember, located in the city. Still had cases of maternal mortality, with two recorded cases The Jember Regency government has implemented various interventions, including the implementation of integrated antenatal care (ANC), the preparation of emergency obstetric and neonatal management guidelines, and collaboration with educational institutions to support pregnant women, strengthen maternal and neonatal referrals, and enhance the PONED and PONEK maternity teams. In line with these programs, there is a need for synergy in utilizing information technology to support the Jember government's efforts to reduce maternal mortality rates through the creation of an early detection system to predict maternal deaths. This research will develop an early detection system for maternal mortality using the KNN method. The attributes used include gestational age, weight, haemoglobin, blood pressure A, blood pressure B, facial swelling, stillbirth, breech birth, bleeding during pregnancy, hydramnios, post-term pregnancy, transverse presentation, preeclampsia/eclampsia, anaemia, tuberculosis, malaria, and heart failure. The system development will utilize the prototype method. The test results show that the system can be used to predict maternal mortality with an accuracy rate of 0.67. This accuracy level depends on the amount of training data entered the system.

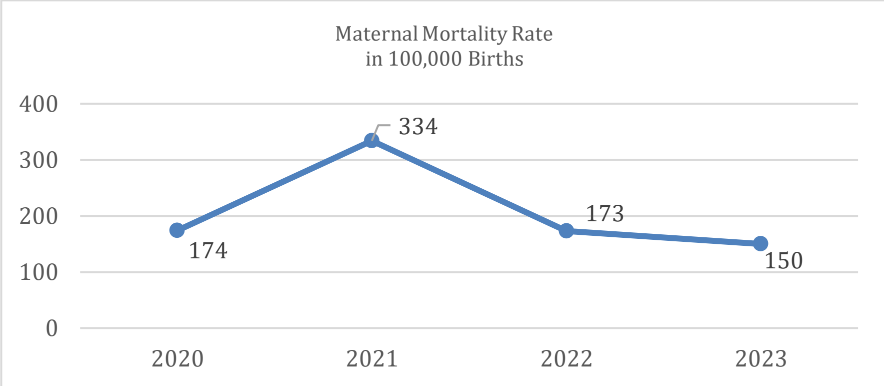
Keywords: MMR (Maternal Mortality Rate), Early Detection, Pregnant Women, KNN (K-Nearest Neighbours), SDLC

Citation: B. H. Prakoso, M. Yunus, A. Rahagiyanto, V. Vestine, G. E. J. Suyoso, and A. Deharja, " Implementation of Risk Factor Detection System Using k-NN Method to Reduce Maternal Mortality Rate at Sumbersari Primary Health Centre", *IJHIS*, vol. 2, no. 3, pp. 117–124, Dec. 2024.

Received: 25-10-2024
Accepted: 21-12-2024
Published: 26-12-2024

1. Introduction

The Maternal Mortality Rate has become a major issue for the Indonesian government as it can be used to measure the reproductive health level of a country. According to data released by the National Central Statistics Agency in 2020, the maternal and child mortality rate in Indonesia stood at 189 per 100,000 live births. This figure is relatively high considering the SDG target to reduce the Maternal Mortality Rate to less than 70 per 100,000 live births. Jember is one of the regencies with a fairly large population in East Java Province. In 2023, it was recorded that the Maternal Mortality Rate was 150 per 100,000 live births. [1]. This figure is quite significant; thus intervention is needed to help reduce the high Maternal Mortality Rate (MMR). Figure 1 shows that over the past four years, the number of maternal deaths has been relatively high.



Source: Jember Regency Health Office

Figure 1. Maternal Mortality Rate in Jember

Sumbersari Primary Heath Centre is one of Primary Health in Jember, located in the city, with a relatively high birth rate. According to data released by the Jember district health office in 2023, Sumbersari Primary Heath Centre still had cases of maternal mortality, with two recorded cases. This situation has become a major concern for the health department, as this area is in the city centre, where maternal mortality rates should be reduced. To reduce the Maternal Mortality Rate (MMR), which is still far from the target set in the SDGs, the Jember Regency Health Office has implemented various interventions. These include the implementation of integrated ANC (Antenatal Care), the development of emergency management guidelines for obstetrics and neonatal care, collaboration with educational institutions for supporting pregnant women, strengthening maternal and neonatal referral systems, and reinforcing PONED (Basic Emergency Obstetric and Neonatal Services) and PONEK (Comprehensive Emergency Obstetric and Neonatal Services) teams in delivery wards. [1]. In line with this program, there is a need for synergy in utilizing information technology to support the Jember government's efforts in reducing the Maternal Mortality Rate (MMR). The use of information technology can enhance healthcare programs and strengthen these efforts. [2]. An implementation that can be carried out is the development of a system that can detect early risk factors for Maternal Mortality Rate (MMR). This system would help identify potential risks early, enabling timely interventions to reduce maternal deaths. [3]. Katja Hannola et al., in their research, demonstrated that early detection systems can predict mortality in pregnant women. This type of system is crucial in identifying high-risk pregnancies, allowing healthcare providers to take preventive measures and provide necessary interventions to reduce maternal deaths. [4]. Meanwhile, Dominguez, in his research, has developed an early prediction system for maternal mortality using data science techniques. This approach leverages data analysis to predict and identify at-risk pregnancies, enabling timely interventions to improve maternal health outcomes. [5]

This early detection system is closely related to the concept of Data Mining. In healthcare, data mining can be used to analyse and predict diseases and assist in early diagnosis of medical conditions. By extracting patterns and insights from large datasets, data mining helps in identifying risk factors and improving patient care. [5]. The concept of predicting a disease in data mining uses classification methods. One of the algorithms used for classification is K-Nearest Neighbours (KNN). KNN is a data mining algorithm that falls under the category of supervised learning. This algorithm performs well in determining the classification of maternal mortality risk, making it a suitable choice for predicting and identifying high-risk pregnancies. [6]. In this study, a system has been developed to identify early risk factors for maternal mortality during pregnancy and childbirth. This system utilizes the K-Nearest Neighbours (KNN) data mining algorithm to determine risk factors for maternal mortality, which can then be used for early risk assessment of pregnant women.

2. Materials and Methods

2.1 MMR (Maternal Mortality Rate)

Maternal mortality rate is one of the indicators used to determine the health level in a region. This indicator is based on the number of maternal deaths due to complications during pregnancy, childbirth, and postpartum per 100,000 live births. In Indonesia, the maternal mortality rate is influenced by several factors, including economic, social, and cultural conditions. [7]

In addition to the previously mentioned factors, the Maternal Mortality Rate (MMR) is also influenced by the mother's own health conditions. Key risk factors include gestational age, body weight, haemoglobin levels, blood pressure (both systolic and diastolic), facial swelling, stillbirths, breech presentation, pregnancy-related bleeding, hydramnios (excess amniotic fluid), prolonged pregnancy, transverse lie (baby lying sideways), pre-eclampsia/eclampsia, anaemia, tuberculosis, malaria, and congestive heart disease[8].

2.2 KNN

K-Nearest Neighbours (KNN) is a data mining algorithm used for classification processes. This algorithm works by finding the 'k' nearest points to a given data point. It then classifies the data point based on the most frequently occurring class among these nearest neighbours. [9]. The process of finding the nearest points in K-Nearest Neighbors (KNN) is calculated using the Euclidean Distance formula [10]

$$d(p,q) = \sqrt{(p_1 - p_1)^2 + (p_2 - p_2)^2 + \cdots + (p_n - p_n)^2} \quad (1)$$

Explanation

- Where p and q are points.
- $(p_1 - p_1)^2$ the square of the difference between two points in the n dimension

The following is the pseudocode

2.3 SDLC

SDLC The Systems Development Life Cycle (SDLC) is a framework used for the development of information systems or applications[11]. In this study, the development method employed is the prototype method. The prototype development method emphasizes customer needs[12]. Some of the stages involved in the prototype method include:

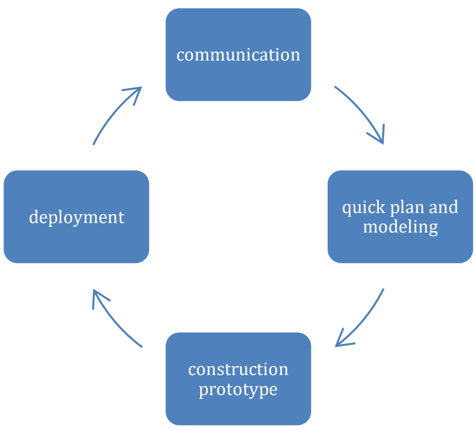


Figure 2. Stages of the Prototype Method

The four main stages in the prototype method are:

1. Communication

Communication is the initial stage in the prototype development method. In this stage, developers establish communication with users. This communication is conducted intensively to gather user requirements.

2. Quick plan and modelling

In this stage, a model of the application is created quickly. This model serves as the foundation for building the application.

3. Construction prototype

During this stage, the application is developed based on the model created in the previous stage.

4. Deployment

Deployment is the final step in the prototype method. After the application is completed and tested with users, it is delivered to them. This stage also ensures that no further revisions are needed for the application.

There are two stages in this research. The first stage is forming a classification model using the KNN algorithm. The second stage is creating an early detection system that includes the KNN model. The development of the classification model begins with collecting data used for the training process. The data used for the prediction or classification process is based on examinations of pregnant women. The data was collected in 2024 from medical records at the Sumbersari Primary Health Center. A total of 98 data points were collected, consisting of 59 data points from the Low-Risk Group (KRR), 35 data points from the High-Risk Group (KRT), and 4 data points from the Very High-Risk Group (KRST). The conceptual framework of the application can be seen in Figure 3 below.

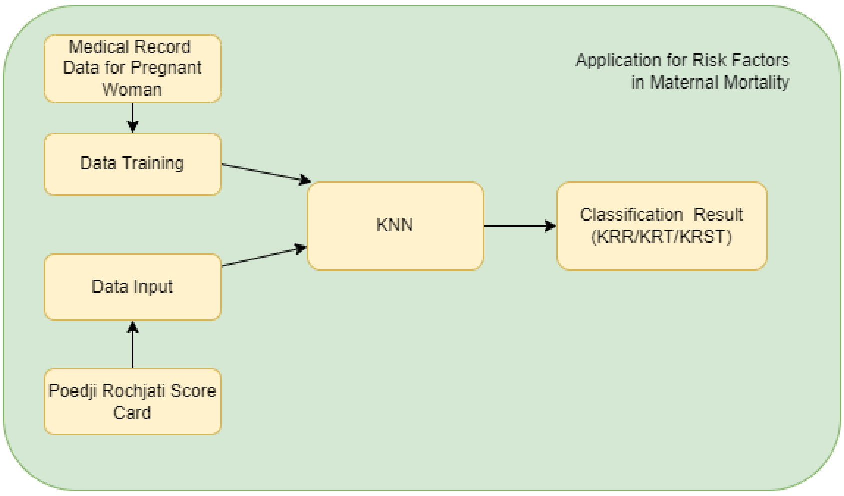


Figure 3. Application Conceptual Framework

Figure 3 explains the conceptual framework of the built application. The application produces a classification of risk factors for maternal mortality. The input data represents the features used to assess the risk factors. It takes Puji Rochyati Score Card. Meanwhile, the training data is taken from real data stored in the database. The classification process is carried out using the KNN algorithm, which will ultimately produce a classification of (KRR) Low-Risk Pregnancy, (KRT) High-Risk Pregnancy, (KRST) Very High-Risk Pregnancy. The model developed will be evaluated for its effectiveness by measuring its accuracy.

The second stage of the research begins with the development of the application. The application development is carried out using the prototype method. According to the theory found in the literature review, the application development process consists of four main stages: Communication, Quick plan and modelling, Construction of the prototype, and Deployment. The prediction system is developed using a web-based concept. Before being handed over to the user, the system will undergo testing to assess its functionality and determine whether it operates properly or not.

3. Results and Discussion

Communication is the initial stage in the prototype development method. At this stage, the developer establishes communication with the users. Communication is built intensively to gather needs. In this stage, communication was established with healthcare professionals (midwives) at a community health centre to identify risk factors related to maternal mortality. The influencing factor take from Pudji Rochjati Scorecard. The influencing factors include Mother's Age, Pregnancy at a Very Young Age, Mother's Age Too Old, Pregnancy Age (weeks), Height, Mother Too Short, Number of Pregnancies, Too Many Children, Previous Miscarriage, Long Interval Between Pregnancies, Quick Succession of Pregnancies, Pregnant Again at an Older Age, First Pregnancy Delayed, First Pregnancy, Arm Circumference, Overdue Pregnancy, Weight (Kg), Blood Pressure A, Blood Pressure B, Breech Baby, Transverse Baby, Vacuum Extraction, Manual Removal of Placenta, Infusion, Caesarean Section (SC), Malaria, Pulmonary Tuberculosis (TB), Heart Failure, Swollen Face, Bleeding During Pregnancy, Haemoglobin (Hb), Anaemia, Sexually Transmitted Infections (STIs), Preeclampsia/Eclampsia, Diabetes, Stillbirth, Twin Pregnancy, Hydramnios (excessive amniotic fluid) These factors will become the input risk factors.

Based on the needs analysis, it was found that the application can be used to enter patient examination data. The input data can be assessed for its risk level, whether it is (KRR) Low-Risk Pregnancy, (KRT) High-Risk Pregnancy, (KRST) Very High-Risk Pregnancy. The application is created using a web-based concept, which allows users to easily access it via mobile phones or browsers. Figure 3 shows one of the designs for the Maternal Examination Input

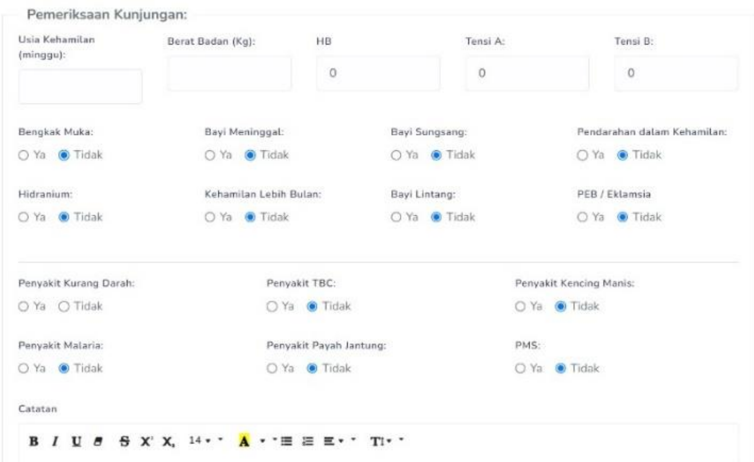


Figure 4. Maternal Examination Input

The test was conducted in two stages. The first stage involved an initial test to assess the accuracy level of the constructed classification model. This test was carried out by creating a confusion matrix, allowing the accuracy level to be calculated from the table.

		Predicted			
		KRR	KRST	KRT	Σ
Actual	KRR	55	0	4	59
	KRST	4	0	0	4
	KRT	24	0	11	35
	Σ	83	0	15	98

Figure 5. *Confusion Matrix Calculation Results*

Based on the data presented in the confusion matrix on Figure 5, it can be used to measure the accuracy level using the formula

$$Accuracy = \frac{TP + TN}{TP+FP+FN+TN} \quad (2)$$

If calculated, the figure obtained would be

$$Accuracy = \frac{55 + 11}{28+11+4+55}$$

$$Accuracy = \frac{66}{98} = 0{,}67$$

Based on these calculations, the accuracy figure mentioned above is still fairly good. Domínguez, in his application, mentioned that the accuracy level for the application developed in the study was 0.7236 [13]. In another study, the use of machine learning to predict maternal health risks also achieved an accuracy of 0.7021[4]. Based on these results, the accuracy rate of 0.67 in this system is still relatively low compared to previous studies. Factors contributing to this could include the unbalanced proportion of data between Low-Risk Pregnancy (KRR), High-Risk Pregnancy (KRT), and Very High-Risk Pregnancy (KRST).

The second trial was conducted to assess the functionality of the classification system built. The trial was carried out using the Blackbox method, allowing users to test the functionality of the developed application. The following is a list of the test results

Table 1. Black Box Test Results

No	Scenario	Expectations	Actual Result	Test Status
1	The user enters the username and password, then presses the login button	The user can access the dashboard page	V	PASS
2	The user enters the examination data, then presses the Calculate Risk button using KNN	The user can view the pregnancy risk prediction results	V	PASS
3	The user edits the value of K and enters a new K	The value of K information is updated	V	PASS
4	The user adds patient data by filling in the provided fields	The patient data increases	V	PASS

Based on the test results in Table 1, the system has been functioning according to the functionality designed in the quick plan and modelling stages. The system can display the classification of toddlers according (KRR) Low-Risk Pregnancy, (KRT) High-Risk Pregnancy, (KRST) Very High-Risk Pregnancy

4. Conclusions

Based on the results of the previous discussions and deliberations, it was concluded that the system developed has an accuracy level below the average of previous research, at 0.67. This figure is still considered relatively low, given that the training data obtained amounted to 98 data points. The system's functionality has worked well and is able to provide the expected output. The novelty of this research is that the system can serve as a prototype model for the development of an early detection system for risk factors of maternal mortality. For future research, more data is needed to assess the accuracy level produced. This way, the model used can be maximized to determine the early detection level of risk factors for maternal mortality.

5. Patents

This section is not mandatory but may be added if there are patents resulting from the work reported in this manuscript.

Supplementary Materials: -

Author Contributions:, Bakhtiyar Hadi Prakoso, Veronika Vestine, Muhaammad Yunus, Angga Rahagiyanto, Atma Deharja, and Gandu Eko Julianto Suyoso; methodology, Bakhtiyar Hadi Prakoso, Muhaammad Yunus, Atma Deharja, and Gandu Eko Julianto Suyoso; software, Bakhtiyar Hadi Prakoso, Muhammad Yunus; validation, Atma Deharja, Gandu Eko Julianto Suyoso, Angga Rahaiganto, Atma Deharja; writing—original draft preparation, Veronika Vestine; writing—review and editing, Veronika Vestine. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by Politeknik Negeri Jember.

Institutional Review Board Statement: Not applicable

Informed Consent Statement: Not applicable.

.

Data Availability Statement: Not applicable.

Acknowledgments: he expression of gratitude is directed towards the State Polytechnic of Jember for providing the Non-Tax Revenue(PNBP) fund and the opportunity for the authors to conduct research. Also, a heartfelt thank you is extended to the Tefa House of Health Promotion for providing the research space

Conflicts of Interest: The authors declare no conflict of interest

References

[1] D. K. K. Jember, *Profil Kesehatan Kabupaten Jember Tahun 2023*. 2023.

[2] A. Chatterjee, A. Prinz, M. Gerdes, and S. Martinez, "Digital Interventions on Healthy Lifestyle Management: Systematic Review," *J. Med. Internet Res.*, vol. 23, no. 11, p. e26931, Nov. 2021, doi: 10.2196/26931.

[3] N. B. Mahiddin, Z. A. Othman, A. A. Bakar, and N. A. A. Rahim, "An Interrelated Decision-Making Model for an Intelligent Decision Support System in Healthcare," *IEEE Access*, vol. 10, pp. 31660–31676, 2022, doi: 10.1109/ACCESS.2022.3160725.

[4] K. Hannola, S. Hoppu, S. Mennander, H. Huhtala, H. Laivuori, and K. Tihtonen, "Obstetric early warning system to predict maternal morbidity of pre-eclampsia, postpartum hemorrhage and infection after birth in high-risk women: a prospective cohort study," *Midwifery*, vol. 99, p. 103015, 2021, doi: https://doi.org/10.1016/j.midw.2021.103015.

[5] P. Chhabra and R. Madaan, "Data mining concepts in healthcare with discussion on prediction of diseases," in *2022 International Conference on Machine Learning, Big Data, Cloud and Parallel Computing (COM-IT-CON)*, May 2022, pp. 71–77. doi: 10.1109/COM-IT-CON54601.2022.9850851.

[6] M. Fatmawati *et al.*, "Maternal Health Risk Classification - A Comparison between Algorithm Decision Tree and k-Nearest Neighbor (kNN)," in *2023 International Conference on Sustainable Emerging Innovations in Engineering and Technology (ICSEIET)*, Sep. 2023, pp. 507–511. doi: 10.1109/ICSEIET58677.2023.10303507.

[7] A. E. L. Takaeb, "Exploration of Socio-Cultural Determinants of Maternal Mortality in Indonesia," 2020. doi: 10.2991/aebmr.k.201212.067.

[8] N. Herlina, S. Nawangsari, R. K. Harahap, E. Ekowati, and A. I. Asmarany, "Pengembangan Skrining Deteksi Resiko Kehamilan Berdasarkan Kriteria Keadaan dan Kondisi Ibu Hamil," *J. Aisyah J. Ilmu Kesehat.*, vol. 6, no. 3, Sep. 2021, doi: 10.30604/jika.v6i3.536.

[9] S. Uddin, I. Haque, H. Lu, M. A. Moni, and E. Gide, "Comparative performance analysis of K-nearest neighbour (KNN) algorithm and its different variants for disease prediction," *Sci. Rep.*, vol. 12, no. 1, p. 6256, Apr. 2022, doi: 10.1038/s41598-022-10358-x.

[10] K. Gouda, M. Hassaan, and M. J. Zaki, "Prism: A Primal-Encoding Approach for Frequent Sequence Mining," in *Seventh IEEE International Conference on Data Mining (ICDM 2007)*, Oct. 2007, pp. 487–492. doi: 10.1109/ICDM.2007.33.

[11] R. S. Ghumatkar and A. Date, "Software Development Life Cycle (SDLC)," *Int. J. Res. Appl. Sci. Eng. Technol.*, vol. 11, no. 11, pp. 1162–1165, Nov. 2023, doi: 10.22214/ijraset.2023.56554.

[12] R. S. Weinberg, "Prototyping and the Systems Development Life Cycle," *J. Inf. Syst. Manag.*, vol. 8, no. 2, pp. 47–53, Jan. 1991, doi: 10.1080/07399019108964983.

[13] R. Domínguez-Domínguez, G. H. Alférez, V. González-Mejia, and N. Donías, "Data Science Application for Creation of Maternal Morbidity and Mortality Predictive Software," Sep. 2023, pp. 1–8. doi: 10.54808/WMSCI2023.01.1.