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Implementation of the Naive Bayes Algorithm for Death Due to Heart Failure Using Rapid Miner

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ABSTRACT

Until now there is no treatment that can specifically treat heart failure problems. Heart failure treatment only functions to control symptoms, improve quality of life so that patients can carry out normal activities, and reduce the risk of complications due to heart failure such as heart rhythm disturbances, kidney and lung function disorders, stroke, and sudden death. Heart failure is a condition when the heart pump weakens so that it is unable to circulate sufficient blood throughout the body. This condition is also called congestive heart failure. Until now there is no treatment that can specifically treat heart failure problems. This research is a descriptive study which aims to describe the condition of heart failure. By using classification techniques in data mining on data from patients suffering from heart failure using the Naive Bayes algorithm. By using the Rapid Miner tool, data processing is based on the dataset, using classification techniques and data mining stages to classify data on patients suffering from heart failure. By using the Rapid Miner tool, the data processing that will be used as a data collection in this research is collected into 90% training data and 10% testing data. The research results showed an accuracy rate of 80.00%, precision of 66.67% and recall of 100.00%. Based on the research that has been conducted, it is concluded that classification techniques using the Naive Bayes algorithm can be used to determine the potential for life and death in heart failure sufferers.

INTRODUCTION

Congestive heart failure is a condition where fluid builds up in the interstitial space and intravascular compartment due to failure of the kidneys to excrete salt and water so that pressure on the heart increases (Yunisa Arini Putri et al., 2023). Globally, this disease is a non-communicable disease which is the number one cause of death every year (Muhammad Faiz Fahrizal Ardhiansyah & Dian Hudiyawati, 2023). eart failure is a health problem that continues to grow in the world. Heart failure is a serious problem in the world. Heart failure can occur at young to old ages, but in old age this disease occurs more often (Lumi, 2021). Based on 2018 Basic Health Research data, the prevalence of heart failure diagnosed by doctors in Indonesia was 1,017,290 (1.5%). In Central Java alone, it is estimated that 132,565 (1.6%) people suffer from heart failure (Latifardani & Hudiyawati, 2023).

Data from the Ministry of the Republic of Indonesia in 2011, heart disease has become one of the important health diseases in society and is the main cause of death. Meanwhile, based on Basic Health Research or Riskesdas in 2009, it shows that heart disease ranks third in the number of patients in hospitals in Indonesia (Ministry of Health, 2008). The high risk of death due to heart failure can be reduced. Lack of public knowledge about deaths due to heart failure. So it is necessary to take early steps as a handling and prevention effort. This can be avoided by utilizing patient data that has been stored in a database to create a pattern for determining heart failure using intelligent computing techniques so that the public knows the factors that cause death due to heart failure.

Based on this background, the author carried out a method for screening deaths due to heart failure by applying data mining. The author carries out a classification technique using the Naive Bayes algorithm to process data on deaths due to heart failure using RapidMiner so that accuracy results from the Naive Bayes algorithm for heart failure will be obtained.

LITERATURE REVIEW

Heart disease is a general term for all diseases that attack the heart, which is a major health problem that is the number one cause of death in the world. Symptoms of heart disease vary greatly, depending on the type of heart disease experienced. In coronary heart disease, the main symptom is chest pain. Some of the causal factors include an unhealthy lifestyle, hypertension, diabetes, obesity and genetic factors (Erdania et al., 2023). In research conducted at RSUD Dr. (H.C.) Ir. Soekarno, Bangka Belitung Province in 2022, using a descriptive design, namely describing factors related to the incidence of Coronary Heart Disease (CHD). A comprehensive assessment of mental and emotional functioning

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can provide important insights for designing appropriate interventions and help individuals with heart disease or other chronic conditions to better manage their mental and emotional conditions (Siallagan, 2021).

Using a sample of 74 respondents. From the results of this study, it was concluded that respondents who rarely exercised less than respondents who exercised frequently. Efforts to prevent and treat heart disease involve a holistic approach, including lifestyle changes, increased awareness of risk factors, and better access to medical care (Nursita & Pratiwi, 2020). In Winda's research, early diagnosis and appropriate treatment are the keys to reducing death rates from heart disease. This includes educating the public about healthy lifestyles (Winda Sinthya Naomi et al., 2021). In his research, it was stated that the highest prevalence of CHD in Indonesia was 2,650,340 people and East Nusa Tenggara Province was in first place with 137,130 cases. CHD is caused by modifiable and non-modifiable risk factors.

Heart failure is a complex syndrome that occurs due to heart defects that damage the ventricles' ability to fill and pump blood effectively (Felsi Ratna Sari et al., 2023). This research used a case study design, implementing 2 heart failure patients in the Heart Room of Jendral Ahmad Yani Hospital, Metro City, using descriptive analysis (Saida et al., 2020). By using a cross-sectional design analysis on 104 heart failure patients, this study used a sampling technique where the sample was selected based on certain criteria determined by the researcher. Statistical analysis was carried out using the chi-square test with a 95% confidence interval (alpha = 0.05).

With the continued development of technology and deep learning methods, the potential for disease identification and diagnosis is expected to increase, bringing significant advances in the fields of medicine and health (Massie & Widodo, 2023). With a better understanding of medical conditions and implementing appropriate lifestyle changes, patients can manage their conditions more effectively and reduce the risk of long-term complications (Andy Susbandiyah Ifada et al., 2017). The Naive Bayes method is an accurate algorithm in making predictions because the accuracy results using Rapid Miner show more than 50%, namely 76.77% (Yunita, 2021). Using a quantitative descriptive research design with a cross sectional approach, with a sample of 30 respondents. The analysis used is univariate to determine the frequency distribution (Andy Kristiyan et al., 2023).

The research "Analysis of Modification of Coronary Heart Disease Risk Factors at RSU Haji Surabaya in 2019" (Selva Dwi Prahasti & Lukman Fauzi, 2021) is research that identifies factors that are proven to contribute significantly to CHD risk. The research uses the Naive Bayes model to identify the factors that most influence the prediction of heart failure, which can provide a basis for recommendations for further prevention or treatment of heart failure, as well as implications for public health policy (Dewi & Sariasih, 2019).

METHOD

Research Stages

There needs to be a research stage in looking for patterns in the data of patients experiencing heart failure so that the research can take place systematically in accordance with the desired objectives, so the research stages are carried out as follows:

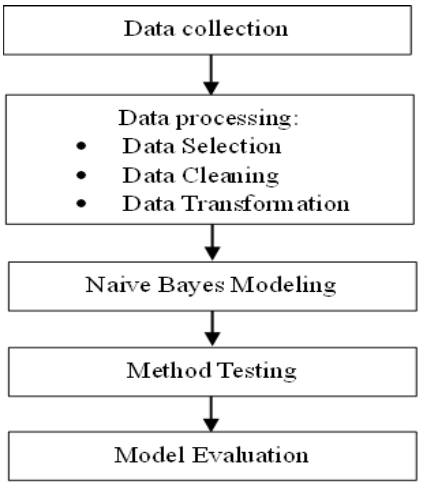

Figure 1. Research Stage

This research uses classification techniques and data mining stages to classify data on patients suffering from heart failure using the Naive Bayes algorithm. The data processing that will be used as a dataset in this research is grouped into 90% training data and 10% testing data. Grouping the data into two, namely training data and testing data, aims to ensure that the model obtained will have good generalization for data classification.

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a. Data Cleaning

Data cleaning is a data cleaning stage that will be used in deleting data by removing missing values, duplicate data, and checking if there are any inconsistencies in the data and then correcting errors in the data. The data cleaning stage was carried out manually with the help of spreadsheet software.

b. Data Selection

Data Selection is the stage of selecting data from a group of operational data before entering the data mining and information process. At this stage, the selection of attributes or variables that are appropriate to those that will be used in the research is used. Because not all attributes in the database can be used to conduct research. By sorting the attributes that will be used and eliminating attributes that are less relevant or if there is data that is damaged or cannot be used. The attributes or variables used in this research can be seen in the following table:

Table 1. Data Selection

Attributes Before Selection		**Attributes After Selection**	
No	Attribute	No	Attribute
1	Status	1	Status
2	Age	2	Age
3	Gender	3	Gender
4	Cancer	4	Cancer
5	Dementia	5	Dementia
6	Diabetes	6	diabetes
7	Hypertension	7	Hypertension
8	Isekimia	8	Isekimia
9	Mental_health	9	Mental_health
10	Chronic pulmonary	10	Chronic pulmonary
11	Obesity	11	Obesity
12	Pvd	12	Pvd
13	Valvular_disease	13	Valvular_disease
14	Pacemaker	14	Pacemaker
15	Pneumonia	15	Pneumonia
16	Stroke	16	Stroke
17	Senile	17	Senile
18	Prosperity	18	Prosperity
19	Ethnicgroup		-
20	Defib		-
21	IHD		-
22	Arrhythmias		-
23	Copd		-
24	Metastatic_cancer		-
25	Prior_appts_attended		-
26	Prior_appts_attended		-
27	Fu_time		-

c. Data Transformation

Data Transformation is a stage of changing the initial data format into a standard data format for the data reading stage with the algorithm in the program to be used. In managing data, in order to achieve good accuracy results, the data must be transformed into a form of data that is easy to understand. In this research, the downloaded data is converted into qualitative data which makes modeling easier, where Binominal is the type used for two classes and Polynominal is the type for more than two classes.

Modeling

The modeling technique used in this research is using data mining classification techniques with the Naive Bayes algorithm. Because the Naive Bayes algorithm is a method commonly used in data mining research to classify the data being studied, especially in the prediction of heart failure. The Naive Bayes algorithm is an algorithm that has been widely used or implemented in classification techniques. This algorithm also has the advantage of good accuracy in handling a dataset. The following is a training data modeling table:

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Table 2. Training Data Modeling

Status	Age	Gender	Cancer	Dementia	Diabetes	Hypertension	Ischemia	Mental Health	Chronic Pulmonary	Obesity	PVD	Valvular Disease	Pacemakers	Pneumonia	Strokes
Life	Elderly	Woman	No	No	No	No	No	No	No	No	No	Yes	No	No	No
Life	Elderly	Man	No	No	No	Yes	Yes	No	No	No	No	Yes	No	Yes	No
Life	Elderly	Woman	No	No	No	Yes	No	No	No	No	No	No	No	No	No
Life	Elderly	Man	No	No	Yes	Yes	Yes	No	Yes	No	No	No	Yes	No	Yes
Life	Elderly	Woman	No	No	Yes	Yes	No	No	No	No	No	No	No	No	No
Life	Elderly	Man	No	No	No	No	No	No	No	No	Yes	Yes	No	Yes	No
Life	Born	Man	No	No	No	Yes	No	No	No	No	No	No	No	No	No
Life	Elderly	Woman	No	No	No	Yes	No	No	No	No	No	No	No	No	No
Life	Elderly	Woman	No	No	No	No	No	No	Yes	No	No	No	No	No	Yes
Life	Born	Woman	No	No	No	No	No	No	No	No	No	No	No	No	No
Life	Elderly	Man	No	No	No	Yes	Yes	No	No	No	No	No	No	No	No
Life	Elderly	Woman	No	No	No	No	Yes	No	Yes	No	No	No	No	No	No
Life	Elderly	Woman	No	No	No	Yes	No	No	No	No	No	No	No	No	No
Life	Born	Man	No	No	No	Yes	Yes	No	No	No	No	No	No	No	No
Life	Elderly	Man	No	No	Yes	Yes	Yes	No	Yes	No	No	Yes	Yes	No	No
Life	Elderly	Man	No	No	No	No	Yes	No	No	No	No	No	No	No	No
Die	Born	Man	Yes	No	Yes	Yes	Yes	No	Yes	No	No	No	No	Yes	No
Die	Elderly	Woman	No	No	Yes	Yes	No	No	Yes	No	No	No	No	Yes	No
Life	Elderly	Man	No	No	Yes	No	Yes	No	No	No	No	No	No	Yes	No
Life	Elderly	Man	No	No	No	Yes	No	No	Yes	No	Yes	Yes	No	No	No
Life	Elderly	Woman	No	No	No	Yes	No	No	Yes	No	Yes	Yes	No	No	No
Life	Elderly	Woman	No	No	Yes	Yes	Yes	No	Yes	No	No	No	No	No	No
Life	Born	Man	Yes	No	Yes	Yes	Yes	No	No	No	No	Yes	No	No	No
Die	Born	Man	No	No	Yes	Yes	Yes	No	No	No	Yes	No	No	No	No
Life	Born	Woman	No	No	No	Yes	Yes	No	No	No	No	Yes	Yes	No	No
Life	Born	Man	No	No	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No

Testing and Validation of Results

The method that will be used in this research is the Naive Bayes algorithm. In modeling the Naive Bayes algorithm, it will be carried out by measuring the results of accuracy, precision and recall on the basis of confusion matrix calculations. The data used has gone through a data learning process, to carry out measurements in this research using the rapidminer tool.

Table 3. Confusion Matrix Formula

		Prediction	
Actual		Positive	Negative
	Positive	True Positive (TP)	False Negative (FN)
	Negative	Negative Positive (FP)	True Negative (TN)

Explanation of the table above:
- TN = actual and predicted values are both positive
- FN = the actual value is positive, but the predicted value is negative
- FP = the actual value is negative, but the predicted value is positive
- TN = actual and predicted values both have negative values. From the table above it can be calculated as follows:

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

$$Precision = \frac{TN}{(TP + FP}$$

$$Recall = \frac{TP}{(TP + FN}$$

The explanation of the formula above is:

Accuracy : The level of closeness between the actual value of the data and the value predictions given from the system

Precision : The level of accuracy between the information requested and the information requested the answer given by the system

Recall : The system's success rate in rediscovering something information

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RESULT

The results of the research are testing the dataset using the naive Bayes algorithm by getting results from the accuracy, precision and recall values and getting predictions that can identify patients who are predicted to die from heart failure or who are still alive.

Test Data

The data source as an object is the type of data used in this research, namely secondary and qualitative data which the author downloaded or obtained from a public site, namely https://www.kaggle.com/ which was uploaded by Jackleen Rasmy with the link https://www .kaggle.com/jackleenrasmybareh/heart-failure. The dataset used in this research contains attributes including: age, gender, cancer, dementia, diabetes, hypertension, isekimia, mental health, chronic lung, obesity, PVD, valvular disease, pacemaker, pneumonia, stroke, senile dementia, prosperity.

Split Validation

Split Validation is a validation technique that groups data into two, namely, training data and testing data. Data that has been prepared for classification is grouped into two, namely, random sampling of training data (90%) and testing data (10%). The following is an example of calculations for creating testing data:

Total amount of data (N) = 250
Number of testing data = 10% x 250 = 25
Number of sampling (n) = 25
Sampling interval (k) = N/n = 250/25 =10

Based on the results above, we obtained testing data with a total of 100 data, then the rest is training data, namely 500 – 100 = 400 data. Testing data can be seen in table 4:

Table 4. Testing Data

Age	Gender	Cancer	Dementia	Diabetes	Hypertension	Ischemia	Mental Health	Chronic Pulmonary	Obesity	PVD	Valvular Disease	Pacemakers	Pneumonia
Elderly	Woman	No	No	No	No	No	No	No	No	No	Yes	No	No
Elderly	Man	No	No	No	Yes	Yes	No	No	No	No	Yes	No	Yes
Elderly	Man	No	No	Yes	Yes	No	No	No	No	No	No	No	No
Elderly	Man	No	No	Yes	Yes	Yes	No	Yes	No	No	No	Yes	No
Lawal	Man	No	No	No	Yes	No	No	No	No	No	No	No	No
Born	Man	No	No	No	No	No	No	No	No	Yes	Yes	No	Yes
Elderly	Woman	No	No	No	Yes	No	No	No	No	No	No	No	No
Elderly	Man	No	No	Yes	Yes	No	No	No	No	No	No	No	No
Elderly	Man	No	No	No	No	No	No	Yes	No	No	No	No	No
Born	Man	No	No	Yes	No	No	No	No	No	No	No	No	No
Born	Man	No	No	Yes	Yes	Yes	No	No	No	No	No	No	No
Elderly	Man	No	No	No	No	Yes	No	Yes	No	No	No	No	No
Elderly	Man	No	No	No	Yes	No	No	No	No	No	No	No	No
Elderly	Man	No	No	Yes	Yes	Yes	No	No	No	No	No	No	No
Elderly	Man	No	No	No	Yes	Yes	No	Yes	No	No	Yes	Yes	No
Elderly	Man	No	No	No	No	Yes	No	No	No	No	No	No	No
Elderly	Woman	Yes	No	No	Yes	Yes	No	Yes	No	No	No	No	Yes
Elderly	Man	No	No	No	Yes	No	No	Yes	No	No	No	No	Yes
Elderly	Man	No	No	Yes	No	Yes	No	No	No	No	No	No	Yes
Elderly	Man	No	No	Yes	Yes	No	No	Yes	No	Yes	Yes	No	No
Elderly	Woman	No	No	No	Yes	No	No	Yes	No	Yes	Yes	No	No
Elderly	Man	No	No	Yes	Yes	Yes	No	Yes	No	No	No	No	No
Elderly	Woman	Yes	No	No	Yes	Yes	No	No	No	No	Yes	No	No
Elderly	Man	No	No	No	Yes	Yes	No	No	No	Yes	No	No	No
Elderly	Woman	No	No	Yes	Yes	Yes	No	No	No	No	Yes	Yes	No
Elderly	Man	No	No	No	Yes	Yes	Yes	Yes	No	No	No	No	No

Manual calculations

Table 5. Posterior Probability

Attribute	Mark	Life	Die
Age	Elderly	0.476	0.476
Gender	Woman	0.600	0.400
Cancer	No	0.652	0.348
Dementia	No	0.600	0.400
Diabetes	No	0.563	0.438
Hypertension	No	0.385	0.615
Isekimia	No	0.500	0.500
Mental Health	No	0.583	0.417
Chronic Pulmonary	No	0.650	0.350

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Obesity	No	0.565	0.435
pvd	No	0.609	0.391
Valvular Disease	No	0.550	0.450
Pacemaker	No	0.565	0.435
pneumonia	No	0.700	0.300
Stroke	No	0.625	0.375
Senile	No	0.625	0.375
Prosperity	Rich	0.500	0.500

Based on the table above, the probability of each existing attribute can be calculated:

1. Probability Calculation "*Life*":
   0.524*0.6*0.625*0.6*0.563*0.385*0.5*0.65*0.565*0.609*0.55*0.565*0.7*0.625*0.625*0.5*0.6 = 0.0000728
2. Probability Calculation "*Die*":
   0.476*0.4*0.348*0.4*0.438*0.615*0.5*0.417*0.35*0.435*0.391*0.45*0.435*0.3*0.375*0.375*0.5*0.476 = 0.00000017416
3. Comparison of probabilities between "*Life*" and "*Die*"
   Probabilitas *Life* = 0.0000728
   Probabilitas *Die* = 0.00000017416

Because the probability value of "Life" is greater than the probability value of "Die", it can be concluded that the testing data is classified as "Life.

DISCUSSION

The discussion of testing in this research is an explanation of the use of rapidminer on datasets with the Naive Bayes *algorithm*.

Data testing stage in RapidMiner

Selecting attributes means knowing the prediction results and classification from RapidMiner. It can be seen in the following picture:

Figure 2. Data Testing Process Using Naive Bayes

The imported training data is entered into the design then input the Naive Bayes algorithm tools then connect the testing data into the Apply model then use the performance tools to display the performance. The next step is to implement the Naive Bayes algorithm by using the rapid miner tool:

a. Determine the accuracy, precision and recall values
   1) Accuracy is the level of closeness of prediction results to fact results.
   2) Percision is the level of accuracy between the information requested by the user and the answer provided by the system.
   3) Recall is the system's success rate in retrieving information.

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b. Determine performance

The next step for the program that has been developed is processing existing data. At this stage, an evaluation of the results of data processing with the program that has been developed is carried out. It contains two parts, namely the training data section (used for the classification algorithm) and testing data using the Apply Model feature to apply the model to the testing data and the Performance feature to display a confusion table, to be able to display the results of accuracy, recall, precision. The following is a PerformanceVector description of the modeling resulting from the Naive Bayes algorithm:

PerformanceVector

```
PerformanceVector:
accuracy: 80.00%
ConfusionMatrix:
True:   Die     Life
Die:    10      5
Life:   0       10
precision: 66.67% (positive class: Die)
ConfusionMatrix:
True:   Life    Die
Life:   10      0
Die:    5       10
recall: 100.00% (positive class: Die)
ConfusionMatrix:
True:   Life    Die
Life:   10      0
Die:    5       10
AUC (optimistic): 0.860 (positive class: Die)
AUC: 0.860 (positive class: Die)
AUC (pessimistic): 0.860 (positive class: Die)
```

Figure 3. Performance Vector

1) Accuracy calculation

Calculations from the Naive Bayes algorithm, accuracy is done by dividing the number of TP + TN by the total amount of testing data tested.

accuracy: 80.00%

	true Die	true Life	class precision
pred. Die	10	5	66.67%
pred. Life	0	10	100.00%
class recall	100.00%	66.67%	

Figure 4. Accuracy

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN} * 100\%$$
$$= \frac{10 + 10}{10 + 10 + 0 + 5} * 100\%$$
$$= \frac{20}{25} * 100\%$$
$$= 0.8 * 100$$
$$= 80\%$$

2) Precision calculations

The precision value is calculated by dividing the amount of correct data with a positive value (True Positive) divided by the number of correct data with a positive value (True Positive) and incorrect data with a positive value (False Positive).

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precision: 66.67% (positive class: Die)

	true Life	true Die	class precision
pred. Life	10	0	100.00%
pred. Die	5	10	66.67%
class recall	66.67%	100.00%	

Figure 5. Precision

$$Precision = \frac{TP}{TP + FP} * 100\%$$
$$= \frac{10}{15} * 100\%$$
$$= 0.6667 * 100$$
$$= 66{,}67\%$$

3) Recall Calculation

The recall value is calculated by dividing the correct data which has a positive value (True Positive) by the sum of the correct data which has a positive value (True Positive) and the incorrect data which has a negative value (False Negative).

recall: 100.00% (positive class: Die)

	true Life	true Die	class precision
pred. Life	10	0	100.00%
pred. Die	5	10	66.67%
class recall	66.67%	100.00%	

Figure 6. Recall

$$Recall = \frac{TP}{TP + FP} * 100\%$$
$$= \frac{10}{10} * 100\%$$
$$= 1 * 100$$
$$= 100\%$$

4) Overall Prediction Results

Table 6. Predictions

Training %	*Testing %*	*Accuracy*	*Precision*	*Recall*
90%	10%	80%	66.67%	100%

From testing data of 25 data, then the results from heart failure data stated the level of accuracy, precision and recall in the Naive Bayes algorithm, showing an accuracy level of 80.00%, Percision 66..67% and Recall 100.00% decision on the classification prediction algorithm of Naive Bayes.

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CONCLUSION

Based on the test results using the Naive Bayes algorithm, it was concluded that the classification technique using the Naive Bayes algorithm can be used to predict the potential for life and death in patients suffering from heart failure. The results of the research obtained data that stated an accuracy level of 80.00%, Precision 66.67% and Recall 100.00% were decided in the Naive Bayes classification.

REFERENCES

Andy Kristiyan, Ninuk Dian Kurniawati, & Junait Junait. (2023). Aplikasi Edukasi Presisi Manajemen Cairan terhadap Kemampuan Manajemen Cairan pada Pasien Congestive Hearth Failure (CHF). *Jurnal Keperawatan*, *16*(1), 383–396.

Andy Susbandiyah Ifada, Deswati Ilahillaili Sarkiyah, & Rizki Nugrahani. (2017). Kepatuhan Terapi Farmakologi dan Non Farmakologi Pada Pasien Diabetes Mellitus Tipe II di Puskesmas Tanjung Karang Tahun 2017. *Jurnal Ilmu Kesehatan Dan Farmasi*, *5*(2), 50–53.

Dewi, Y. N., & Sariasih, F. A. (2019). METODE SAMPLE BOOTSTRAPPING UNTUK MENINGKATKAN PERFORMA ALGORITMA NAIVE BAYES PADA CITRA TUNGGAL PAP SMEAR. *JURNAL TEKNIK INFORMATIKA*, *12*(1), 1–10. https://doi.org/10.15408/jti.v12i1.11031

Erdania, E., Faizal, M., & Anggraini, R. B. (2023). FAKTOR – FAKTOR YANG BERHUBUNGAN DENGAN KEJADIAN PENYAKIT JANTUNG KORONER (PJK) Di RSUD Dr. (H.C.) Ir. SOEKARNO PROVINSI BANGKA BELITUNG TAHUN 2022. *Jurnal Keperawatan*, *12*(1), 17–25. https://doi.org/10.47560/kep.v12i1.472

Felsi Ratna Sari, Anik Inayati, & Nia Risa Dewi. (2023). Penerapan Hand-Held Fan Terhadap Dyspnea Pasien Gagal Jantung Di Ruang Jantung Rsud Jend. Ahmad Yani Kota Metro). *Jurnal Cendekia Muda*, *3*(3), 323–330. https://jurnal.akperdharmawacana.ac.id/index.php/JWC/article/view/475

Latifardani, R., & Hudiyawati, D. (2023). Fatigue Berhubungan dengan Kualitas Hidup pada Pasien Gagal Jantung. *Jurnal Keperawatan Silampari*, *6*(2), 1756–1766. https://doi.org/10.31539/jks.v6i2.5697

Massie, J. I., & Widodo, S. M. S. P. A. M. (2023). Deep Learning untuk Klasifikasi Penyakit Retinopati Diabetik Menggunakan Arsitektur Alexnet dan Generative Adversarial Network. *Simetris: Jurnal Teknik Mesin, Elektro Dan Ilmu Komputer*, *14*(2), 251–260. https://doi.org/10.24176/simet.v14i2.9498

Muhammad Faiz Fahrizal Ardhiansyah, & Dian Hudiyawati. (2023). Hubungan Tingkat Stres Dengan Kualitas Tidur Pada Pasien Gagal Jantung. *Health Information Jurnal Penelitian*, *15*.

Nursita, H., & Pratiwi, A. (2020). Peningkatan Kualitas Hidup pada Pasien Gagal Jantung: A Narrative Review Article (Improved Quality of Life in Heart Failure Patients: A Narrative Review Article). *Jurnal Berita Ilmu Keperawatan*, *13*(1), 10–21. https://doi.org/10.23917/bik.v13i1.11916

Saida, S., Haryati, H., & Rangki, L. (2020). Kualitas Hidup Penderita Gagal Jantung Kongestif Berdasarkan Derajat Kemampuan Fisik dan Durasi Penyakit. *Faletehan Health Journal*, *7*(02), 70–76. https://doi.org/10.33746/fhj.v7i02.134

Selva Dwi Prahasti, & Lukman Fauzi. (2021). Risiko Kematian Pasien Gagal Jantung Kongestif (GJK): Studi Kohort Retrospektif Berbasis Rumah Sakit. *Indonesian Journal of Public Health and Nutrition*, *1*(3), 388–395.

Siallagan, A. M. (2021). SYSTEMATIC REVIEW: KUALITAS HIDUP PASIEN GAGAL JANTUNG KONGESTIF. *Jurnal Medika : Karya Ilmiah Kesehatan*, *6*(2). https://doi.org/10.35728/jmkik.v6i2.696

Winda Sinthya Naomi, Intje Picauly, & Sarci Magdalena Toy. (2021). FAKTOR RISIKO KEJADIAN PENYAKIT JANTUNG KORONER (Studi Kasus di RSUD Prof. Dr. W. Z. Johannes Kupang). *Media Kesehatan Masyarakat*, *3*(1), 99–107. https://ejurnal.undana.ac.id/index.php/MKM/article/view/3622

Yunisa Arini Putri, Fakhira Arminda, & RE Rizal Effendi. (2023). Penatalaksanaan Gagal Jantung Kongestif pada Pria Usia 73 Tahun dengan Prinsip Pendekatan Kedokteran Keluarga. *Jurnal Penelitian Perawat Profesional*, *5*(1), 323–334.

Yunita, Y. (2021). Implementasi K-Nearest Neighbor Dalam Prediksi Mahasiswa Berhenti Kuliah. *JURNAL MEDIA INFORMATIKA BUDIDARMA*, *5*(3), 866. https://doi.org/10.30865/mib.v5i3.3049