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ORIGINAL ARTICLE

MAPPING SPREAD OF COVID-19 CASES IN TODDLERS AND CHILDREN AT CENTRAL JAVA USING K-MEANS CLUSTER

Pemetaan Persebaran Kasus COVID-19 pada Balita dan Anak di Jawa Tengah Menggunakan K-Means Cluster

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ABSTRACT

Background: Toddlers and children under 12 are still easily sick, particularly during the COVID-19 epidemic. The high number of COVID-19 cases in toddlers and children in Central Java Province must be monitored to prevent transmission to toddlers and children still susceptible to the disease. **Purpose:** The purpose of this study was to map the spread of COVID-19 cases in toddlers aged 0-5 years and children aged 6-11 years in the province of Central Java using the K-means cluster **Methods:** This was a descriptive observational study with a cross-sectional design. Data on COVID-19 cases in children 6-11 years and toddlers 0-5 years from 35 cities in Central Java in 2020-2021 were analyzed using the K-means cluster. The K-means cluster was used to cluster low, medium, and high cases and then map the spread of COVID-19. **Results:** Semarang, Semarang Regency, Boyolali, Klaten, Surakarta, and Banyumas became high cluster areas in cases of COVID-19 toddlers and children in 2021. Based on the mapping data, COVID-19 spread in young children and toddlers in 2020 and 2021 followed a nearly identical pattern. The high zone of COVID-19 in toddlers and children mostly had a higher total population, healthcare facilities, and population density than the medium and low zones. **Conclusion:** Semarang City, Semarang Regency, Boyolali, Klaten, Surakarta, and Banyumas should be looking for COVID-19 cases in toddlers and young children.

ABSTRAK

Latar Belakang: *Kelompok usia balita dan anak di bawah 12 tahun*

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*tergolong masih rentan terhadap penyakit terutama dimasa pandemi COVID-19. Tingginya kasus COVID-19 pada balita dan anak di provinsi Jawa Tengah perlu diwaspadai untuk mencegah penularan ke balita dan anak yang masih rentan penyakit.**Tujuan:** Tujuan penelitian ini adalah untuk memetakan penyebaran kasus COVID-19 pada balita usia 0-5 tahun dan anak usia 6-11 tahun di provinsi Jawa tengah menggunakan K-means cluster. **Metode:** Sumber data dari Dinas Kesehatan Provinsi Jawa Tengah dengan obyek penelitian adalah 35 kota/ kabupaten di provinsi Jawa Tengah. Diperoleh data yaitu jumlah kasus COVID-19 pada balita usia 0-5 tahun dan anak usia 6-11 tahun per kota/kabupaten per tahun 2020 dan 2021. K-means cluster digunakan untuk klasterisasi kasus rendah, sedang dan tinggi kemudian dilakukan pemetaan persebaran COVID-19. **Hasil:** Hasil penelitian menunjukkan Kota Semarang menjadi area dengan klaster tinggi pada kasus COVID-19 balita dan anak di tahun 2020. Kota Semarang, Kab Semarang, Boyolali, Klaten dan Banyumas menjadi area klaster tinggi pada kasus COVID-19 balita dan anak di tahun 2021. Dari hasil pemetaan persebaran COVID-19 pada balita dan anak memiliki pola yang hampir sama baik di tahun 2020 dan tahun 2021. **Simpulan:** Area yang perlu diwaspadai dalam persebaran kasus COVID-19 pada balita dan anak yaitu Kota Semarang, Kab Semarang, Boyolali, Klaten dan Banyumas.*

INTRODUCTION

Coronaviruses are viruses that can cause respiratory tract infections in humans in the form of coughs and colds. COVID-19 cases in Indonesia on April 26, 2022, reached 6,044,647 cases, and the province of Central Java was ranked 3rd in the number of COVID-19 cases in Indonesia (1). Central Java Province is divided into 35 cities/regencies with a population that includes the fifth most populous province in Indonesia (2). Ages under 12 years, namely toddlers aged 0-5 years and children aged 6-11 years are still classified as susceptible to disease (3).

Since March 2020, there have been over 300 probable COVID-19 deaths in Indonesia, with a 1.1% fatality rate (4). According to research conducted by the Indonesian Pediatrician Association in 2020 (5), Central Java has Indonesia's highest incidence of COVID-19 among young people. Children are still susceptible to illness; thus, it is essential to carry out the best possible prevention of transmission to children in this alarming circumstance. To stop COVID-19 cases among young people, the government must make apparent efforts and implement initiatives. The high number of COVID-19 cases in toddlers and children in Central Java Province must be monitored to prevent transmission to toddlers and children still susceptible to the disease. The spatial and temporal development of COVID-19 is needed to help prevent the spread of the disease in children.

An overview of the time and location of the number of cases of COVID-19 in children is needed to prevent the transmission of COVID-19 in children. By knowing the location of COVID-19 cases in toddlers and children, prevention efforts can be made at that location, and analyzing the timing of the occurrence of COVID-19 will help in understanding the trends and predictions of COVID-19 cases for toddlers and children. Spatial and temporal analyses were done by mapping COVID-19 cases in toddlers and children in 2020-2021 using the Quantum Geographic Information System (QGIS) software. In epidemiology, creating a spatial map is one method for determining the distribution of cases and regions with a high risk of disease occurrence (6).

The k-means cluster can be used to determine the high-case area. The k-means cluster creates clusters based on data characteristics (7). The K-means technique does not affect the order of the objects, which are chosen randomly from one of the starting points of the calculation; the population produced is the same when different objects are used as the cluster's focal point (8). Moreover, when aggregating transaction data, the K-means algorithm outperforms the K-medoids algorithm in terms of the David Bouldin Index (9). The k-means cluster can identify areas with high, medium, and low COVID-19 cases in toddlers and children.

Previous studies in Central and West Java used the k-means cluster to determine the spread of COVID-19 (10), but no mapping of COVID-19 among toddlers and children was done in Central Java Province. To help increase public awareness in areas with high cases of COVID-19 in toddlers and children, mapping the spread of COVID-19 in toddlers and children can help. This study used the K-means cluster to map the spread of COVID-19 in toddlers aged 0-5 years and children aged 6-11 years in the province of Central Java. As a result, this study aimed to map the spread of COVID-19 in toddlers aged 0-5 years and children aged 6-11 years in the Central Java province.

METHODS

Ethical Clearance Number: 255/EA/KEPK-Fkes-UDINUS/VI/2022. The study was descriptive and observational, with a cross-sectional design. The research method used was quantitative research, with the research site being the Central Java Provincial Health Office, and the research was carried out in November-December 2021 at the Central Java Provincial Health Office. The population used in this study was cases of COVID-19 in toddlers and children in Central Java in 2020 and 2021, per city/district per month, using a sampling technique known as a saturated sample. A total population sampling technique was used to collect samples. Data were collected using observation sheets as a recapitulation of the number of COVID-19 cases in children aged 0 to 5 years and the number of COVID-19 cases in children aged 6 to 11 years.

From the initial data per month, they were grouped into two years, namely 2020, from March to December 2020, and 2021 from January to November 2021. The number of COVID-19 cases in children aged 0-5 years and children aged 6-11 years per year was added to every city/district in the province of Central Java. In 2020, there will be 2286 cases of COVID-19 in children, while in 2021, there will be 16628 cases. In 2020, there were 2055 cases of COVID-19 in toddlers; in 2021, there were 13205 cases. Clustering was processed using the k-means clustering method on Rapidminer software (11). The value of k chosen is 3, so it produces low, medium, and high clusters (12). Data display becomes more efficient and informative with 3 (three) clusters, and in prior experiments, three clusters had a low sum of squares error (SSE) (13).

Data in the form of COVID-19 cases in children under five per district/city per year are entered into the rapidminer. Then the k-means cluster feature is added to produce a centroid or cluster center point, where the point close to the centroid will form a cluster (14). The placement of an area in the low, middle, or high cluster is determined by the centroid value. Furthermore, the attributes of the city/district name, the number of cases of COVID-19 cases for children aged 0-5 years and children aged 6-11 years, as well as the results of the clustering of low-, medium-, and high-risk locations were entered into the shp map of the province of Central Java to produce a COVID-19 mapping. For toddlers and children between 2020-2021. There are four maps of the results of data processing cases of toddlers and children in 2020-2021, which were processed using QGIS software.

QGIS is software that provides information about an area to assist in mapping locations (15). QGIS users can modify object layers, georeference data, digitize data, edit object layers, and map layouts. Georeferencing is a technique for determining where an object is concerning another, using coordinates. Digitization converts Real-world geographic features into vectors of points, lines, and polygons in shapefile format. Complete graphic editing and attribute editing operations must be completed after georeferencing and digitization. Finally, the map layout determines the composition of components on the map. The QGIS software mapped the low, medium, and high areas within each cluster after the clustering procedure. The province of Central Java's map was georeferenced using QGIS as a starting point, after which the polygons were digitally separated into districts and cities. The coloring process is based on region clustering, providing the region's name and the number of cases. The layout procedure was completed to display the clustering legend.

From the data obtained, the number of COVID-19 cases in toddlers and children in 2020-2021 was carried out by clustering analysis using the k-means cluster to identify areas with high, medium, or low COVID-19 children under five. The data required were the name of the city/district and the number of COVID-19 cases in toddlers and children per year. Data on instances of COVID-19 children in 2020 (C-2020), cases of COVID-19 children in 2021 (C-2021), cases of COVID-19 toddlers in 2020 (T-2020), and cases of COVID-19 19 toddlers in 2021 (T-2021) were

subjected to the clustering procedure using the Rapidminer program. The clustering process uses Rapidminer software to process the data presented in Figure 1 below.

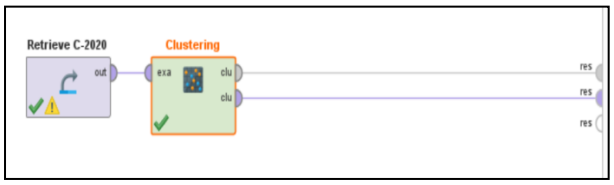

Figure 1. Clustering Process in Rapidminer

The first step in Rapidminer is retrieving the COVID-19 data, which are then connected to the clustering box by providing three cluster criteria: low, medium, and high cases. Rapidminer's first step is to retrieve COVID-19 data, after which it connects to the clustering box by assigning three cluster criteria: low, medium, and high. Connecting the clustering box to the output and clicking "run" or "play" will cause each district or city's centroid and cluster values to appear as clustering results. The Rapidminer process generates centroids and locations per cluster. These steps were repeated for data C-2020, C-2021, T-2020, and T-2021.

RESULTS

The centroid results serve as the foundation for classifying the areas based on the number of instances surrounding the centroid. The results of the COVID-19 centroid in toddlers aged 0-5 years and children aged 6-11 years per district per city per year are presented in Table 1.

From the rapidminer results at the age of toddlers in 2020, it is known that the low cluster has a cluster center point of 29.95 cases, the medium cluster has a cluster center point of 87.09 cases, and the high cluster has a cluster center point of 408 cases. At the age of toddlers in 2021, it is known that the low cluster has a cluster center point of 175.22 cases, the medium cluster has a cluster center point of 508.42 cases, and the high cluster has a cluster center point of 965.16 cases. The age of children in 2020 is known that low cluster with a cluster center point of 35.08 cases, medium cluster with a cluster center point of 98.53 cases, and high cluster with a cluster center point of 269 cases. In 2021, low clusters with a cluster center point of 221.95 cases, medium clusters with a cluster center point of 596.37, and high clusters with a cluster center point of 1199.33 cases.

Table 1
Results of Centroid K-means Cluster

Cluster	Toddler aged 0-5 years		Children aged 6-11 years	
	2020	**2021**	**2020**	**2021**
Low	29.95	175.22	35.08	221.95
Medium	87.09	508.42	98.53	596.37
High	408	965.16	269	1199.33

The results of the cluster location of cases of high, medium, and low age under five years 2020-2021 are presented in Figure 2.

Coloring was carried out to identify the number of high-five COVID-19 toddlers in red, the number of medium-sized COVID-19 children in red and yellow, and the number of low-five COVID-19 children in green. From the mapping results of 2020, it is known that the number of COVID-19 in toddlers is high in Semarang, with moderate cases in 11 cities and 23 cities being the low number of COVID-19. From the results of the mapping in 2021, it is known that the number of COVID-19 in toddlers is high in the city of Semarang, Semarang District, Boyolali, Surakarta, Klaten, and Banyumas. The number of COVID-19 toddlers was moderate in 7 cities, and 23 cities had a low number of COVID-19 toddlers. The results of the cluster location of cases of high-, medium-, and low-age children in 2020-2021 are presented in Figure 3.

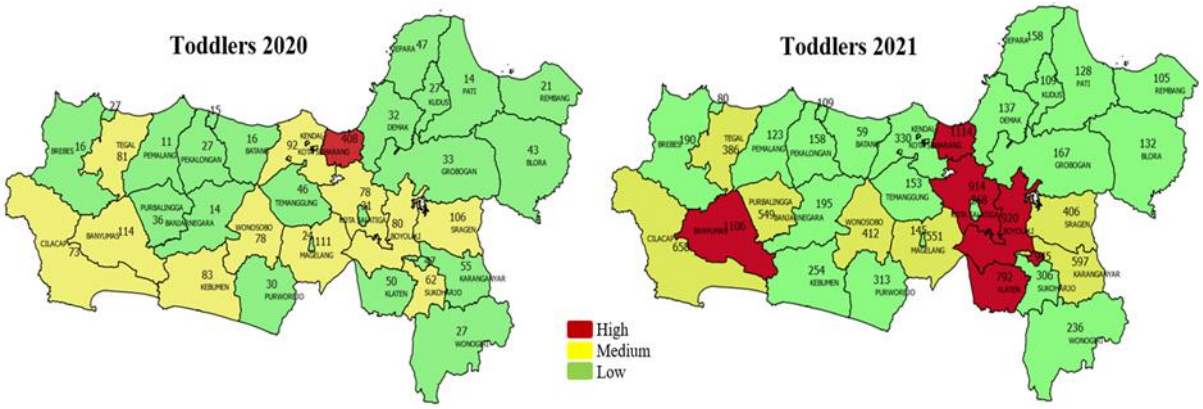

Figure 2. Mapping of COVID-19 Cases Toddlers in 2020-2021

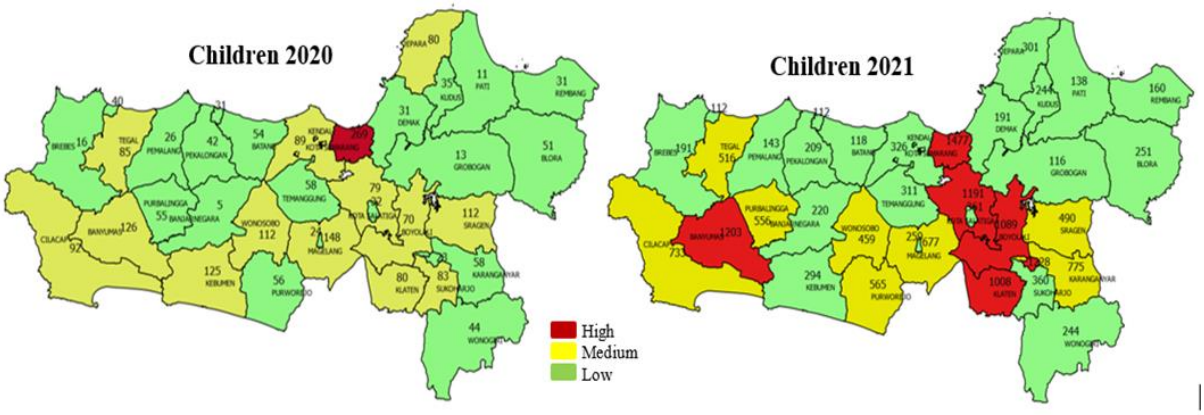

Figure 3. Mapping of COVID-19 Cases Children in 2020-2021

From the mapping results of 2020, it is known that the number of COVID-19 in children is high in Semarang, moderate in 13 cities, and low number of COVID-19 in 21 cities. From the mapping results of 2021, it is known that the number of COVID-19 children is high in the city of Semarang, Semarang District, Boyolali, Klaten, Surakarta, and Banyumas. There, COVID-19 children are moderate in 8 and 22 cities, with a low number of COVID-19 children.

In children and toddlers, the regional distribution of the incidence of COVID-19 in 2020-2021 displays the same pattern. From the mapping results, Semarang City, Semarang Regency, Boyolali, Klaten, and Banyumas are high cluster locations in cases of COVID-19 toddlers and children, according to the results of the mapping of toddlers and children from 2020 to 2021. Semarang has consistently been part of the COVID-19 high-cluster area from 2020 to 2021. Regional characteristics can be a factor causing the spread of COVID-19 among toddlers and children, including the number of healthcare facilities, total population, and population density (16). Table 2 shows the regional characteristics, including the number of healthcare facilities, total population, and population density in 2020 based on high, moderate, and low COVID-19 zones in toddlers and children.

According to the area's characteristics, the high zone of COVID-19 in toddlers and children had a higher total population, healthcare facilities, and population density than the medium and low zones.

Table 2
Region Characteristics

Zone	City/ District	Health care	Total Population	Population Density
High	Semarang City	66	1.653.524	4.424
	District Semarang	31	1.053.094	943
	Surakarta City	36	522.364	11.353
	District Boyolali	36	1.062.713	1.915
	District Klaten	46	1.260.506	1.856
	District Banyumas	62	1.776.918	1.474
Moderate	District Sragen	36	976.951	722
	District Karanganyar	29	931.963	1.038
	District Wonosobo	28	879.124	1.179
	District Purworejo	39	769.880	896
	District Magelang	35	1.299.859	1.054
	District Cilacap	50	1.944.857	1.331
	District Purbalingga	30	998.561	994
	District Tegal	38	1.596.996	1.040
Low	District Banjarnegara	39	1.017.767	1.114
	District Kebumen	46	1.350.438	705
	District Sukoharjo	22	907.587	582
	District Wonogiri	43	1.043.177	1.202
	District Grobogan	39	1.453.526	490
	District Blora	32	884.333	727
	District Rembang	20	645.333	889
	District Pati	39	1.324.188	1.997
	District Kudus	29	849.184	1.119
	District Jepara	27	1.184.947	1.338
	District Demak	31	1.203.956	1.108
	District Temanggung	30	790.174	911
	District Kendal	35	1.018.505	1.017
	District Batang	24	801.718	1.157
	District Pekalongan	31	968.821	1.316
	District Pemalang	34	1.471.489	1.823
	District Brebes	52	1.978.759	1.047
	Magelang City	13	121.526	7.567
	Salatiga City	12	192.322	3.353
	Pekalongan City	23	307.150	6.788
	Tegal City	12	273.825	6.901

(*Continued*)

Table 2
Continue

Zone	City/ District	Health care	Total Population	Population Density
Low	District Kendal	35	1.018.505	1.017
	District Batang	24	801.718	1.157
	District Pekalongan	31	968.821	1.316

DISCUSSION

The location of COVID-19 cases in children can be identified so that prevention measures can be taken (17). In 2020, 13 of the 57 high-risk regions in the nation, according to the zoning system of COVID-19 cases, were provincial capital cities (18). Analyzing the spatiotemporal distribution of COVID-19 cases will also provide patterns and future projections for cases of COVID-19 in children. From 2020 to 2021, COVID-19 cases in Indonesia have increased across the board, including in Central Java (1). From June 2020 until peaking in September 2020, childhood cases in India climbed before dropping (19). From March to July 2020, there will be an increase in COVID-19 cases among children in several nations (20). COVID-19 cases in children in Central Java have been mapped, and there has been an increase in the number of COVID-19 cases in toddlers and children by 2021. Delta and Omicron variants of COVID-19 are more contagious than prior variants, which caused a rise in COVID-19 cases in 2021 (21).

Using K-means clustering, clustering can be performed based on the properties of the data. In some nations, COVID-19 risk zones have been mapped using k-means clustering. The highest

degree of COVID-19 spread in Iran province belongs to Cluster 1, and the lowest to Cluster 10, according to a k-means cluster analysis (22). The time-varying spatial autocorrelation curves of the 49 states in the US were categorized into four categories by K-means clustering: continuous, fluctuating, weak, and weak negative (23). The best method is UMAP-assisted K-means clustering because of its dependable, efficient, and consistent performance, capacity to increase clustering accuracy, particularly for large Jaccard distance-based datasets, and superior clustering visualization (24).

The findings of this study indicate that there are many COVID-19 cases among children and toddlers in the city of Semarang. Mahmudan's research findings from 2020 read as follows: the total number of COVID-19 cases in Semarang is the highest in Central Java (25). This is also consistent with the findings of the Gayatri 2021 study, which found that in Central Java Province, only Semarang City had the highest level of COVID-19 susceptibility (26). The city of Semarang is the capital of Central Java Province, with a population of 1,667,222 in December 2021, including the fifth most populous city in Central Java (2). The population density affects the transmission of COVID-19 (27). The city of Semarang is included in the cluster with a high number of COVID-19 toddlers and children in 2020 and 2021; therefore, public vigilance is needed to prevent COVID-19 in toddlers and children. The high zone of COVID-19 in toddlers and children mostly had a higher total population, healthcare facilities, and population density than the medium and low zones. High-density cities are more vulnerable to the rapid spread of infectious diseases (28).

The Indonesian government implemented social restrictions, PCR tests, and vaccinations, especially in Central Java, to reduce the number of COVID-19 cases (29). The government has also implemented a "school from home" policy to stop the spread of COVID-19 in schools. The Indonesian Pediatrician Association additionally offers information on handling COVID-19 in children, including self-isolation manuals and guidelines for limiting children's activities outside the home during the pandemic (30).

Research Limitation

This study is limited to the causes of the number of healthcare facilities, population, and population density in cities and regions in Central Java Province from 2020 to 2021. More research can be conducted on the effects of governmental policies such as social restrictions and vaccination on the spread of COVID-19 in toddlers and children to determine the factors that lead to the development of COVID-19 in toddlers and children.

CONCLUSION

Clustering using the k-means resulted in three clusters, namely high, medium, and low, in cases of COVID-19 toddlers and children in 2020-2021. The distribution pattern of COVID-19 cases for toddlers and children was almost the same in 2020-2021. In 2020-2021, it was known that Semarang City, Semarang Regency, Boyolali, Klaten, and Banyumas are high cluster areas in cases of COVID-19 toddlers and children that need to be watched out for in the spread of COVID-19 cases in toddlers and children. The high zone of COVID-19 in toddlers and children mostly had a higher total population, healthcare facilities, and population density than the medium and low zones.

CONFLICT OF INTEREST

The authors have no financial interests or benefits related to this research to disclose.

AUTHOR CONTRIBUTION

All authors declare that they are actively participating in research and article writing and are partly responsible for the content of the writing, including in the preparation and writing of concepts, designs, analysis, or revision of the article. The role(s) of all authors are EW: Conceptualization, Methodology, Visualization; WRW: Permission to the health office; Writing-Original draft preparation. ATW: Data collection and validation; FA: Writing, reviewing, and editing.

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