

Regional network (centrality) and Covid-19 spread in West Kalimantan



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ARTICLE INFO

Article history

Received February 12, 2022

Revised March 12, 2022

Accepted April 10, 2022

Available online April 28, 2022

Keywords

Covid-19

Regional Network

West Kalimantan

ABSTRACT

coronavirus 2019 or Coronavirus Disease (Covid-19). This disease quickly spread to other nations, including Indonesia and West Kalimantan. The alert for the Covid-19 outbreak in West Kalimantan began with the release of the Covid-19 emergency response circular letter by the Governor of Kalbar. The spread of infectious diseases can occur because of the “connectivity” between areas. This paper is intended to describe the interaction between cities/ regencies in West Kalimantan and the relation to the spread of the Covid-19 pandemic. This paper used centrality measurement (network analysis) as a primary method. Afterward, it will then be superimposed with the Covid-19 spread data, which results in several trends in the position of each regency. From findings, cities/ regencies with high centrality scores tend to have a high number of confirmed cases (positive) of Covid-19.

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1. Introduction

At the end of 2019, a disease that attacked the respiratory tract began to be identified in the Wuhan region, Hubei Province, China. This disease is caused by a new type of coronavirus with a close relationship with coronavirus as it causes severe acute respiratory syndrome (SARS) [1]. It also has similarities with coronavirus found in horseshoe bats in China [2]. The World Health Organization (WHO) then announced the disease as coronavirus 2019 or Coronavirus Disease (Covid-19). This disease quickly spread to other areas since it was first identified in the Wuhan region. Covid-19 has symptoms, characteristics, and ways of spread that have begun to be identified through several studies. The condition of fever, cough, and fatigue are the most dominant symptoms found [3], [4]. Severe symptoms and fatal risk occur in this disease in the form of respiratory disorders [5]. Covid-19 transmission is believed to arise from human to human [6], through the spread of droplets and aerosols [7], [8]. The closeness of the area (to the Covid-19 origin) also has a big influence on the risk of the spread of Covid-19 [9].

The rapid spread of the Covid-19 also occurs in Indonesia. The first positive case in Indonesia was detected on March 2, 2020, when two people were confirmed to have been infected by a Japanese citizen [10]. A month later than the first case, on April 9, the Covid-19 pandemic had spread to 34 provinces in Indonesia with East Java, DKI Jakarta and South Sulawesi as the most exposed provinces [11]. In West Kalimantan (Kalbar), the alert for the Covid-19 outbreak began with the release of the Covid-19 emergency response circular letter on March 17, 2020 by the Governor of Kalbar with the detection of 110 people in monitoring and 15 people under surveillance. Based on data updates as of.

21 July 2020, [12] the highest number of positive (confirmed) were in Pontianak, as much as 122 people and the lowest in Kapuas Hulu Regency 2 people.

Related to the spread of infectious diseases (pandemic/endemic), some discussions in previous studies illustrate that the spread of infection can occur because of the ease of transportation [13], and the ease of interconnection between regions/ areas [14], [15]. On the other hand, about the "connectedness" (networks) between regions and the mobility that occurs, connection between regions are needed to complement the basic needs that include capital flows, finance, goods and services, and government spending. The Area should be related to one another to share the flow of goods and services. To be able to interact, areas should be connected (connected), in the sense of the ease of moving locations, which is often called "connectivity" [16]. In its calculations, connectivity has a close relationship with the concept of network analysis formed by nodes and links, each of which can provide a "value" for connectivity between regions [16]. Downs and Horner continued [17] that graphic illustrations and network analysis approaches (network analysis) can be used to analyse relationships between locations in the form of nodes (nodes/ vertices) and their links (links/ edges).

From the descriptions above, this paper is intended to describe the interaction or networking (by centrality measurement) between cities / regencies in West Kalimantan (Kalbar). Besides, it is also described the relation to the spread of the Covid-19 pandemic. In general, a description of the trend in the distribution of Covid-19 in Kalbar is conveyed on a time scale. Afterward, it will then be superimposed on the character of interaction between regencies through network analysis, which results in several trends in the position of each regency.

2. Method

In exploring networks in West Kalimantan (Kalbar), the method used in this paper is the network analysis approach, which is used to analyse the relationship between locations or areas in the form of nodes (vertices) and their links (edges). According to Borgatti, Everett, & Johson [18], in general, there are at least three basic approaches in network analysis that can be used to do calculations and see trends in a network. These approaches are (1) centrality, (2) sub-graphs or groups (subgraphs), and (3) equivalence. In this paper, we used centrality measurement such as in/out degree, closeness, betweenness, and eigenvector. After discovering the regional network (centrality), the results then be discussed with the spread of Covid-19 cases in West Kalimantan. Several steps were carried out, include:

- Weekly data collection related to the trend of spread of Covid-19 cases in West Kalimantan
- Data collection in regional (regencies) "interaction" in West Kalimantan in the form of relationship between regencies (node by node) or incoming/ outgoing links. This interaction data is taken based on the network or transportation facility either by land (road), air, and water in West Kalimantan
- Network analysis by analyzing and describing trends in regional centrality. UCINET software [19] is used to perform the network analysis
- The result of regional centrality then superimposed with the highest/ lowest number of Covid-19 cases in West Kalimantan areas. In this part, we will see the relationship between network configuration and the spread of Covid-19 cases in West Kalimantan.

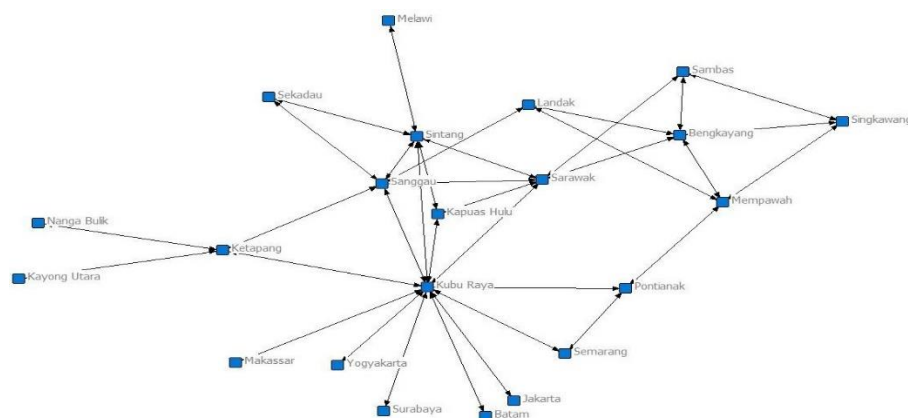
3. Results and Discussion

3.1. Network Analysis (Centrality Measurement) in West Kalimantan

From several data, especially in West Kalimantan geospatial [20], the node-by-node relationship between cities/ regencies in West Kalimantan are as follows (Table. 1 and Fig. 1).

Table 1. Node-by-node Area Interaction in West Kalimantan

No	Origin	Direction	No	Origin	Direction	No	Origin	Direction
1	Pontianak	Kubu Raya	24	Sanggau	Landak	47	Ketapang	Kayong Utara
2	Pontianak	Mempawah	25	Sanggau	Kubu Raya	48	Kayong Utara	Ketapang
3	Kubu Raya	Sanggau	26	Sanggau	Sekadau	49	Kubu Raya	Sintang
4	Kubu Raya	Pontianak	27	Sanggau	Sarawak	50	Kubu Raya	Kapuas Hulu
5	Mempawah	Pontianak	28	Sanggau	Ketapang	51	Kubu Raya	Ketapang
6	Mempawah	Landak	29	Ketapang	Sanggau	52	Kubu Raya	Sarawak
7	Mempawah	Singkawang	30	Ketapang	Nanga Bulik	53	Kubu Raya	Jakarta
8	Mempawah	Bengkayang	31	Nanga Bulik	Ketapang	54	Kubu Raya	Surabaya
9	Singkawang	Mempawah	32	Sintang	Sanggau	55	Kubu Raya	Semarang
10	Singkawang	Bengkayang	33	Sintang	Sekadau	56	Kubu Raya	Batam
11	Singkawang	Sambas	34	Sintang	Melawi	57	Kubu Raya	Yogyakarta
12	Landak	Mempawah	35	Sintang	Sarawak	58	Kubu Raya	Makassar
13	Landak	Bengkayang	36	Sintang	Kapuas Hulu	59	Sintang	Kubu Raya
14	Landak	Sanggau	37	Sekadau	Sanggau	60	Kapuas Hulu	Kubu Raya
15	Bengkayang	Landak	38	Sekadau	Sintang	61	Ketapang	Kubu Raya
16	Bengkayang	Mempawah	39	Melawi	Sintang	62	Sarawak	Kubu Raya
17	Bengkayang	Singkawang	40	Kapuas Hulu	Sintang	63	Jakarta	Kubu Raya
18	Bengkayang	Sambas	41	Kapuas Hulu	Sarawak	64	Surabaya	Kubu Raya
19	Bengkayang	Sarawak	42	Sarawak	Sambas	65	Semarang	Kubu Raya
20	Sambas	Singkawang	43	Sarawak	Bengkayang	66	Batam	Kubu Raya
21	Sambas	Bengkayang	44	Sarawak	Sanggau	67	Yogyakarta	Kubu Raya
22	Sambas	Sarawak	45	Sarawak	Sintang	68	Makassar	Kubu Raya
23	Sanggau	Sintang	46	Sarawak	KapuasHulu	69	Pontianak	Semarang
						70	Semarang	Pontianak

**Fig. 1.** Regional (Regencies) Network in West Kalimantan

Network analysis in West Kalimantan is carried out with centrality measurement of interconnected regions (cities/ regencies) in West Kalimantan. In calculations, UCINET network analysis software is used [19]. In the calculation of centrality, some detailed calculations performed are: (1) degree, (2) closeness, (3) betweenness, (4) eigenvector. By definition, a degree is the number of lines (links) associated with a single point [21], [18]. Closeness reflects how close the actors/ points reach another; one point becomes central if it can interact quickly with other points [22]. Betweenness is an actor/ point in the middle, a point between others. A point that bridges and controls flow in the network [22], [18]. The Eigenvector is an effort to find the most central actor/ point in overall network structure [22]–[24].

From the results below Table. 2 , we can see Kubu Raya Regency is the regency with the highest score (score) in each calculation category. For in/out degrees, Kubu Raya, Sarawak, Sanggau, Sintang are the regencies with the most connected with other cities/regencies. After that, followed by Bengkayang and others. For closeness, Kubu Raya, Sanggau, Sarawak, Sintang, Ketapang, and Kapuas Hulu in sequences each have higher values compared to other regencies. It is indicating that each becomes the fastest area in reaching different regencies inside the existing network configuration. For betweenness measurement, Kubu Raya, Sarawak, Ketapang, Sanggau, and Sintang have an average score that is quite high compared to other regencies. It can be indicated that these areas have an effective "reach" to reach different regencies and become a "bridge" or hub in connecting other areas. For eigenvector, we can see that areas such as Kubu Raya, Sarawak, Sintang, and Sanggau are some of the central areas in the network configuration in West Kalimantan.

Table 2. Centrality Measurement in West Kalimantan

No	Area	Degree	Closeness	Betweenness	Eigenvector
1	Batam	4.762	41.176	0.000	14.907
2	Bengkayang	23.810	42.000	5.493	25.830
3	Jakarta	4.762	41.176	0.000	14.907
4	Kapuas Hulu	14.286	47.727	0.000	37.005
5	Kayong Utara	4.762	32.813	0.000	5.916
6	Ketapang	19.048	47.727	18.571	28.212
7	Kubu Raya	57.143	67.742	59.461	71.087
8	Landak	14.286	42.857	3.662	19.816
9	Makassar	4.762	41.176	0.000	14.907
10	Melawi	4.762	35.000	0.000	10.816
11	Mempawah	19.048	39.623	4.495	17.052
12	Nanga Bulik	4.762	32.813	0.000	5.916
13	Pontianak	14.286	47.727	6.712	22.603
14	Sambas	14.286	39.623	2.591	19.439
15	Sanggau	28.571	56.757	17.126	51.614
16	Sarawak	28.571	55.263	18.991	53.800
17	Sekadau	9.524	38.889	0.000	21.640
18	Semarang	9.524	43.750	0.000	19.647
19	Singkawang	14.286	31.818	0.397	13.069
20	Sintang	28.571	52.500	12.976	51.578
21	Surabaya	4.762	41.176	0.000	14.907
22	Yogyakarta	4.762	41.176	0.000	14.907

Overall, in West Kalimantan Province, it can be seen that Kubu Raya regency, which is close to Pontianak city (the Capital of the Province), is one of the key areas in the "system" of interaction between regencies in West Kalimantan. Kubu Raya has many interactions/relations with outside areas

in West Kalimantan, because in Kubu Raya has a Supadio International Airport, which the main entrance gate to West Kalimantan. Besides, Kubu Raya is also a regency directly adjacent to the Pontianak city, which is only about 50 Km from the city center. With the closeness to Pontianak city, Kubu Raya is not uncommon to be one of the development buffer areas of Pontianak city, where development in Kubu Raya tends to support progress in Pontianak city. Sintang and Sanggau regencies are also becoming the key areas in the configuration of the interaction network in West Kalimantan. Sintang and Sanggau are included in significant scores in each calculation category. Sintang and Sanggau are regencies that are geographically located in the "middle" of the Province of West Kalimantan, connecting the West and East and North-South side to the border area directly adjacent to Sarawak, Malaysia. Also, these regencies have borders (northern part) that can access directly to neighboring countries (Sarawak, Malaysia).

3.2. Regional Network and Covid-19 Spread in West Kalimantan

Summarized from the West Kalimantan Public Health Office (<https://dinkes.kalbarprov.go.id/covid-19/>) Table. 3 and Fig. 2, cities/ regencies such as Pontianak, Kubu Raya, Ketapang, Sintang, and Sanggau tend to an increase in confirmed patients (positive). These regencies, "consistently", have the highest confirmed Covid-19 patients in West Kalimantan. For people under supervision, consistently areas such as Sambas, Bengkayang, Landak, Ketapang, and Sekadau have a significant number compared to other regencies. Each of these regencies has thousands, even compared to Pontianak, which has the highest number of confirmed patients. Whereas, patients under surveillance, areas such as Pontianak, Singkawang, Mempawah, Ketapang, and Kubu Raya tend to be the areas with the highest number of patients under surveillance. On 13 July 2020, the government began to give a new term to people / patients affected by Covid-19, the new term including (1) confirmed cases, (2) close contact, and (3) suspect. In this new term, by 20 July 2020, the fact of Covid-19 in West Kalimantan recorded areas such as Pontianak, Kubu Raya, Ketapang, Sintang, and Sanggau had the most confirmed cases. As for close contact, regencies such as Sambas, Bengkayang, Ketapang, Landak and Sekadau have the most evidence of close contact. Whereas for cases of suspected, areas such as Pontianak, Sambas, Mempawah, Singkawang, and Landak have the highest number of cases.

Table 3. Covid-19 Trends in West Kalimantan

No	City/ Regency	Covid-19 Cases in West Kalimantan											
		01 July 2020			06 July 2020			13 July 2020			20 July 2020		
		C	US1	US2	C	US1	US2	C	US1	US2	C	CC	S
1	Pontianak	118	813	7	118	822	6	122	845	1	122	854	150
2	Singkawang	12	691	4	12	691	4	12	691	0	12	691	28
3	Mempawah	9	284	4	9	284	4	10	284	0	10	284	30
4	Bengkayang	5	2189	1	5	2189	0	5	2340	0	5	2340	22
5	Sambas	12	3840	1	12	3840	2	12	3840	0	12	3840	44
6	Landak	19	1480	2	20	1480	1	20	1480	0	20	1480	23
7	Sanggau	18	278	0	18	278	0	25	332	1	25	372	16
8	Kubu Raya	34	226	4	34	278	4	36	278	0	40	278	71
9	Kayong Utara	3	197	0	3	197	0	3	201	0	3	201	7
10	Ketapang	39	1835	5	39	1854	5	41	1894	0	41	1980	19
11	Sekadau	7	937	0	7	962	0	7	1077	0	6	1124	6
12	Melawi	21	228	0	21	228	0	21	228	0	21	228	4
13	Sintang	27	770	0	29	770	0	29	770	0	29	770	1
14	Kapuas Hulu	2	634	3	2	634	3	2	674	3	2	687	11

^a Note: C = Confirm; US1 = Under Supervision; US2 = Under surveillance; CC = Close Contact; S = Suspect

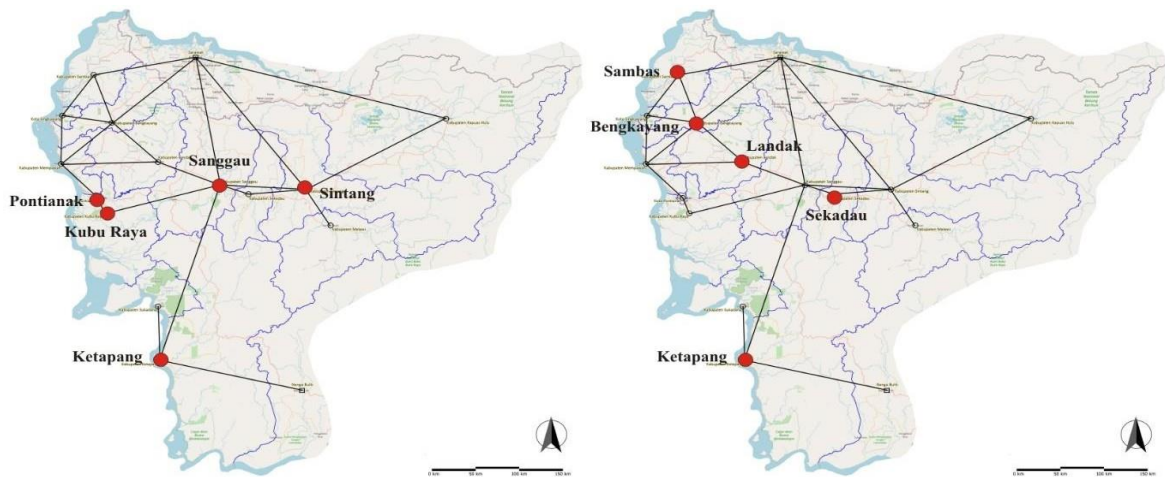


Fig. 2. (Left): Confirm Cases Distribution; (Right): People Under Supervision/ Close Contact Cases Distribution

From superimpose, which carried out between the network and the distribution of confirm cases and People Under Supervision in West Kalimantan, it can be seen how the distribution of covid-19 cases and the network configuration influenced each other. For confirmed cases [Fig. 2](#), some cities/regencies such as Pontianak and Kubu Raya have the highest number of confirmed cases. Viewed from the existing network, Pontianak and Kubu Raya are two areas that are close together and support one another. Seen from the centrality score [Table. 2](#), it also shows Kubu Raya as the most central area in the network configuration in West Kalimantan. Kubu Raya is regency which International airport located, and the only one in West Kalimantan. This regency is the main gate to West Kalimantan from another Province. The closeness to Pontianak is also a consideration. Kubu Raya and Pontianak are two city/regency that are close together and support each other. Pontianak is the provincial capital of West Kalimantan with all kinds of facilities and infrastructure that support services. Besides, Pontianak, under a National City hierarchy included as a national activity centre, which serve a national trade activity and supports other areas in delivering goods and services. So that, Pontianak becomes the primary "transit" area for visitors whose come from Kubu Raya (airport). Besides, the existence of the main sea port is also in Pontianak. Other areas, such as Sanggau and Sintang are also regencies with the most confirmed cases. Judging from the score of centrality [Table. 2](#), these two regencies (outside Ketapang) also have the highest average centrality score after Kubu Raya. These two regencies are the central areas in the East part of West Kalimantan and are directly bordered to Sarawak Malaysia. Sanggau also tends to be a "hub" area that distributes mobility or movement to other cities/ regencies in West Kalimantan. Seeing from the existing network, Sanggau is directly connected to Kubu Raya as Pontianak, and then Sanggau is directly related to Sintang and Kapuas Hulu.

From close contact cases (People Under Supervision), it can be seen that regencies such as Sambas, Bengkayang, Landak, Sekadau, and Ketapang have a high average of close contact cases compared to other regencies. However, it is interesting to see that these regencies' centrality score is not too high compared to regencies with the most confirmed cases previously. In this paper, the author has not been able to find a relationship between the centrality score and the distribution of close contact cases. The score of centralities in the regencies found no significant value compared to the high number of close contact cases. Further research should be carried out in the future by looking at the details and character of each regencies. However, demographically, as an initial indication, these regencies tends to have a high population density compared to other regencies

4. Conclusion

From the centrality measurement and the distribution of Covid-19 confirmed cases in West Kalimantan, in general, areas (cities/ regencies) with high centrality scores tend to have a high number of confirmed cases (positive) of Covid-19. Besides, these cities/ regencies play as the main entrance to the province and also a big city or provincial capital. Also, areas with a high centrality score are

interconnected with one another with direct links between areas. It is also interesting to find that cities/regencies with a low centrality score have many close contacts (People Under Supervision) up to thousands of people, leaving behind the areas with the highest centrality score. However, viewed from the population density, those cities/regencies are areas with a high density in West Kalimantan. Of course, it is interesting to proceed these findings into further research by looking at more in detail the characters and variables of each city and regencies.

Acknowledgment

We thank to Ministry of Research, Technology, and High Education Indonesia (Kemenristekdikti - Kemenristek/BRIN) for financial support of the research through Multi-Years Basic Research Scheme (re-focusing Covid-19).

Declarations

Author contribution. All authors contributed equally to the main contributor to this paper. All authors read and approved the final paper.

Funding statement. None of the authors have received any funding or grants from any institution or funding body for the research.

Conflict of interest. The authors declare no conflict of interest.

Additional information. No additional information is available for this paper.

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