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Maternal and Child Healthcare Services in Aceh Province, Indonesia: A Correlation and Clustering Analysis in Statistics

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Abstract

Infant mortality remains a public health problem in Aceh Province, Indonesia. Health services during pregnancy are an essential factor in reducing infant mortality. Studies examining factors such as maternal and child health services that have implications for infant mortality in Aceh province are still scarce. Therefore, this study aims to examine the correlation between maternal and child health services variables such as Blood-Supplementing Tablets (TTD), Coverage of the First Visit of Pregnant Women (K1), Coverage of the First Visit of Pregnant Women (K4), and management of Obstetric Complications to live births and to map the maternal and child health services obtained during pregnancy. A cross-sectional study was used as the research study. This study used descriptive statistics, such as measures of data centering and data dispersion. In this work, inferential statistical analysis was conducted using the Shapiro-Wilk test, Spearman test, and fuzzy c-means. The result of the Shapiro Wilk test stated that the live birth rate variable and all Maternal and Child Healthcare Services variables were not normally distributed (p-value < 0.05), all Maternal and Child Healthcare Services variables were positively correlated to live birth rate based on the Spearman test (p-value < 0.05). Based on the Silhouette Index with 0.555, the formation of 3 clusters is the optimal cluster. The clustering is based on the Maternal and Child Healthcare Services that have been provided, where the first, second, and third clusters consist of five districts/city, eight districts/city, and ten districts/city, respectively, as a result of Fuzzy C-Means Clustering.

1. Introduction

Population increase is a significant problem, especially in developing countries. Indonesia is facing various population problems in order to achieve better living conditions. Based on the results of the 2020 Population Census (SP), Indonesia's population reached 273.5 million [1]. The Central Statistics Agency (BPS) states that this number will continue to grow, and in 2030, Indonesia is predicted to reach a demographic bonus.

Live birth rate (ALH) is a population indicator used in the SP and the Intercensal Population Survey (SUPAS). ALH is the number of live births to different groups of women during the reproductive period [2]. It includes all babies who, at birth, show signs of life, such as heartbeat, breathing, crying, and other signs. Calculating ALH involves comparing the number of live births between groups of women at various age ranges, such as 15-19, 20-24, and 45-49 years [1].

Total live births in Aceh Province reached 89,910, with an average of 3,874 per district/city [3]. In the care of pregnant women, various health services are provided by health facilities such as health centers, government hospitals, and private health facilities [4]. The main focus is on maternal health during labor, delivery, and family planning, in accordance with antenatal care guidelines, with an emphasis on health promotion and prevention of health problems [5].

Many studies have examined live birth rate factors but only from the perspective of individual factors. A study showed that pregnancy pattern, age, and number of tubal ostia seen on second-look hysteroscopy affect live birth rates [6]. Other studies have also shown that age, body mass index, and lifestyle factors [7–9]. There has never been a study in Aceh Province that examines Maternal and Child Healthcare Services factors associated with birth rates seen through the service system and maps them in the form of maps in Aceh Province.

Based on the description, a study was conducted with the aim of examining the correlation between live birth rates and the Maternal and Child Healthcare Services variable obtained and to map Maternal and Child Healthcare Services obtained during pregnancy in Aceh Province. Correlation analysis needs to be conducted to determine the variables associated with live birth rates and provide a clear picture in the form of policy recommendations through clustering in the form of mapping.

2. Materials and Methods

2.1. Study Desain dan Setting

This study used a cross-sectional study as the study design. Further, the study used data from all districts/cities in Aceh Province, namely five cities and 18 districts.

2.2. Variables and Data Source

In this study, five variables were used. The number of live births rate was used as the dependent variable (Y). Blood-supplementing tablets (TTD), coverage of the first visit of pregnant women (K1), coverage of the fourth visit of pregnant women (K4), and Management of obstetric complications are used as independent variables (X). All independent variables are Maternal and Child Healthcare Services. The data used in this study are secondary data obtained from the 2021 Aceh Health Profile published by the Aceh Provincial Health Office. All variables are annual data, and the measurement scale of all data used is ratio.

2.3. Data Analysis and Software

The analytical steps involved are outlined as follows: Firstly, we will embark on the search for secondary data, encompassing both dependent and independent variables. These valuable data sources have been procured from the Aceh Health Profile for the year 2021. Subsequently, a descriptive data exploration will be executed to gain a comprehensive understanding of the research dataset [10–12]. This phase will provide insights into the characteristics and distributions of the data [13–15].

The following steps involve Inferential statistics: normality tests and Spearman correlation tests will be conducted on each variable. These tests aim to assess the data's distribution and identify potential relationships between variables [16, 17]. Following the statistical analyses, we will employ Fuzzy C-Means (FCM) clustering to categorize the data into distinct clusters based on similarities. This clustering technique will help unveil patterns within the dataset [18–20]. To visualize the clustered data, a cluster plot will be generated, offering a clear representation of the identified groupings [18].

Validation of the clustering results will be performed using the Silhouette Index (SI). These validation metrics will assess the quality and coherence of the clusters [21–24]. Finally, the conclusion will be the culminating step of this study. The insights gained from the data analysis and clustering will inform our final interpretations and contribute to the study's overall findings. Data obtained in this study undergo a systematic process utilizing R software version 4.3.1 for Windows.

2.4. Live Birth Rates

Many factors influence the birth rate, including age at first marriage, family planning program, education level, and employment status [25, 26]. The birth rate, also known as natality, is the frequency of live births in a population, which is obtained from the number of live births per thousand population each year [27]. Birth rate is a measure that shows the population growth in a country [28]. Indonesia itself experienced an increase in 4 periods, namely in 2002, 2007, 2012, and 2013, by 2.6 children per 100 women of childbearing age, which was measured from the average ASEAN country.

2.5. Blood-Supplementing Tablets (TTD)

Blood-supplementing tablet (TTD) is the number of pregnant women who get at least 90 blood supplement tablets during their pregnancy period in a certain period [29]. A high level of compliance will have an impact on reducing the incidence of anemia in pregnant women. Things that need to be done to improve the compliance of pregnant women taking TTD include providing information and education about TTD, the minimum amount of TTD a day and or the amount of TTD during pregnancy that must be taken, informing that TTD side effects are physiological reactions of the body where the dose of TTD can be reduced if they feel these side effects and the role of the family in helping pregnant women to drink TTD [30].

2.6. Coverage of the First Visit of Pregnant Women (K1)

Coverage of the First Visit of Pregnant Women (K1) is the number of pregnant women who received their first antenatal care from a health worker [31]. The importance of conducting K1 examinations is related to the significant role of mothers in realizing health development goals, so it is necessary to establish synergy between the role of the government and the community to reduce maternal mortality, known as the Mother Mortality Rate (MMR) and infant mortality rate (IMR) which is still relatively high [32]. At the first visit, anamnesis is carried out about the history of pregnancy, what diseases are suffered in the current pregnancy, family history, general examination, obstetric special examination, laboratory examination (Hb, urine, etc.), obstetric examination, administration of TT immunization, administration of drugs and vitamins, breast care, and health counseling related to pregnancy.

2.7. Coverage of the First Visit of Pregnant Women (K4)

K4 coverage is the number of pregnant women who have received antenatal care according to the standard at least four times according to the recommended schedule [33]. When a pregnant woman has received a K4 code, it means that she has made four pregnancy visits and received standardized pregnancy care from a health worker. K4 coverage itself is the percentage of pregnant women in an area within a specific time who get antenatal care according to the standard (≥ 4), measured with a checklist, good criteria ≥ 95%, not good < 95%. To reduce the maternal mortality rate, which is still relatively high, the Ministry of Health has made various policy efforts, one of which is through the antenatal program by setting a K4 coverage target in Indonesia in 2010 of 95% [34].

2.8. Management of Obstetric Complications

Management of obstetric complications is crucial to ensure the safety of both the mother and the fetus during pregnancy and childbirth. Complications can arise due to various reasons, such as pre-existing medical conditions, new ones caused by pregnancy, or unforeseen circumstances. Early detection and prompt treatment can help reduce the chance of serious complications. The clinical principles of managing complications in pregnancy and childbirth include making incisions with great care and proceeding one layer at a time. In case of major obstetric hemorrhage, the management consists of fluid resuscitation, administration of blood and blood products, and conservative measures such as uterine cavity tamponade and sutures [35]. Hospitals with a more extensive caseload should perform elective cesarean sections to maintain the ability to do emergency procedures. Appropriate treatment of pregnancy complications can decrease the maternal complications rate and improve neonatal outcomes.

2.9. Shapiro Wilk Test

The Shapiro-Wilk test is a statistical test used to check if a continuous variable follows a normal distribution [36]. Individual normality tests were carried out on each variable used. The normality test aims to see whether the data is normally distributed or not. So that it can be determined what method will be used for the next test. The following p-value is obtained. It is a hypothesis test that evaluates whether a data set is normally distributed. The null hypothesis states that the variable is normally distributed, while the alternative hypothesis states that the variable is not normally distributed [37].

2.10. Spearman Test

The Spearman's rank correlation test is a statistical test used to measure the strength and direction of association between two ranked variables [38]. It is a non-parametric test that evaluates whether there is a monotonic relationship between two variables. The null

Table 1. Descriptive statistics of variables.

Variable	Minimum	Maximum	Mean	Std
Live Birth Rates	684	8,775	3,874	2,247.4
Blood-Supplementing Tablets	670	10,736	4,021	2,415.9
K1	199	14,135	4,390	3,042.9
K4	686	11,933	4,356	2,598.9
Management of Obstetric Complications	79	2,877	820.6	671.4

Table 2. Normality test.

Variable	***Normality test***
	p-*value*
Live Birth Rates	0.044
Blood-Supplementing Tablets	0.039
K1	0.005
K4	0.023
Management of Obstetric Complications	0.003

hypothesis states that there is no correlation between the two variables, while the alternative hypothesis states that there is a correlation between the two variables. The Spearman's rank correlation test is based on the difference between the ranks of the two variables and provides a measure of the degree of association between the two variables. The Spearman's rank correlation coefficient can range from -1 to +1, where a value of +1 means a perfect association of rank, and a value of 0 means that there is no association between ranks. A value of -1 means a perfect negative association of rank. The Spearman's rank correlation test is often used when the data is not normally distributed or when the relationship between the variables is non-linear [39].

2.11. Fuzzy C-Means Clustering

The Fuzzy C-Means (FCM) method is a statistical method that can group mapping data with a data clustering technique in which the existence of each data in a cluster is determined by its membership value and the value of the degree of membership whose value range is 0 to 1 [40–42]. The basic concept of FCM is to determine the cluster center that will mark the average location for each cluster, where the initial state of the cluster center is still not precise or accurate [18]. By iteratively fixing the cluster center and the value of the membership of each data, it is seen that the cluster center will move towards the intended location and is also precise or accurate.

3. Results and Discussion

3.1. Descriptive Analysis

Table 1 presents the descriptive statistics of several variables related to maternal and child healthcare services. The first variable, "Live Birth Rates," shows a range from a minimum of 684 to a maximum of 8,775, with a mean value of 3,874 and a standard deviation of 2,247.4. This indicates a considerable variation in live birth rates across the studied areas, with some districts or cities experiencing significantly higher rates than others.

The subsequent variables, including "Blood-Supplementing Tablets," "K1," "K4," and "Management of Obstetric Complications," exhibit similar patterns. They all display wide ranges and notable standard deviations, reflecting substantial variability in the provision and utilization of maternal and child healthcare services. Additionally, the relatively higher means for "Blood-Supplementing Tablets," "K1," and "K4" suggest that, on average, these services are relatively well-received across the districts or cities. Conversely, the lower mean for "Management of Obstetric Complications" indicates potential gaps in addressing obstetric complications.

Furthermore, Table 1 showed underline the significant disparities and variations in maternal and child healthcare services across the studied districts or cities. While some areas exhibit higher live birth rates and better access to services such as blood-supplementing tablets and antenatal care (K1 and K4), challenges in the management of obstetric complications are apparent. These findings emphasize the need for targeted interventions and resource allocation to ensure equitable access to quality maternal and child healthcare services in the region.

3.2. Normality Test

Table 2 presents the results of the normality tests conducted on four key variables: "Blood-Supplementing Tablets," "K1," "K4," and "Management of Obstetric Complications." The p-values associated with each variable are indicators of how closely their data

Table 3: Correlation test.

Variable	*Correlation Test (Spearman Test)*	
	p-value	*ρ*
Blood-Supplementing Tablets	0.000	0.749
K1	0.009	0.533
K4	0.000	0.747
Management of Obstetric Complications	0.003	0.599

distributions align with a normal (Gaussian) distribution. In statistical analysis, a p-value less than 0.05 is typically considered as evidence to reject the null hypothesis, suggesting that the data significantly deviates from normality.

In this context, "Blood-Supplementing Tablets" and "K4" both have p-values of 0.039 and 0.023, respectively, which are slightly above the conventional significance level of 0.05. These results indicate a relatively mild departure from normality. On the other hand, "K1" and "Management of Obstetric Complications" have considerably lower p-values of 0.005 and 0.003, respectively, strongly suggesting that their data distributions significantly deviate from normality.

Consequently, these normality test results imply that while "Blood-Supplementing Tablets" and "K4" exhibit only minor deviations from a normal distribution, "K1" and "Management of Obstetric Complications" have more pronounced deviations. This information is essential for subsequent statistical analyses, as it helps determine the appropriateness of specific parametric tests and informs the need for potential data transformations or non-parametric approaches. So, it can be concluded that the correlation test that can be done is the Spearman test.

3.3. Correlation Analysis

Each independent variable is tested for correlation using the Spearman test with the dependent variable (Y). Table 3 presents the results of the Spearman correlation test conducted to assess the relationships between various maternal and child healthcare service variables in the study. The table includes the p-values, which indicate the statistical significance of the correlations, and the correlation coefficient (ρ), which quantifies the strength and direction of these correlations.

The analysis reveals several significant correlations among the variables. Notably, the "Blood-Supplementing Tablets" variable exhibits a strong positive correlation with a correlation coefficient (ρ) of 0.749 and a highly significant p-value of 0.000. This suggests that there is a robust and positive relationship between the utilization of blood-supplementing tablets and some other factor(s) related to maternal and child healthcare services. Similarly, the "K4" variable, representing the coverage of at least four antenatal care visits, also shows a strong positive correlation with a ρ of 0.747 and a significant p-value of 0.000. Furthermore, the "Management of Obstetric Complications" variable demonstrates a moderately positive correlation (ρ = 0.599) with a statistically significant p-value of 0.003. On the other hand, the "K1" variable, indicating the coverage of early antenatal care, exhibits a weaker, yet still statistically significant, positive correlation with a ρ of 0.533 and a p-value of 0.009. These findings suggest that higher utilization of blood-supplementing tablets, comprehensive antenatal care, and better management of obstetric complications are positively associated with improved maternal and child healthcare outcomes in the studied districts or cities of Banda Aceh.

The results from the Spearman correlation test in Table 4 highlight significant associations between the maternal and child healthcare service variables studied. These findings imply that efforts to enhance the utilization of blood-supplementing tablets, early antenatal care (K1), comprehensive antenatal care (K4), and the management of obstetric complications can potentially contribute to improved maternal and child healthcare outcomes in the districts or cities of Banda Aceh. This information can guide healthcare policymakers and practitioners in developing targeted interventions and strategies to address maternal and child health challenges effectively.

3.4. Clustering Analysis

Based on the correlation test, Table 4 presents the correlation matrix showing the Spearman correlation coefficients between different maternal and child healthcare service variables (X1, X2, X3, and X4). The results of the correlation analysis of the two variables for all variables analyzed showed that all variables were correlated (p-value <0.05).

The analysis reveals several significant findings. Firstly, X1 (Blood-Supplementing Tablets) exhibits a strong positive correlation with X3 (K4) with a correlation coefficient of 0.978. This suggests that there is a highly positive relationship between the utilization of blood-

Table 4. Correlation matrix.

	X1	X2	X3	X4
X1	1.000	0.375	0.978	0.804
X2	0.375	1.000	0.448	0.161
X3	0.978	0.448	1.000	0.7559
X4	0.804	0.161	0.755	1.000

where: X1= Blood-Supplementing Tablets, X2 = K1, X3 = K4, X4 = Management of Obstetric Complications

Table 5. Cluster validation results with Silhouette Index.

No	Number of Clusters	Value Index
1	3	0.555
2	4	0.526
3	5	0.488

supplementing tablets and the coverage of at least four antenatal care visits (K4). Additionally, X1 also shows a strong positive correlation with X4 (Management of Obstetric Complications) with a correlation coefficient of 0.804, indicating that improved management of obstetric complications is associated with higher utilization of blood-supplementing tablets.

Conversely, K1 (X2), representing the coverage of early antenatal care, displays weaker correlations with the other variables, suggesting that its relationship with the utilization of blood-supplementing tablets (X1), K4 (X3), and the management of obstetric complications (X4) is less pronounced.

The correlation matrix in Table 4 reveals significant relationships between maternal and child healthcare service variables. The strong positive correlations between the utilization of blood-supplementing tablets (X1) and both the coverage of K4 (X3) and the management of obstetric complications (X4) imply that efforts to promote the use of blood-supplementing tablets may positively impact these other aspects of maternal and child healthcare. Conversely, K1 (X2) shows weaker correlations with the other variables, indicating that interventions to improve early antenatal care may need to be supplemented with strategies targeting the broader spectrum of maternal and child healthcare services to achieve comprehensive improvements in maternal and child health outcomes.

Table 5 provides the cluster validation results using the Silhouette Index for different numbers of clusters in the analysis. The Silhouette Index is a metric that measures the quality and appropriateness of clustering, with higher values indicating better-defined and more separate clusters. In this context, the analysis appears to have been conducted with varying numbers of clusters (ranging from 3 to 5), and the Silhouette Index values corresponding to each of these cluster numbers are presented.

Starting with the results, when the data is divided into three clusters, the Silhouette Index value is 0.555. This value suggests that the three-cluster solution has relatively well-defined and distinct clusters, indicating that the data points within each cluster are more similar to each other compared to data points in other clusters. A Silhouette Index value above 0.5 is generally considered good, indicating that the clustering has resulted in reasonably distinct groups.

When the number of clusters increases to four, the Silhouette Index value decreases slightly to 0.526. While this value is lower than that of the three-cluster solution, it still suggests a reasonable level of separation among the clusters. However, the decrease in the Silhouette Index value indicates that adding cluster may not provide as much meaningful differentiation among the data points.

Finally, with five clusters, the Silhouette Index value further decreases to 0.488. Although this value is still above 0.5, it indicates a diminishing level of separation among the clusters. The reduction in the Silhouette Index value suggests that the five-cluster solution may not be as meaningful in distinguishing distinct groups within the data compared to the three-cluster or four-cluster solutions.

The cluster validation results based on the Silhouette Index suggest that a three-cluster solution may be the most appropriate for this analysis, as it yields the highest Silhouette Index value, indicating well-defined and relatively distinct clusters.

The cluster plot presented in Figure 1 reveal the formation of distinct clusters among the various regions in the study area. Cluster 1 comprises Simeulue, Aceh Singkil, Aceh Selatan, Aceh Tenggara, and Aceh Tengah. This cluster suggests a commonality in maternal and child healthcare service characteristics among these regions, potentially indicating similar healthcare needs and challenges.

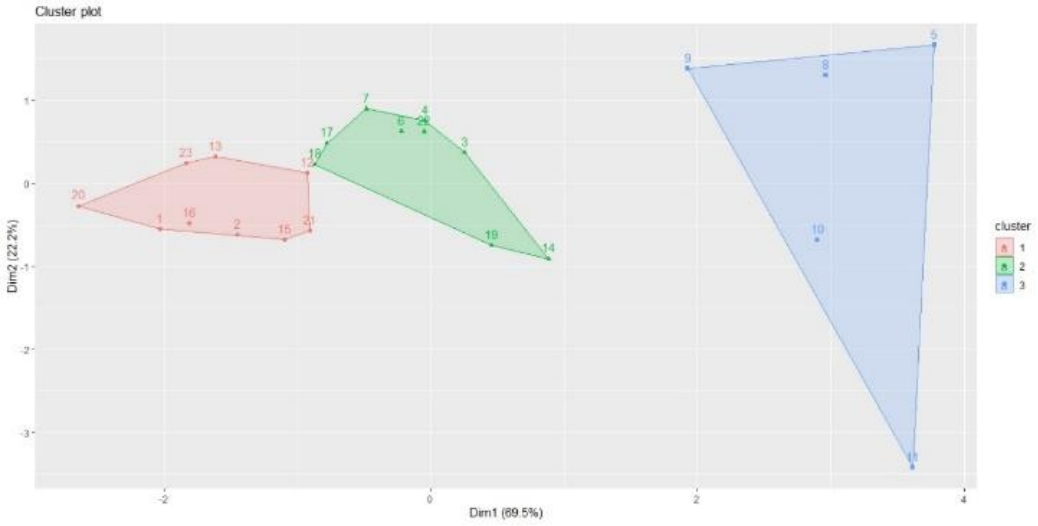

Figure 1. Cluster plot of maternal and child healthcare services in Aceh Province in 2021.

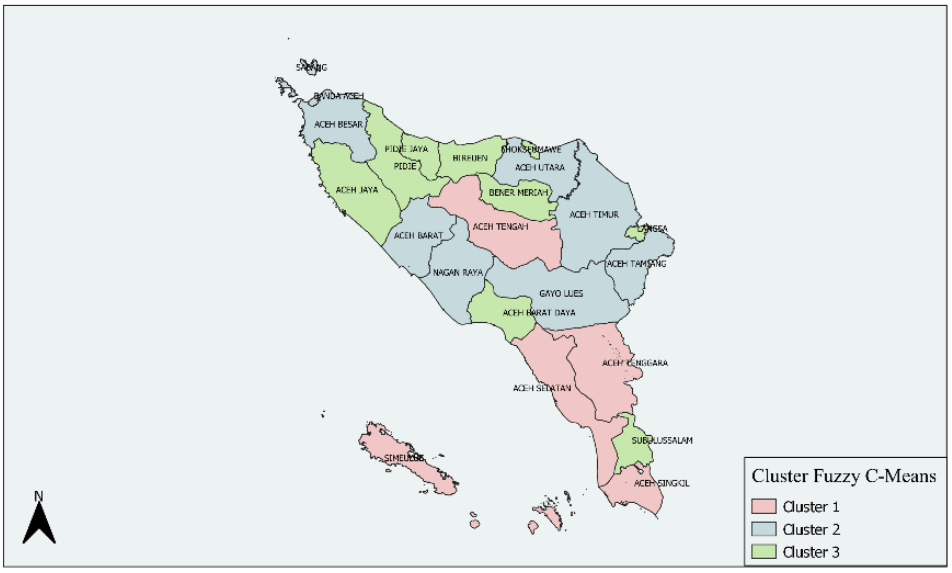

Figure 2. Cluster map of maternal and child healthcare services.

In Cluster 2, we found Aceh Timur, Aceh Barat, Aceh Besar, Bireuen, Aceh Utara, Gayo Lues, Aceh Tamiang, Banda Aceh, and Sabang. This cluster represents a group of regions with shared maternal and child healthcare service patterns that distinguish them from Cluster 1. Understanding the specific characteristics of this cluster can inform targeted interventions and policies tailored to their unique healthcare dynamics.

Lastly, Cluster 3 encompasses Pidie, Bireuen, Aceh Barat Daya, Aceh Utara, Nagan Raya, Aceh Jaya, Bener Meriah, Langsa, Lhokseumawe, and Subulussalam. These regions exhibit maternal and child healthcare service profiles that differentiate them from the previous clusters. The identification of this cluster can guide efforts to address maternal and child health disparities and promote equitable access to healthcare services within these specific areas.

The clustering map depicted in Figure 2 reveal distinctive patterns in maternal and child healthcare services across different regions. These clusters provide valuable insights for policymakers and healthcare professionals, enabling them to tailor interventions and allocate resources effectively to address the unique healthcare needs of each cluster of regions.

The study conducted an in-depth analysis of maternal and child healthcare services in Aceh Province through a combination of correlation and clustering methods. The research aimed to contribute valuable insights to the field of public health by exploring the relationships between crucial healthcare variables and identifying meaningful

clusters within the data [43]. This discussion delves into the implications and significance of the findings, addressing both the practical applications and the potential for further research.

The results of the correlation analysis shed light on the intricate web of associations among maternal and child healthcare variables. Notably, the strong positive correlation observed between the utilization of blood-supplementing tablets and comprehensive antenatal care (K4) underscores the importance of early intervention and comprehensive maternal care [44]. The positive correlation between the management of obstetric complications and both blood-supplementing tablets and comprehensive antenatal care further emphasizes the need for a holistic approach to maternal healthcare [45]. Early antenatal care (K1) also exhibited a statistically significant positive correlation with these critical variables [46], although the strength of the relationship was somewhat weaker. These findings collectively underscore the interconnectedness of these healthcare components in improving maternal and child health outcomes [44].

The clustering analysis, validated using the Silhouette Index, provided valuable insights into the grouping of districts and cities within Aceh Province based on maternal and child healthcare services. The emergence of a three-cluster solution with a high Silhouette Index value of 0.555 suggests the presence of well-defined and distinct clusters. These clusters are of paramount importance as they offer a practical framework for healthcare policymakers to tailor interventions and allocate resources effectively. It is crucial to acknowledge that the clustering analysis has the potential to guide the development of region-specific healthcare strategies, addressing the unique needs and challenges faced by each cluster [47].

The findings of this study bear substantial implications for public health practice in Aceh Province. They highlight the importance of comprehensive maternal care that encompasses blood-supplementing tablet utilization, early antenatal care, and the management of obstetric complications. By identifying distinct clusters, this research equips healthcare authorities with a nuanced understanding of regional healthcare disparities and allows for the targeted allocation of resources and interventions [48]. Additionally, the study lays the foundation for future research endeavors in the realm of maternal and child health, encouraging further investigations into the factors influencing healthcare outcomes and the efficacy of tailored interventions [49].

Maternal and Child Healthcare Services in Aceh Province: A Correlation and Clustering Analysis in Statistics contributes valuable insights to the field of public health. The study's findings underscore the interconnectedness of healthcare variables and provide a practical framework for regional healthcare improvement. As Aceh Province continues to strive for enhanced maternal and child health outcomes, evidence-based strategies rooted in rigorous statistical analysis will play a pivotal role in shaping the future of healthcare in the region.

4. Conclusions

Each Maternal and Child Healthcare Services variable, namely Blood-supplementing tablets (TTD), coverage of the first visit of pregnant women (K1), coverage of the fourth visit of pregnant women (K4), and Management of obstetric complications has a positive relationship with Live Birth Rates in Aceh Province. Then, the formation of 3 clusters for the Maternal and Child Healthcare Services case is the optimal number of clusters based on the Silhouette Index (SI). The first, second, and third clusters consist of five districts/city, eight districts/city, and ten districts/city, respectively. The clustering is based on the Maternal and Child Healthcare Services that have been provided. It is recommended that Aceh Province continues to promote and expand these services, emphasizing community engagement, monitoring, and evaluation to improve maternal and child health outcomes while considering the specific needs of each cluster. Further research may also be beneficial to uncover specific factors contributing to the observed positive relationship.

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