Jurnal Informasi dan Teknologi

https://jidt.org/jidt

2025 Vol. 7 No. 2 Hal: 1-10 e-ISSN: 2714-9730

Implementation Clustering Diabetes Suffering Areas Using Web-Based Dbscan Algorithm North Aceh District

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Abstract

Diabetes has shown a significant increase in Indonesia, including in the North Aceh District. This research implements the DBSCAN algorithm (Density-Based Spatial Clustering of Applications with Noise) web-based method to map diabetes distribution patterns in 27 North Aceh sub-districts. This system was built using the PHP programming language and database MySQL. Proses clustering utilizing data on population, number of sufferers, and number of deaths from 2021-2023 obtained from Prima Inti Medika Hospital and Cut Meutia RSU, with parameters epsilon = 0.5 and MinPts = 3. Results clustering shows an increase in high-risk areas from year to year. In 2021, 2 high-risk sub-districts were identified, Dewantara and Lhoksukon, increasing to 3 sub-districts in 2022 Dewantara, Lhoksukon, and Nisam, in 2023 to 4 sub-districts Dewantara, Lhoksukon, Nisam and Muara Batu. The resulting web-based system succeeded in visualizing diabetes distribution patterns and can be used to plan more effective and targeted health programs.

Keywords: *Clustering, Diabetes, DBSCAN Algorithm, Website*.

1. Introduction

Diabetes mellitus is a chronic metabolic disorder characterized by increased blood glucose levels or hyperglycemia [1]. This condition is generally caused by a lack of insulin production, body resistance to insulin, or a combination of both [2]. If not treated properly, diabetes can cause various serious complications such as nerve damage, impaired kidney function, impaired vision, and cardiovascular disease [3]. This disease broadly impacts individual health, community productivity, and the burden on the health system [4].

Data from the World Health Organization (WHO) and the International Diabetes Federation (IDF) show that the number of people living with diabetes in Indonesia continues to increase every year and is estimated to reach 21.3 million people in 2030 [5]. At the local level, a similar phenomenon also occurred in North Aceh Regency, where diabetes cases increased yearly. This shows the importance of early detection efforts and mapping affected areas so that interventions can be more targeted [6].

The main problem is the absence of an information system describing the spatial and dynamic distribution of diabetes cases in the region. The existing data has not been utilized optimally to analyze the geographic patterns of disease distribution. Spatial information is essential for decision-making in health intervention planning [7]. Therefore, an approach is needed that can automatically and accurately group regions based on the level of case density and identify outlier areas.

This study proposes using an algorithm called Density-Based Spatial Clustering of Applications with Noise (DBSCAN) to cluster diabetes-affected areas in the North Aceh Regency. DBSCAN was chosen because of its ability to group data based on density without having to determine the number of clusters from the start, and it is tolerant of noisy data. Compared to methods such as K-Means, DBSCAN is more suitable for complex and irregular spatial data. This system is implemented as a web-based application so interested parties, including local governments and health institutions, can widely use it.

This study aims to design and build a web-based information system that maps diabetes case clusters using the DBSCAN algorithm. This system is expected to help identify areas with low, medium, and high-risk levels more precisely. The benefits to be achieved include increasing the effectiveness of health education, efficient resource allocation planning, and support for data-based policy making. Thus, this study is expected to contribute to efforts to prevent and control diabetes more optimally, especially in the North Aceh Regency area.

Receipt: 02-01-2025 | Revision: 10-03-2025 | Publish: 31-05-2025 | doi: 10.60083/jidt.vi0.622

2. Research Methods

This study began with collecting primary data from health institutions and developing a clustering system for people with diabetes using the web-based DBSCAN algorithm. The waterfall model is used to create the system, from literature studies to system evaluation. The primary focus of this study is to group areas with different levels of diabetes spread based on hospital data.

2.1 Research Workflow

The research stages carried out show the waterfall methodology flow with the following sequence :

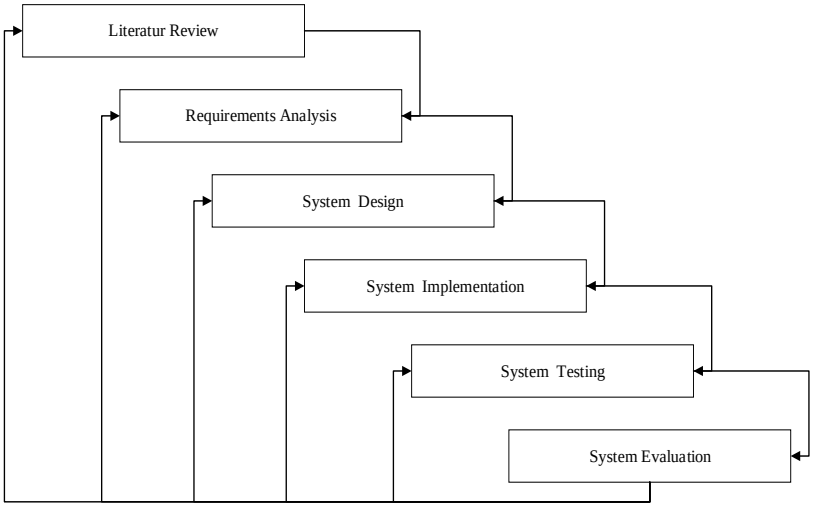

Figure 1. Research Workflow

1. Literature Review: The initial stage in this research is to conduct a literature study to gain an in-depth understanding of the topic, especially regarding the DBSCAN algorithm, clustering techniques, and relevant previous studies. Literature is collected from scientific journals, textbooks, and trusted online sources as a conceptual basis for designing the system.
2. Requirements Analysis: Needs analysis is conducted to formulate the data and functionality needed in the system. At this stage, the researcher identified the need for primary data from Prima Inti Medika Hospital and RSU Cut Meutia as the primary basis for developing the clustering system.
3. System Design: System design is done in several stages, namely system architecture design, database, and user interface. Context diagrams and system display designs are compiled to describe data flow and user interaction in a web-based system.
4. System Implementation: This stage realizes the design into a functional system using software such as XAMPP and Sublime Text. The system uses the DBSCAN algorithm to process data and produce clusters of diabetes sufferer areas.
5. System Testing: The system that has been built is tested to ensure that the functionality runs according to specifications. Testing is done by entering actual data from the hospital to see if the clustering results are following expectations.
6. System Evaluation: After testing, the system results are evaluated to identify deficiencies or errors. This evaluation is the basis for system improvements and ensures alignment between data analysis results and system output.

2.2 Place and Time of Research

This research was conducted in two healthcare institutions, namely Prima Inti Medika Hospital and Cut Meutia Hospital. Data collection was conducted directly on-site in early 2024, and the system development and testing process was carried out until mid-2025.

2.3 Data Collection and Processing

The primary data used is in the form of information on people living with diabetes from both hospitals. This data includes the geographic location of patients and relevant parameters for the clustering process. Data processing uses the DBSCAN (Density-Based Spatial Clustering of Applications with Noise) algorithm to group areas based on the density of people with diabetes.

2.4 Calculation scheme DBSCAN

The DBSCAN (Density-Based Spatial Clustering of Applications with Noise) algorithm is used in this study to cluster diabetes patient data based on the density of the area distribution. DBSCAN utilizes two main parameters: Eps (maximum Radius between points in one cluster) and MinPts (minimum number of points to form a cluster). This algorithm can recognize arbitrary cluster shapes and separate noise data. The DBSCAN algorithm work process includes the following stages:

a. Parameter Initialization: Determine the Eps and MinPts values as the basis for cluster formation.
b. Starting Point Selection (p): Select one data point randomly as the starting point.

$$d(x, y) = | x - y | \sqrt{\sum_{i=1}^{n} (x_i - y_i)^2} \quad (1)$$

c. Distance Calculation: Calculate the distance between point and other points using the Euclidean formula:
d. Cluster Formation: If the number of points within a radius is Eps ≥ MinPts, the points become core points and form clusters. Points that are adjacent and reachable to each other will be included in the cluster.
e. Noise Identification: Points not meeting the clustering requirements will be marked as noise.
f. Iteration: the process is repeated until all points have been processed.

After the DBSCAN system is built, the system will be tested to ensure that all functions run according to design, including the accuracy of the algorithm in forming clusters and the speed of response in the web interface. Evaluation is carried out by comparing the results of the system with actual data and validation from experts or related institutions

3. Results and Discussion

In this study, the algorithm tested Density-Based Spatial Clustering of Application with Noise (DBSCAN) and obtained the results of grouping areas based on the level of diabetes distribution. DBSCAN was chosen because of its ability to identify clusters based on data density and recognize outliers. Regional data in North Aceh was collected and entered into the database at the initial stage. The data used include population, number of people living with diabetes, and number of deaths due to diabetes for each region. The DBSCAN algorithm is then applied to group regions based on similarities in the characteristics of diabetes distribution.

3.1. Data Distribution Analysis

Regarding the prevalence rate and impact of diabetes in North Aceh Regency, it is necessary to review data on the number of diabetes cases, deaths due to diabetes, and the population from 2021 to 2023. This data provides an initial overview of the trend of cases and death rates and the ratio of comparison to the total population. This information is the basis for further analysis of public health conditions in the region. The following presents data on the number of diabetes cases, deaths due to diabetes, and the population of North Aceh Regency from 2021 to 2023.

Table 1. Data Distribution

No	Name	Total Population			Number of Diabetes Cases			Number of Diabetes Death		
		2021	2022	2023	2021	2022	2023	2021	2022	2023
1	Baktiya	38057	38534	39016	28	43	26	1	2	1
2	Baktiya Barat	19117	19292	19468	40	29	32	2	1	2
3	Banda Baro	7951	7991	8031	20	37	22	1	2	1
4	Cot Girek	20428	20591	20756	6	12	8	0	1	0
5	Dewantara	45951	46107	46264	381	586	839	19	29	42
6	Geuredong Pase	5631	5740	5851	3	11	8	0	1	0
7	Kuta Makmur	26742	27161	27587	9	17	24	0	1	1
8	Langkahan	22591	22708	22826	3	10	10	0	0	0

No	Name	Total Population			Number of Diabetes Cases			Number of Diabetes Death		
		2021	2022	2023	2021	2022	2023	2021	2022	2023
9	Lapang	8864	8940	9017	6	9	15	0	0	0
10	Lhoksukon	50134	50638	51149	375	502	409	15	25	20
11	Matang Kuli	18927	19135	19346	0	6	10	0	0	1
12	Meurah Mulia	21306	21634	21967	5	8	12	0	0	1
13	Muara Batu	27996	28295	28598	5	115	227	0	6	11
14	Nibong	10921	11086	11254	54	13	12	3	1	1
15	Nisam	19853	20084	20317	26	270	316	1	14	16
16	Nisam Antara	13554	13669	13785	9	26	44	0	1	2
17	Paya Bakong	15804	16088	16377	89	9	8	0	0	0
18	Pirak Timu	8912	9044	9178	0	5	14	0	0	0

Meanwhile, the number of deaths due to diabetes also shows an increasing trend, especially in Dewantara District, which recorded the highest number of deaths each year, namely 19 cases in 2021 and increasing to 29 cases in 2022. In 2023, Dewantara remains the district with the highest number of deaths due to diabetes, although the exact figure is not stated in the data. Regarding population, Lhoksukon District had the highest population during the 2021–2023 period, while Geurodong Pase District had the lowest population during the same period.

3.2. Implementation DBSCAN

In this manual implementation, the process begins by determining the appropriate eps and minPts parameter values based on the characteristics of the data. Next, for each point in the dataset, the distance to other points is calculated to identify neighbors within the eps radius. If the number of neighbors meets the minds requirement, then the point is marked as a core point and forms the beginning of a cluster. Points around the core point and still within the eps radius will be included in the same cluster. This process continues iteratively until all core points and their associated neighbors are included in the cluster. Points that do not meet the requirements as core points and are not neighbors of any core point will be categorized as noise or outliers:

a. Data Normalization

The first step in the clustering process is to normalize the data so that the scale of each variable is uniform. This study uses Standard Scaler as a normalization method; here are the results of normalization on several data samples:

Table 2. Sample Data Normalization Results

Nama	2021			2022			2023		
	Case	Death	Residents	Case	Death	Residents	Case	Death	Residents
Baktiya	-014	-0.12	1.27	-0.17	-0.15	1.30	-0.32	-0.30	1.31
Baktiya Barat	-0.02	0.10	-0.30	-0.27	-0.29	-0.29	-0.28	-0.18	-0.29
Banda Baro	-0.22	-0.12	-1.22	-0.22	-0.15	-1.22	-0.34	-0.30	-1.23
Cot Girek	-0.37	-0.35	-0.19	-0.39	-0.29	-0.18	-0.42	-0.41	-0.18

Nama	2021			2022			2023		
	Case	Death	Residents	Case	Death	Residents	Case	Death	Residents
Dewantara	3.49	3.91	1.93	3.57	3.53	1.93	4.25	4.25	1.90

b. Data Normalization Determining Epsilon and MinPts Values
epsilon (ε) value is used to determine how close two points are to be considered in one cluster. The MinPts value is the minimum number of neighbors within a radius of ε for a point to become a core point. In this study, the epsilon (0.5) and MinPts (3) parameters were determined based on observations of the distribution of the closest distances between points in the normalized dataset.

c. Euclidean Distance Calculation
The next step is calculating the distance between data using the Euclidean Distance formula. Here are the results of calculating the distance between points (using only the Case and Death attributes) for 2023:

Table 3. Results of Euclidean Distance Calculation

Point	Baktiya	Baktiya Barat	Banda Baro	Cot Girek	Dewantara
Baktiya	0	0.165	0.020	0.149	6.419
Baktiya Barat	0.165	0	0.184	0.295	6.313
Banda Baro	0.020	0.184	0	0.169	6.440
Cot Girek	0.149	0.295	0.169	0	6.535
Dewantara	6.419	6.313	6.440	6.535	0

From the table above, it can be seen that only Baktiya, Baktiya Barat, Banda Baro, and Cot Girek have close distances between points. Meanwhile, Dewantara is very far from other points.

d. Euclidean Distance Calculation
The next step is calculating the distance between data using the Euclidean Distance formula. Here are the results of calculating the distance between points (using only the Case and Death attributes) for 2023:
The cluster formation process starts from the starting point and continues to its neighbors within a radius of ε:
Iterasi 1 : Starting Point = Baktiya

Table 4. Iterasi 1 Starting Point of Baktiya

Point	Distance to Baktiya	In Radius (≤ 0.5)?
Baktiya	0	Yes
Baktiya Barat	0.165	Yes
Banda Baro	0.020	Yes
Cot Girek	0.149	Yes
Dewantara	6.419	No

Baktiya has four neighbors within an epsilon radius, thus qualifying as a core point and forming a cluster with its neighboring points.
Iterasi 2: Continue Point = Banda Baro

Table. 5 Iterasi 2 Continue Point Banda Baro

Point	Distance to Banda Baro	In Radius?
Baktiya	0.020	Yes
Baktiya Barat	0.184	Yes
Cot Girek	0.169	Yes
Dewantara	6.440	No

Banda Baro also has a minimum of three neighbors within a radius and is part of the same cluster as Baktiya.

Iterasi 3: Continue Point = Cot Girek

Table 6. Iterasi 3 Continue Point Cot Girek

Point	Distance to Cot Girek	In Radius?
Baktiya	0.149	Yes
Baktiya Barat	0.295	Yes
Banda Baro	0.169	Yes
Dewantara	6.535	No

Cot Girek has enough neighbors within an epsilon radius and remains in the previously formed cluster.

Iterasi 4: Continue Point = Dewantara

Table 7. Iterasi 4 Continue Point Dewantara

Point	**Distance to Dewantara**	**In Radius?**
Baktiya	6.419	No
Baktiya Barat	6.313	No
Banda Baro	6.440	No
Cot Girek	6.535	No

Dewantara has no neighbors within an epsilon radius, so it is categorized as an outlier because it cannot form or join any cluster.

e. DBSCAN Clustering Final Results 2023

Final results of the clustering process using the DBSCAN algorithm on five sub-district samples in North Aceh Regency in 2023. These results show which sub-districts are included in the cluster and which are included as outliers. Clustering is carried out based on diabetes prevalence data in each sub-district, which has been normalized so that it can be processed optimally by the algorithm:

Table 8. Final Results of Sample Data Clusters

Point	Cluster
Baktiya	1
Baktiya Barat	1
Banda Baro	1
Cot Girek	1
Dewantara	-1 (Outlier)

Results of clustering in 2023, four sub-districts, namely Baktiya, Baktiya Barat, Banda Baro, and Cot Girek are included in one cluster that represents an area with a relatively low to moderate density of diabetes distribution. These four areas have case and death values close to the average and spatially close to each other (in the data space after normalization).

Meanwhile, Dewantara District is not included in any cluster because it has a very high number of cases and deaths compared to other districts. The long distance to other points causes Dewantara not to meet the minimum requirements as a core or reachable point in DBSCAN. Therefore, Dewantara is classified as an outlier or anomalous point, which in this context can be interpreted as an area with a high risk of spreading diabetes

3.3. System Implementation

System implementation aims to visualize the output of the diabetes clustering system using the DBSCAN algorithm that has been created. The following are the results of the analysis implementation into the system.

1. Page Dashboard

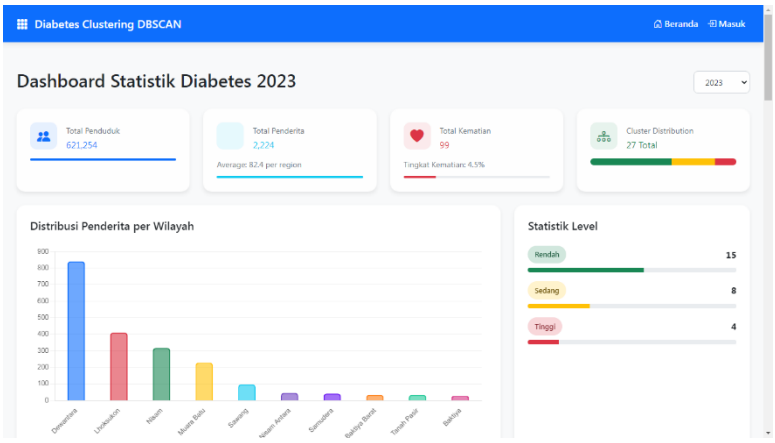

Figure 2. Page Dashboard

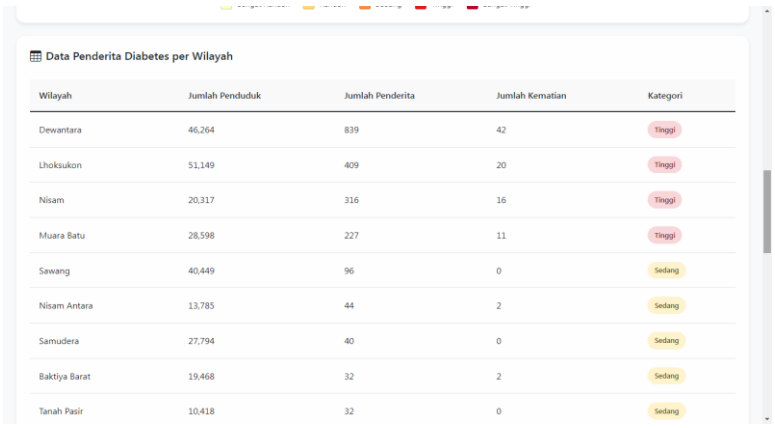

Figure 3. Page Dashboard (Continued)

The Dashboard page is where the general public can see information on people living with diabetes in North Aceh Regency, such as total population, sufferers, and deaths from diabetes. The public can also see data on people living with diabetes in 2021 - 2023 in tables and sub-district area categories, including high, medium, and low.

2. Login Page

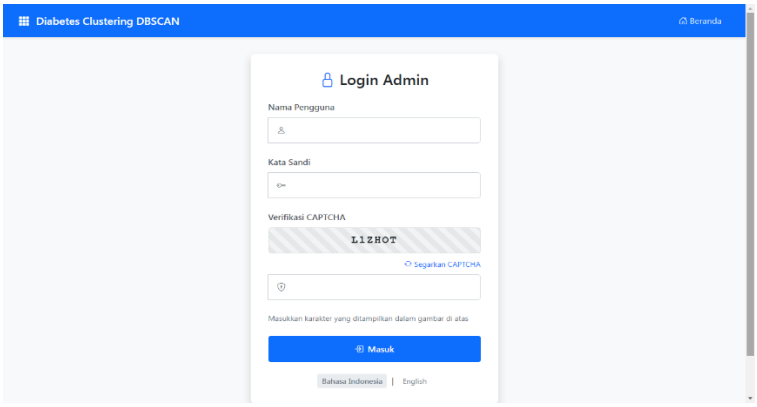

Figure 4. Login Page

Page login is the page where users can log into the system website. This is a vital component of an information system that functions as a digital security gateway. Users are asked to input their identity on this page, usually by a combination of username and password, for the authentication process. The system will verify the conformity of the data entered with database-registered users before granting access rights.

3. Add Data Page

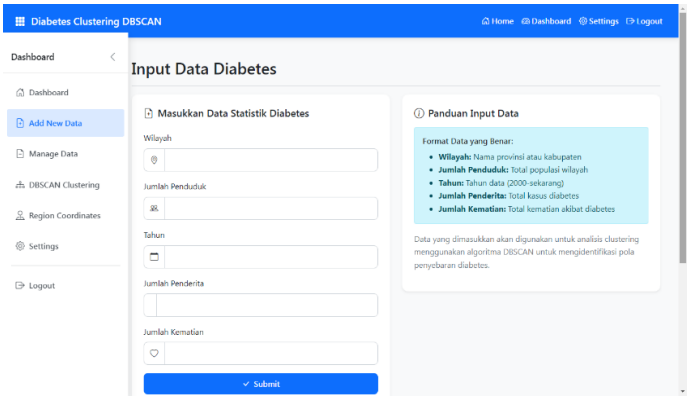

Figure 5. Add Data Page

This page displays a form to fill in data on people living with diabetes consisting of several forms: region, population, year, number of sufferers, and number of deaths.

4. DBSCAN Calculation Page

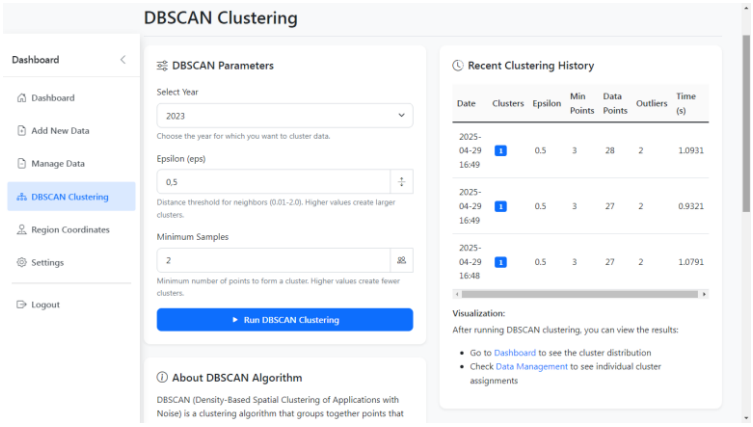

Figure 6. DBSCAN Calculation Page

Users use this page to perform process clustering on diabetes data using the DBSCAN algorithm. Users can select the year of data they want to analyze and then determine the parameter values. Epsilon (maximum distance between points considered neighbors) and minimum samples (the minimum number of points required to form a cluster). Once the parameters are specified, the user presses the Run DBSCAN Clustering button to start the clustering process.

4. Conclusion

Based on the research results, a web-based cluster mapping information system has been successfully built using the DBSCAN (Density-Based Spatial Clustering of Applications with Noise) algorithm to map areas of people living with diabetes in North Aceh Regency. This system can identify patterns of the spread of diabetes by classifying areas into three risk-level categories: high, medium, and low. Implementing the DBSCAN algorithm in this system can group 27 sub-districts in North Aceh Regency with the parameters epsilon (ε) = 0.5 and MinPts = 3. The mapping results show that in 2021, the areas with the highest risk are Dewantara and Lhoksukon. In 2022, the high-risk areas will increase to Dewantara, Lhoksukon, and Nisam. Then, in 2023, the high-risk areas will include Dewantara, Lhoksukon, Nisam, and Muara Batu. The test results show that the model can group areas prone to diabetes well to be a reference in policy-making and preventive measures in North Aceh Regency.

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