The Spatial Analysis of the 2019 Coronavirus Disease in the City of Ternate in 2023

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Abstract: One of the diseases that spreads quickly and can be fatal is Covid-19. The demographic factor is one of numerous factors that may have contributed to the formation of Covid-19. With 15.21 cases per 100,000 people per week in 2022, Ternate City had the highest number of extra confirmed Covid-19 infections in the province of North Maluku. This research is intended to illustrate the distribution of Covid-19 incidence based on population density in Ternate City in 2020-2022 in the form of a map. The method used was descriptive quantitative with a spatial analysis approach using the Quantum Geographic Information System (QGIS) 3.28.1 application. This study used secondary data with population density variables and 3164 cases of Covid-19 confirmation. According to the findings of the spatial study, the distribution of confirmed Covid-19 cases in 2020 will have the highest range of cases which is 268-534 cases, is found in areas with high population density, namely Central Ternate District. In 2021, areas with the highest range of Covid-19 confirmed cases reached 535-801 cases in high population density areas, namely Central Ternate and South Ternate sub-districts. In 2022 the total incidence of Covid-19 in all sub-districts was in the range of 1-267 cases.

Keywords: Covid-19; Population Density; Spatial Analysis

1. Introduction

Since the discovery of the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) virus in Wuhan, China on December 31, 2019, the whole world has been shocked by the emergence of a new type of pneumonia disease called Coronavirus Disease 2019 which was later abbreviated to Covid-19.[1] Covid-19 is an environment-based disease that is categorized as a zoonosis. This is because it can transmit from animals to humans. In its development, it was found that this virus is able to transmit between individuals to one another.[2]

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[1] Yuliana. 2020, "Corona Virus Diseases (Covid-19): Sebuah Tinjauan Literatur." *Wellness And Healthy Magazine* 2 (1): 187–92. https://doi.org/10.30604/well.95212020.

[2] Wahyuni, Dwi Novia, "Pengaruh Kepadatan Penduduk Terhadap Jumlah Kasus Mingguan Covid-19 di Kabupaten Badung Provinsi Bali." *Jurnal Geografi, Edukasi dan Lingkungan* no. 1(2021): 46-51, https://doi.org/10.22236/jgel.v5i1.5424.

The World Health Organization (WHO) reports that the global situation of Covid-19 incidence from the beginning of its emergence until May 31, 2023 amounted to 767 million confirmed cases with 6.9 million cases of death due to Covid-19. The spread of Covid-19 at the beginning of its discovery was able to reach 114 countries with a total of 118 thousand cases, so on this basis Covid-19 was designated as a pandemic.[3] The pandemic status inaugurated by the World Health Organization on March 11, 2020 shows that the level of spread of Covid-19 has covered a large area or worldwide in a short period of time.

The number of confirmed cases of Covid-19 in Indonesia until May 31, 2023 reached 6.8 million cases starting from the initial appearance of Covid-19 in Indonesia, namely on March 2, 2020 when two Indonesians were announced to be confirmed positive due to interaction with a Japanese citizen. Not only that, Covid-19 has also caused many deaths in Indonesia as of May 31, 2023, cases of death due to Covid have reached 161.7 thousand cases.[4] Community mobility and Indonesia's high population support the transmission of Covid-19 to all parts of Indonesia in a short time.[5]

The increase in the number of Covid-19 confirmed cases is inseparable from the disease determinants or risk factors that influence it. One of the variables that can act as a risk factor for the emergence of infectious diseases such as Covid-19 is the level of population density.[6] The level of population density in an area can indicate the massive proliferation of the virus in the area, in other words, a dense area can be vulnerable to the distribution of an infectious disease such as Covid-19. Ternate City is the region with the highest population density in North Maluku Province in 2022 at 1275 people/Km^2.[7] The effect of population density on the emergence of confirmed cases of Covid-19 has been proven by Edriani et al.[8] and Rakuasa et al.[9] who proved the relationship between

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[3] Gugus Tugas Percepatan Penanganan Covid-19 2019. *Protokol Percepatan Penanganan Pandemi Covid-19 (Corona Virus Disease 2019).* Jakarta: Gugus Tugas Percepatan Penanganan Covid-19, 2019, https://covid19.go.id/storage/app/media/Protokol/2020/Mei/Protokol Percepatan Penanganan Pandemi Corona Virus Disease 2019.pdf.

[4] Satuan Tugas Penanganan Covid-19. *Situasi Covid-19 di Indonesia (Update per 31 Mei 2023).* Satuan Tugas Penanganan Covid-19, 2023, https://covid19.go.id/artikel/2023/05/31/situasi-covid-19-di-indonesia-update-31-mei-2023.

[5] Kementerian Komunikasi dan Informasi Republik Indonesia. *Memantau Mobilitas dan Kualitas Informasi di Tengah Pandemi.* Jakarta: *Kemenkominfo*, 2021, https://www.kominfo.go.id/content/detail/35573/memantau-mobilitas-dan-kualitas-informasi-di-tengah-pandemi/0/artikel.

[6] Achmadi, Umar Fahmi. *Manajemen Penyakit Berbasis Wilayah Edisi Revisi*, edk 2. Jakarta: Raja Grafindo Persada, 2014.

[7] Badan Pusat Statistik Kota Ternate. *Kota Ternate dalam Angka 2023*, Ternate: Badan Pusat Statistik Kota Ternate, 2023.

[8] Edriani, Tiara Shofi, Anisa Rahmadani and D. Michiko M. Noor. "Analisis Hubungan Kepadatan Penduduk dengan Pola Penyebaran Covid-19 Provinsi DKI Jakarta menggunakan Regresi Robust", *Indonesian Journal of Applied Mathematics*, no. 2 (2021): 51-60, https://journal.itera.ac.id/index.php/indojam/ (accessed August 2, 2022).

[9] Rakuasa, Heinrich, Mangapul Parlindungan Tambunan and Rudy ParluhutanTambunan. "Analisis Sebaran Spasial Tingkat Kejadian Kasus Covid-19 dengan Metode Kernel Density di Kota Ambon", *Jurnal Geografi*, no. 2(2021): 76-82, https://doi.org/10.15294/jg.v18i2.28234.

population density and the incidence of Covid-19 in Ambon City with a positive relationship direction.

Many methodologies can be used to see the relationship between Covid-19 confirmation cases and population density, one of which is the spatial analysis method. According to Achmadi[10], spatial analysis can be used as a pioneering effort or an opening of the way for more accurate research so that spatial analysis is very suitable for researching new diseases that have never been identified before such as Covid-19. Various Covid-19 studies with spatial analysis methods utilize Geographic Information Systems (GIS) to analyze spatial data from geographic phenomena. Geographic Information System (GIS) plays a role in providing significant information, one of which is through risk mapping[11]. The existence of a digital Covid-19 problem mapping application can help interested parties in obtaining actual information about the condition of their area.[12] The utilization of GIS in the context of controlling Covid-19 has been carried out by Siahaan[13] in his research entitled "Spatial Distribution of Covid-19 in DKI Jakarta, Indonesia (January 2021-October 2021)".

The first confirmed Covid-19 case report in North Maluku Province occurred on March 23, 2020 in Ternate City.[14] According to the Covid-19 Handling Task Force [15], until February 13, 2022, the number of confirmed Covid-19 cases in North Maluku reached 14,604 cases spread across all districts/cities. Among the 10 districts/cities in North Maluku, Ternate City occupies the first position as the highest number of additional confirmed Covid-19 cases in North Maluku province with 15.21 cases per 100 thousand population per week on February 13, 2022, followed by North Halmahera in second position with 12, 68 cases, then Central Halmahera with 8 cases, South Halmahera 8 cases, Sula Islands 5 cases, East Halmahera 5 cases, Tidore Islands City 4 cases, Morotai Island 4 cases, Taliabu Island 1.8 cases, and West Halmahera 1.6 cases.[16]

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[10] Achmadi, Umar Fahmi. *Manajemen Penyakit Berbasis Wilayah Edisi Revisi*, edk 2. Jakarta: Raja Grafindo Persada, 2014.

[11] Pourghasemi, Hamid Reza, Soheila Pouyan, Zakariya Farajzadeh, Niteshnirmal Sadhasivam, Bahram Heidari, Sedigheh Babaei & John P. Tiefenbacher. "Assessment of The Outbreak Risk, Mapping and Infection Behavior of Covid-19: Application of The Autoregressive Integrated-Moving Average (ARIMA) and Polynomial Models", *PLoS ONE*, no. 17(2020), https://doi.org/10.1371/journal.pone.0236238.

[12] Fahri, Muhammad Ullil. "Melihat Peta Penyebaran Pasien Covid-19 dengan Kombinasi QGIS dan Framework Laravel", *Jurnal Teknologi Terpadu*, no. 1(2020): 25-30, https://doi.org/10.54914/jtt.v6i1.248.

[13] Siahaan, Arianty, Martya Makful, Budi Utomo, Risma, Roma Yuliana and Ngabila Salama. "Distribusi spasial Covid-19 di DKI Jakarta, Indonesia (Januari 2021- Oktober 2021)". *Journal of Health Epidemiology and Communicable Diseases*, no. 2(2021): 84-92 https://doi.org/https://dx.doi.org/10.22435/jhecds.v7i2.5552.

[14] CNN Indonesia. *Kasus Pertama di Malut, Satu Pasien Positif Corona di Ternate.* https://www.cnnindonesia.com/nasional/20200323190435-20-486205/kasus-pertama-di-malut-satu-pasien-positif-corona-di-ternate.

[15] Satuan Tugas Penanganan Covid-19. *Peta Sebaran Covid-19*. 2022, https://covid19.go.id/peta-sebaran.

[16] Databoks. *Jumlah Konfirmasi Positif Mingguan di Maluku Utara Paling Tinggi Terjadi di Kota Ternate*. 2022, https://databoks.katadata.co.id/datapublish/2022/02/16/jumlah-konfirmasi-positif-mingguan-di-maluku-utara-

The use of GIS to create a map or portal that either illustrates or analyzes the pattern of spread or the level of incidence of Covid-19 in Ternate City spatially is not yet available. On the basis of all these problems, research with the title "Spatial Analysis of the Incidence of Coronavirus Disease 2019 in Ternate City in 2023" is important to do.

2. Method

The type of research used is descriptive quantitative with a spatial analysis approach. This research was conducted in the administrative area of Ternate City for 2 (two) months starting from April - June 2023. The research population used was all Covid-19 confirmation cases in Ternate City in 2020, 2021, and 2022. The population data was taken from the Ternate City Health Office which amounted to 3164 cases. The research sample taken amounted to 3164 cases of Covid-19 confirmation based on the total sampling method where the number of samples was the population itself. The variables studied were population density and Covid-19 confirmation cases. The instruments used consisted of hardware in the form of a Personal Computer, keyboard, and mouse and software in the form of Microsoft Excel 2019 and Quantum Geographic Information System (QGIS) 3.28.1.

The data used in this research is secondary data which is divided into:

1. Population density data of Ternate City in 2020-2022—obtained from the Central Bureau of Statistics of Ternate City.
2. Data on Covid-19 confirmed cases in Ternate City in 2020-2022—obtained from the Ternate City Health Office in the form of fixed address data of Covid-19 confirmed patients in Ternate City in the span of 2020-2022.
3. Spatial data in the form of raw files of administrative areas of Ternate City per sub-district in shp format—obtained from the Public Works and Spatial Planning Office of Ternate City.

The results of measuring the population density variable are determined by the orange color gradation symbol which represents the category (1) Low (1-1360 Jiwa/Km^2) (2) Medium (1361-2721 Jiwa/Km^2) (3) High (2722-4080 Jiwa/Km^2) while the results of measuring Covid-19 confirmation cases are determined by the red centroid point symbol with a small-large size level representing the interval class: (1) 1-267 cases (2) 268-534 cases (3) 535-801 cases. The data analysis applied is spatial analysis with overlay technique.

3. Result and Discussion

Ternate City is located in eastern Indonesia and is one of 2 cities and 8 regencies in North Maluku Province. North Maluku Province is bordered by the Pacific Ocean to the north; Seram Sea and Maluku Province to the south; Maluku Sea and Sulawesi Island to the west; and the Pacific Ocean and West Papua Province to the east. Based on its geographical

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position, Ternate City is located at 02°28'54.51" South latitude, 02°39'28.76" North latitude, and located between 124°16'58.62" -129°40'57.62" East Longitude. The areas that directly border Ternate City are Tidore Islands City and South Halmahera Regency in the South. Ternate City has an area of 5,709.72 Km^2 which includes a land area of 162.20 Km^2 and an ocean area of 5,547.52 Km^2 [17].

The initial establishment of Ternate City was as an Administrative City under the guidance of the North Maluku Province. The status of Ternate City was then changed to a municipality along with the establishment of North Maluku Province through Law Number 11 Year 1999. During this period, the Ternate City area was administratively formed from 3 sub-districts and 58 villages. Furthermore, in 2001 the Ternate City area was divided into 4 sub-districts. The Ternate City area was then further divided into 7 sub-districts in 2009 and in 2018 through Ternate City Regional Regulation No. 1/2018, the Ternate City area was divided into 8 sub-districts with West Ternate Sub-district as a new area that was expanded from Ternate Island Sub-district.
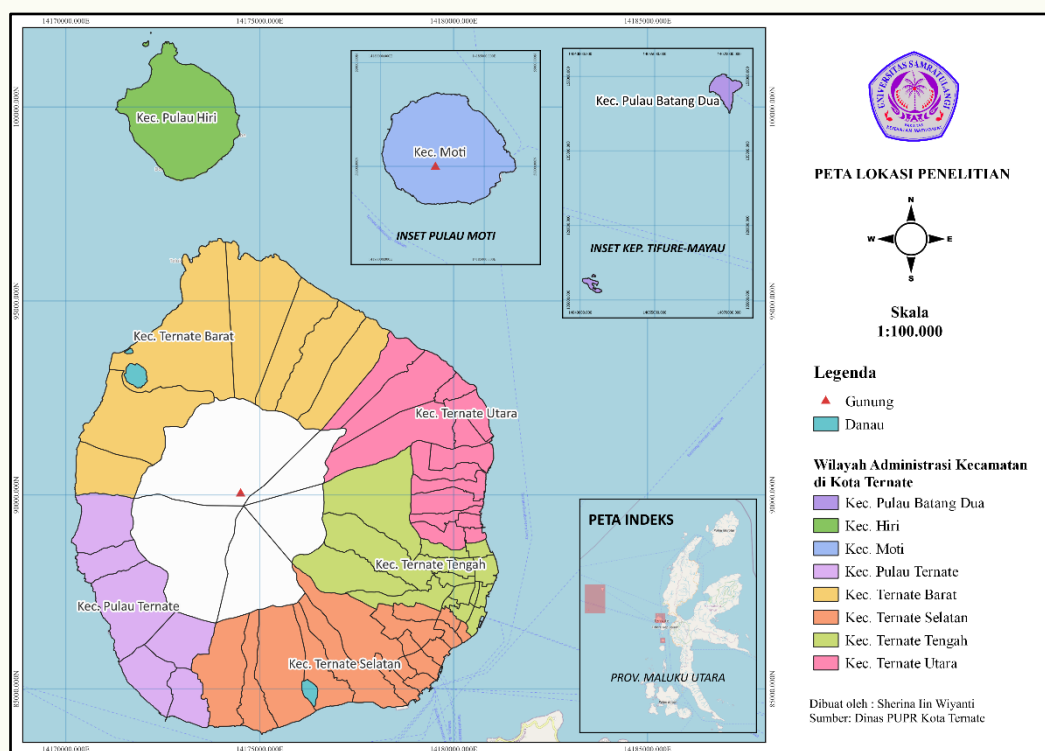
Figure 1. Research Location Map

Figure 2 shows the area that is the location of this research, which includes all sub-districts in Ternate City, totaling 8 sub-districts, namely Ternate Island Sub-district, Moti Sub-district, Batang Dua Island Sub-district, Hiri Island Sub-district, West Ternate Sub-

[17] Badan Pusat Statistik Kota Ternate. *Kota Ternate dalam Angka 2023*, Ternate: Badan Pusat Statistik Kota Ternate, 2023.

district, South Ternate Sub-district, Central Ternate Sub-district, and North Ternate Sub-district.

Tabel 1. Distribution of Population Density per Sub-district Area in Ternate City 2020-2022

Sub-district	Population Density per Year (Population/Km^2)		
	2020	2021	2022
Pulau Ternate	507	507	507
Moti	196	194	196
Pulau Batang Dua	97	96	97
Pulau Hiri	303	436	303
Ternate Barat	262	262	262
Ternate Selatan	3707	3700	3707
Ternate Tengah	4080	4057	4080
Ternate Utara	3548	3524	3548

Source: Badan Pusat Statistik Kota Ternate, 2023

The data presented in Table 2 shows that from 2020 to 2022 the population density in Ternate City has remained relatively constant or experienced insignificant changes. The average densest sub-district area from 2020 to 2022 is the Central Ternate sub-district area while the sub-district area with the lowest average population density is the Batang Dua Island sub-district.

Tabel 2. Frequency Distribution of Covid-19 Incidence per District Area in Ternate City in 2020-2022

Sub-district	Number of Covid-19 Confirmation Cases per Year		
	2020	2021	2022
Pulau Ternate	20	51	44
Moti	1	3	4
Pulau Batang Dua	0	9	25
Pulau Hiri	0	15	7
Ternate Barat	11	21	15
Ternate Selatan	238	800	184
Ternate Tengah	274	591	129
Ternate Utara	160	469	93
Total	710	1959	501

Source: Dinas Kesehatan Kota Ternate, 2022

The table above shows that throughout 2020-2022 the number of confirmed Covid-19 cases in Ternate City occurred the most in 2021 with a total of 1959 cases and the least in 2022 with a total of 501 cases.

3.1. Spatial Distribution of Covid-19 Incidence Based on Population Density in 2020

Figure 4. Spatial Distribution of Covid-19 Incidence Based on Population Density in Ternate City in 2020
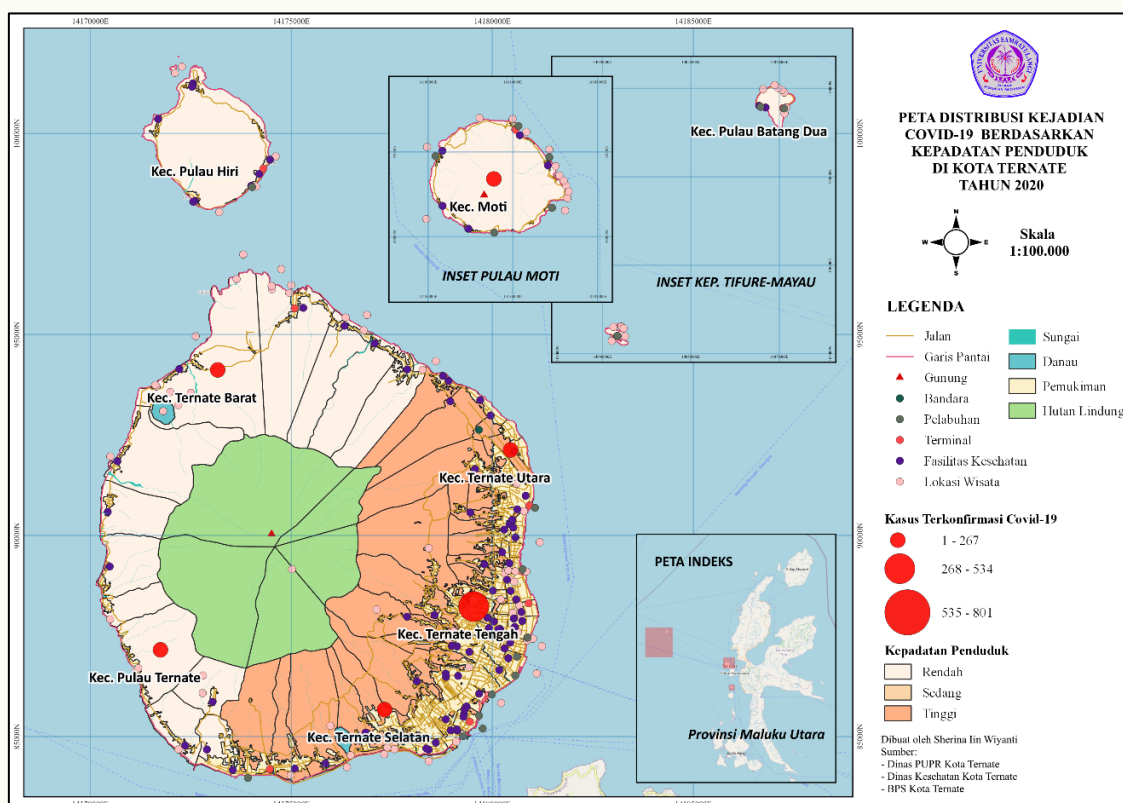

Figure 2 shows that in 2020 the highest number of Covid-19 confirmed cases in Ternate City reached 268-534 cases which were found in areas with high population density, namely Central Ternate Sub-district. Other sub-district areas with high population density categories such as North Ternate and South Ternate sub-districts have the same low number of cases as sub-district areas with low population density categories such as West Ternate sub-district, Ternate Island sub-district, and Moti sub-district, which are in the range of 1-267 cases while other low population density areas such as Batang Dua Island sub-district and Hiri Island sub-district have no Covid-19 incidence.

The information found in the research results regarding the incidence of Covid-19 based on Population Density in Ternate City in 2020 (Figure 4) shows the trend of the spread of Covid-19 in the District area in Ternate City. This spread occurred in several densely populated areas as well as areas with low density. Table 5 shows that sub-district areas with high average number of cases are areas with high population density (Table 4). Based on the theory of Area-Based Disease Management, high population density

areas indicate a high population in a narrow area so that interactions between residents in the area have great potential to transmit diseases such as Covid-19.[18]

The highest spread point of Covid-19 in Ternate City is known to be in the Central Ternate Sub-district area, while Covid-19 transmission in Ternate City in 2020 has not yet reached Batang Dua Island and Hiri Island Sub-districts. The incidence of Covid-19 found in Central Ternate Sub-district when compared to other areas with high population density such as South Ternate Sub-district and North Ternate Sub-district actually found a lower number of confirmed cases of Covid-19. This finding can be said to be not in line with the previous theory that dense areas will increase the risk of transmission of infectious diseases, but this could be caused by a lot of ambiguous data at the time of the initial data entry of Covid-19 confirmed cases such as information obtained from the Ternate City Health Office so that quite a lot of patient's permanent address data were found to be empty (missing data) which could be case data contained in areas with high population density such as South Ternate District and North Ternate District.

3.2. Spatial Distribution of Covid-19 Incidence Based on Population Density in 2021

Figure 3. Spatial Distribution of Covid-19 Incidence Based on Population Density in Ternate City in 2021

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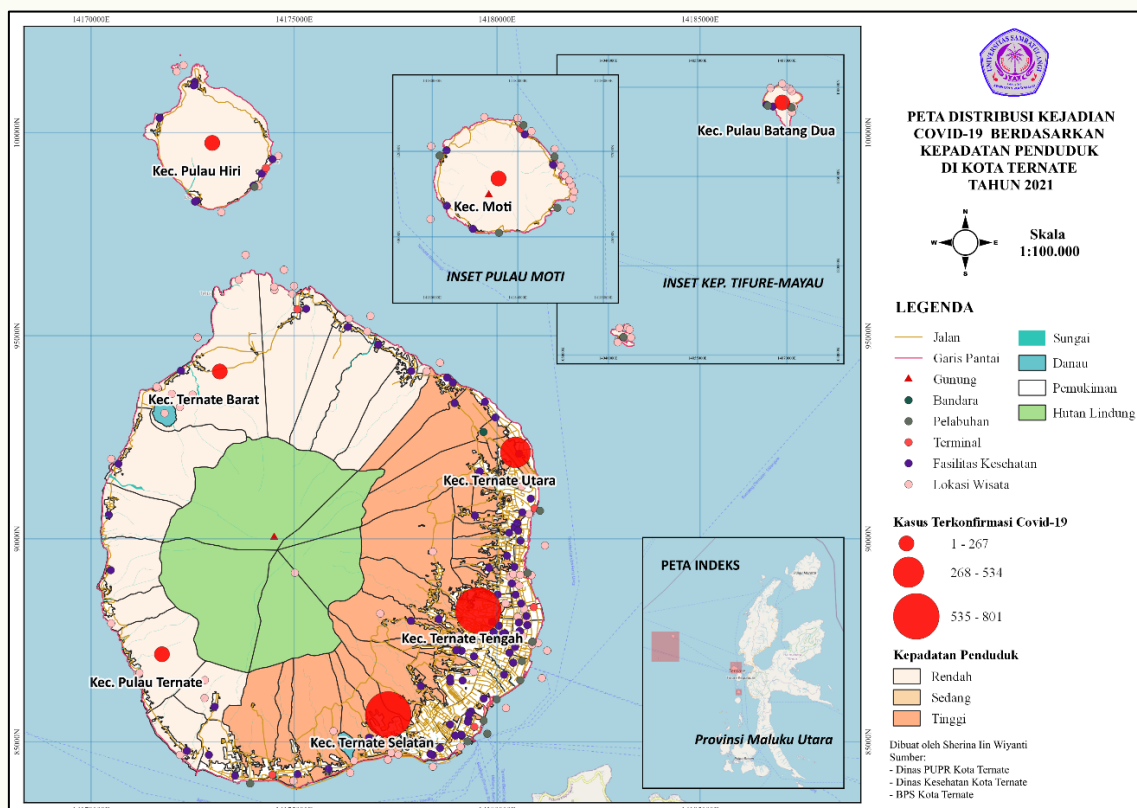
[18] Achmadi, Umar Fahmi. *Manajemen Penyakit Berbasis Wilayah Edisi Revisi*, edk 2. Jakarta: Raja Grafindo Persada, 2014.

The research results displayed in Figure 5 show that in 2021 the highest number of confirmed cases of Covid-19 in Ternate City reached 535-801 cases which can be found in areas with high population density categories, namely South Ternate and Central Ternate Districts, while other areas with the same category, namely North Ternate District, have a lower number of cases, ranging from 268-534 cases. Areas with low population density categories including West Ternate Sub-district, Ternate Island Sub-district, Moti Sub-district, Batang Dua Island Sub-district, and Hiri Island Sub-district were found to have low Covid-19 incidence rates, ranging from 1-267 cases.

The incidence of Covid-19 in Ternate City in 2021 experienced a spike in the number of cases as shown in Table 5 which shows that the increase in the number of confirmed cases of Covid-19 in Ternate City occurred in all sub-districts in Ternate City. A significant increase in the number of cases mainly occurred in 3 areas, namely North Ternate District, Central Ternate District, and South Ternate District. These findings are in line with previous research by Edriani et al[19] who found a significant influence of the population density factor with the spike in Covid-19 confirmed cases that occurred in DKI Jakarta Province due to intense interactions between regions as well as very high population mobility.

Based on the results of spatial identification, this distribution is thought to come from 2 factors, namely geographic and demographic factors in regions in Indonesia including Ternate City. According to the theory put forward by Coccia,[20] geographic factors that affect the proliferation of Covid-19 are the availability of public facilities such as traditional markets and supermarkets, the level of air pollution and the location of borders with other regions. Demographic factors that also influence are population mobility, population density, socioeconomic conditions, the number of confirmed Covid-19 problems and population attitudes.[21]

The three sub-districts that are the epicenter of the proliferation of the virus that causes Covid-19 in Ternate City, including North Ternate, Central Ternate, and South Ternate sub-districts, when viewed from the aspect of population density, are areas with high population density (Figure 5). Based on the research results in Figure 5, these areas are identified as areas that dominate the growth and development in almost various essential sectors in Ternate City such as the health sector and the economic sector. The existence of the health sector, characterized by the availability of health facilities such as pharmacies and public hospitals, can only be found in these three areas. The trade sector

[19] Edriani, Tiara Shofi, Anisa Rahmadani and D. Michiko M. Noor. "Analisis Hubungan Kepadatan Penduduk dengan Pola Penyebaran Covid-19 Provinsi DKI Jakarta menggunakan Regresi Robust", *Indonesian Journal of Applied Mathematics*, no. 2 (2021): 51-60, https://journal.itera.ac.id/index.php/indojam/.

[20] Coccia, Mario. "Diffusion of Covid-19 Outbreaks: The Interaction Between Air Pollution-To- Human and Human-To-Human Transmission Dynamics in Hinterland Regions With Cold Weather and Low Average Wind Speed", *SSRN Electronic Journal*, no. 48(2020), https://doi.org/10.2139/ssrn.3567841.

[21] Dewie, Artika, Pont, Anna Veronica and Hasnah. "Penyuluhan Berpengaruh Terhadap Peningkatan Pengetahuan Ibu Hamil Tentang Senam Hamil", *Ahmar Metastasis Health*, no. 1 (2021): 36–42, http://journal.ahmareduc.or.id/index.php/AMHJ.

is also similar, with markets, shops, stalls, restaurants, industries, service sectors; and public facilities such as worship facilities, terminals, ports, and airports mostly found in the three sub-districts.[22] The existence of these various essential sectors is an attraction for residents to live their lives so that these three areas have the potential to become the center of the spread of Covid-19 in Ternate City.

Another factor that may be the cause of the increase in the Covid-19 incidence rate in 2021 is the non-compliance of the people of Ternate City with health protocols such as wearing masks, maintaining distance, avoiding crowds and washing hands with soap, which according to Robo and Selajar [23] this non-compliant behavior is caused by the less than optimal application of sanctions by the Ternate City Task Force for violators of health protocols so that many people are still negligent in implementing health protocols. In addition, the lack of information about the distribution of Covid-19 in the local area can also be the cause of the low level of awareness of most residents to avoid areas that are vulnerable to transmission of the Sars Cov-2 virus in Ternate City. Djamrud et al[24] have also previously studied residents' attitudes towards the implementation of health protocol policies in the Gamalama Market area located in Central Ternate District and found that most traders or buyers still ignore the Health protocol and vaccination policies because they do not believe in the content of vaccines and lack of knowledge of the importance of vaccination even though the call for vaccination has entered stage 3 or booster vaccines. Most people are only motivated to carry out the vaccination process when they are looking for work or visiting outside the region, not to reduce the adverse effects of contracting Covid. This can then become one of the aspects supporting the spread of Covid-19 in Ternate City.

Other areas such as Ternate Island Sub-district, Batang Dua Island Sub-district, Hiri Island Sub-district, Moti Sub-district, and West Ternate Sub-district also experienced an increase in the number of Covid-19 confirmed cases which was not so high when compared to the three sub-districts above. The five sub-districts based on the results displayed in Figure 5 on average have similar characteristics such as having a low population density and the presence of minimal public facilities so that interactions between individuals are also not as massive as in North Ternate, Central Ternate, and South Ternate sub-districts. The spread of Covid-19 in the five areas mentioned is thought to be caused by activities in the tourism sector. This finding is based on the existence of 30 beach tourism objects and 13 cultural tourism objects, most of which are located in the West Ternate sub-district area.[25] This assumption is supported by research conducted by Taghulihi [26] which proves that throughout the last 5 years even though the

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[22] Badan Pusat Statistik Kota Ternate. *Kota Ternate dalam Angka 2022*, Ternate: BPS Kota Ternate, 2022, https://doi.org/1102001.8271.

[23] Robo, Basto Daeng and Sophian Yahya Selajar. "Penerapan Sanksi Bagi Pelanggar Protokol Kesehatan Pandemi Covid-19 di Kota Ternate", *Jurnal Legal Reasoning*, no. 1(2022): 23-40, https://journal.univpancasila.ac.id/index.php/jlr.

[24] Djamrud, Rasmi, Masje S. Pangkey and Novie Palar, "Perilaku Masyarakat Pada Pelaksanaan Kebijakan Protokol Penanganan Covid-19 Di Pasar Gamalama Kota Ternate", *Jurnal Administrasi Publik*, no. 3 (2023): 113-123, https://ejournal.unsrat.ac.id/v3/index.php/JAP/article/view/47468/42625.

[25] Badan Pusat Statistik Kota Ternate. *Kota Ternate dalam Angka 2022*, Ternate: BPS Kota Ternate, 2022, https://doi.org/1102001.8271.

[26] Kourgiantakis, Markos, Alexandros Apostolakis, & Irini Dimou, "Covid-19 and Holiday Intentions: The Case of Crete, Greece", *An International Journal of Tourism and Hospitality Research*, no. 1(2021): 148–151,

Covid-19 pandemic made the tourism zone face a very significant shrinkage in visits in all regions of Indonesia let alone in the world, tourist visits to tourist attractions in Ternate City are still the same. This matter is shown through the level of mobility of domestic tourists and local tourists who are still busy in Ternate City. Kourgiantakis et al [27] mentioned in their research that areas that become holiday destinations have a greater ability to transmit diseases than other areas that do not have tourist destinations given the high tourist traveling activities.

3.3. Spatial Distribution of Covid-19 Incidence Based on Population Density in 2022

Figure 4. Spatial Distribution of Covid-19 Incidence Based on Population Density in Ternate City in 2022
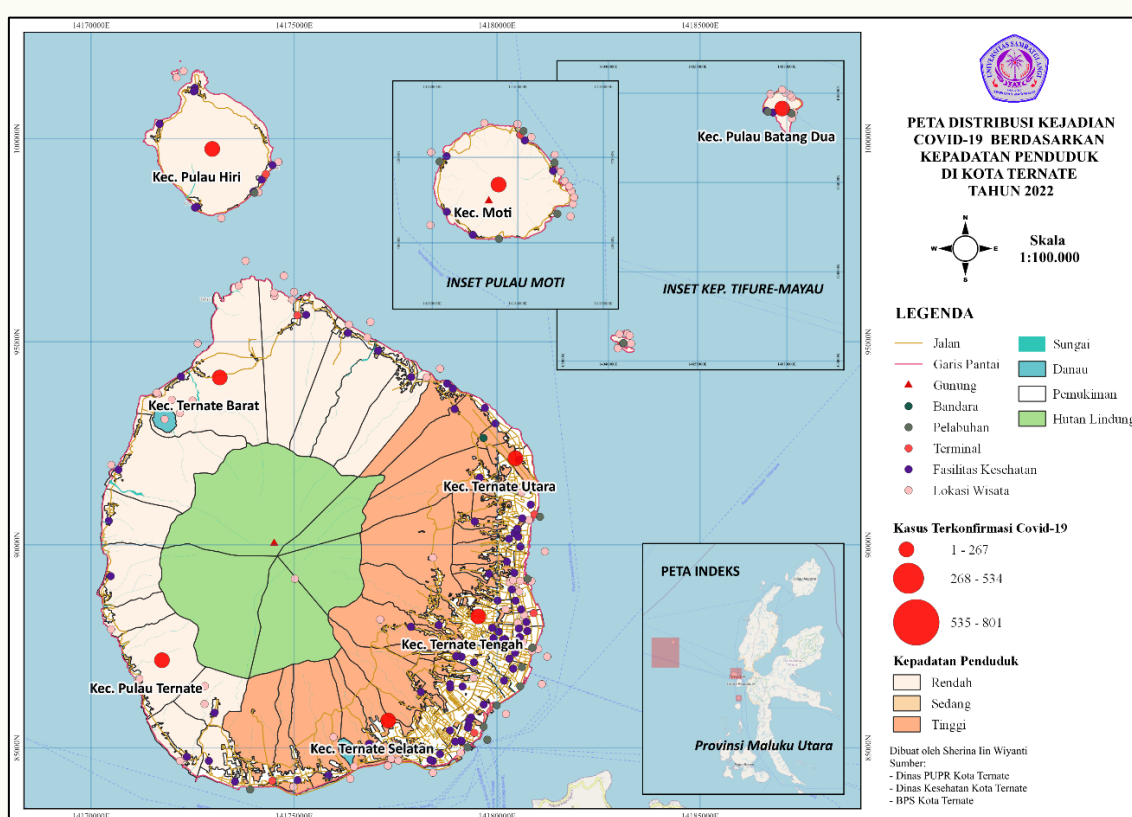
The results presented in Figure 6 show that in 2022 all sub-districts in Ternate City, both areas with high population density, namely South Ternate, Central Ternate, North Ternate sub-districts and low population density, namely Ternate Island, West Ternate, Hiri Island, Moti, and Batang Dua Island sub-districts, have relatively low total Covid-19 confirmation cases, which range from 1-267 cases.

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[27] Kourgiantakis, Markos, Alexandros Apostolakis, & Irini Dimou, "Covid-19 and Holiday Intentions: The Case of Crete, Greece", *An International Journal of Tourism and Hospitality Research*, no. 1(2021): 148–151, https://doi.org/10.1080/13032917.2020.1781221.

The results of the study on the incidence of Covid-19 based on population density in Ternate City in 2022 show that there are several sub-district areas in Ternate City that have a low population density that actually experienced an increase in the number of Covid-19 cases from the previous year such as Moti Sub-district and Batang Dua Island Sub-district, while other sub-districts tend to experience a decrease in the number of cases (table 5). Although there is a decrease or increase in the number of Covid-19 cases, the average number of cases is only in the range of 1-267 cases as shown in Figure 6. When viewed from the aspect of population density per sub-district in Ternate City, the number of population densities in each region remained relatively constant from 2020-2022. This indicates the possibility of other factors influencing the decrease in the number of confirmed Covid-19 cases in all sub-districts in Ternate City.

The location of the spread of the highest Covid-19 confirmed cases until 2022 is still located in the South Ternate, Central Ternate, and North Ternate sub-districts, although the number of cases appearing in the three areas has decreased. The decrease in the number of confirmed Covid-19 cases in 2022 as shown in Figure 6 is likely supported by the vaccination program that began in early 2021, which at the end of 2022 the Covid-19 vaccination program has reached the standard of creating herd immunity as reported by the Ministry of Health of the Republic of Indonesia on December 31, 2021[28] that the number of Indonesians who have been vaccinated first reached 77.49% and the vaccine on December 31, 2022 has reached 86.81%. According to an article written by the Ministry of Health of the Republic of Indonesia [29], it is explained that when the population is dominated by people who are already immune to an infectious disease, it will indirectly create protection for groups that are not immune to the disease (group immunity). This theory is supported by research conducted by Normelia et al [30] that the increase in the number of confirmed cases of Covid-19 when there is no vaccine and after the vaccine has a difference which shows the effectiveness of vaccines that can reduce the number of confirmed cases of Covid-19 in Indonesia. Thus, areas with high population density and the availability of adequate health facilities certainly have a greater chance of preventing the severity caused by Covid-19 through vaccination.

In addition to the vaccination program launched by the government, policies such as Circular Number 23 and 24 of 2022 regarding domestic travel rules during the Covid-19 pandemic and the implementation of restrictions on community activities level 3, level 2, and level 1 and maximizing Covid-19 handling posts at the village and sub-district levels to control the spread of Covid-19 in the regions of Sumatra, Nusa Tenggara, Kalimantan, Sulawesi, Maluku, and Papua participated in helping control Covid-19 in Ternate City. All

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[28] Kementerian Komunikasi dan Informasi Republik Indonesia. *Memantau Mobilitas dan Kualitas Informasi di Tengah Pandemi*. Jakarta: *Kemenkominfo*, 2021, https://www.kominfo.go.id/content/detail/35573/memantau-mobilitas-dan-kualitas-informasi-di-tengah-pandemi/0/artikel.

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[30] Normelia, Rizky, Titian Dewi Fortuna, Elen Prihana Putri, dan Edy Widodo. 2022. "Analisis Mann-Whitney untuk Mengetahui Efektivitas Vaksin pada Jumlah Penderita Covid-19 di Indonesia." *Jurnal Sains Matematika dan Statistika* 8 (1): 27. https://doi.org/10.24014/jsms.v8i1.15087.

of these policies lead to the supervision of community mobility where one form of implementation of this policy is the existence of Covid-19 screening posts in the airport area located in North Ternate District and at the port located in almost every sub-district in Ternate City, thus the potential for reducing Covid-19 in both less dense and densely populated areas becomes greater.

4. Conclusion

The conclusion from the research results obtained is that the incidence of Covid-19 in Ternate City in 2020 is mostly found in high population density areas, namely Central Ternate District. The incidence of Covid-19 in 2021 is mostly found in high population density sub-districts, namely Central Ternate and South Ternate sub-districts. In 2022, all sub-district areas, both high and low population density areas, have a low number of Covid-19 incidents.

Acknowledgments

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