Media Kesehatan Masyarakat Indonesia
Volume 21 Issue 1 2025
DOI : 10.30597/mkmi.v21i1.33183
Website : http://journal.unhas.ac.id/index.php/mkmi

Social Determinants of Covid-19 Morbidity in Indonesia: Observational District Level Analysis

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ARTICLE INFO

Article History:
Received Aug, 27th, 2024
Accepted Jan, 7th, 2024
Published online Mar, 31st, 2025

Keywords:
Covid-19;
Pandemic;
Social Determinants;
Morbidity;
Delta Wave;

ABSTRACT

Since the COVID-19 pandemic globally struggled in late 2019, the global community has become aware that outbreaks of infectious diseases are associated with conditions beyond health factors, such as social, economic, demographic, geographic, and lifestyle. This paper aims to identify the influence of Social Determinants of Health (SDOH) on COVID-19 morbidity rates in Indonesia. The study analyzed morbidity cases during the second wave of the COVID-19 pandemic, namely the Delta variant wave. Multivariate analysis with linear regression was used to determine the predictors that affect COVID-19 morbidity in 128 districts/cities of the Java and Bali isles, which were controlled by the pandemic stages including pre, resurgence, decline, and post. Morbidity data was collected cross-sectionally from the National COVID-19 Task Force dataset and the social determinant of the 2021 Central Statistics Agency report. The number of health facilities is the most influential characteristic of the regency/city to COVID-19 morbidity at the pre-and resurgence-pandemic stages. The ratio of the immune population is the most influential characteristic when the pandemic experiences a decline stage; meanwhile, during the post-pandemic, the second dose of vaccination is the most influential characteristic. We recommended that testing, tracing, quarantine, and isolation intervention should be prioritized in the districts/cities with higher health facilities (pre- and resurgence-stage), higher herd immunity (decline-stage), and booster vaccination (post-stage). Social determinants of health are suggested to be used as a basis for predicting the risk factors for an outbreak of infectious diseases in a region and contributing to different SDOH factors in different outbreak stages.

INTRODUCTION

Severe Acute Respiratory Syndrome (SARS) Coronavirus 2 (SARS-CoV-2) disease or COVID-19 is an infectious disease caused by a beta-coronavirus first identified in December 2019 in Wuhan, China.[1] After infecting 114 countries and causing 4,291 deaths, a 13-fold increase since it was first discovered on March 11, 2020, the WHO declared the "pandemic statue" of COVID-19 spreading. "We have therefore made the assessment that COVID-19 can be characterized as a pandemic," said WHO Director-General Tedros Adhanom Ghebreyesus during a media briefing.[2] WHO announced nine days after the Indonesian first and second COVID-19 cases on March 2, 2020.[3]

The three-year COVID-19 pandemic has struggled 231 countries worldwide. It has made the global community realize that the control of disease outbreaks is closely related to the characteristics of the affected region. The disease outbreak control strategy is similar in each country. However, each region has different challenges and limitations, resulting in differences in responding to outbreaks, such as controlling the COVID-19 pandemic in Palestine.[4] The COVID-19 control response strategy difference becomes even clearer when ethical, value, moral, and cultural aspects are considered between countries, for example, in a study of China and Korea.[5] The difference in response and the completeness of disease outbreak management planning depends on the country's wealth, as in Latin American countries, in handling the influenza pandemic.[6] In the case of the polio outbreak, the difference in country conditions and risks plays an important role in outbreak response preparation and assessment of vaccine stockpile needs.[7]

Two factors caused the discrepancy in COVID-19 outbreak control and management in various countries: 1) the distinction between health systems and infrastructure capability, and 2) the role of social determinants in local communities.[8] Social determinants of health officially established by the WHO Ottawa Charter as the cause of health problems can then be applied as direct or indirect predictors of disease outbreaks. Learned from two years of the COVID-19 pandemic, Hoven et al. (2022) recommended that SDOH needs to be considered in planning preparedness for infectious disease pandemics.[9] In a study of the South Korea Middle East Respiratory Syndrome (MERS) outbreak, SDOH directly and indirectly influenced hand washing behavior and "not to seek" medical attention decision at a hospital even if symptoms were present.[10] SDOH was also associated with mosquito repellent utilization in pregnant women in Brazil to combat the Zika outbreak, even though it is harmful to the delivery process.[11]

A study of the Covid-19 pandemic in 175 countries showed that SDOH, such as expenditure on medical treatment, smoking behavior and healthy behavior guidelines were considered to reduce transmission and death,[12] likewise, studies at the district/district level in India showed a relationship between SDOH and an increasing of Covid-19 cases.[8] For the Latino ethnic population in America, mental health problems due to the Covid-19 pandemic are correlated with SDOH such as immigration status and gender,[13] as well as for the adult and elderly population in Luxembourg.[14] SDOH also significantly associated with increasing cases of dengue fever outbreaks. Sujatha et al. (2021) reported a correlation between SDOH and deaths due to high fever during the dengue outbreak in India.[15]

We have not even found the study of COVID-19 SDOH predictor in Indonesia at district/cities level. Several studies focus on individual level at 5 rural provinces,[16–18] and in hospital setting.[19] Socio-demographic factors were studied in COVID-19 prevention behavior such as compliance in face mask wearing at individual level.[20]

This study analyzed morbidity cases during the second wave of the COVID-19 pandemic, known as the Delta wave, which was a critical period in controlling the SARS-CoV-2 outbreak in Indonesia. In this period, the Covid-19 vaccination program was initiated for the first time in Indonesia and was reinforced with layered policies to limit people's activities and mobility. The Delta Covid-19 variant caused daily morbidity cases in Java-Bali to reach the highest number of more than 76,000 confirmed cases. The islands of Java and Bali are the areas with the most dense populations. Firstly Covid-19 cases were discovered, the epicenter area of transmission of the SARS-CoV-2 virus, as the center of economic activities, and the most public commuter and mobility in Indonesia. As

13 August 2021, all districts and cities in Java and Bali contributed 60% of total morbidity cases in Indonesia. This study aims to identify the social determinants that influence morbidity rates due to COVID-19 in Indonesia.

MATERIAL AND METHOD

Covid-19 morbidity data collected from the National Covid-19 Task Force dataset is the number of confirmed cases of the SARS-CoV-2 virus examined using the Poly Chain Reaction (PCR) method. The concept of social determinants of health are non-medical factors that influence health and include conditions of birth, growth, work environment, life, and forces/ systems that shape human living conditions from day to day data were collected from the Indonesia Statistical Agency.[21] This study analyzed 128 districts/cities on Java and Bali islands using a cross-sectional design controlled based on pre-, resurgence, decline and post-pandemic stages from 1 March 2021 – 23 October 2021. Multivariate linear regression was used to analyze the determinants of Covid-19 morbidity after selecting variables based on the Pearson correlation parameter above 0.40.

To produce a robust linear regression model, we carried out a series of tests on the data, namely missing data, outliers, normality, linearity and bivariate correlation tests. The test results show that there are no variables with missing data, while the outlier test results show that most of the data has outliers (Apendix 1). In this study, we did not delete outlier data due to the nature of the districts/cities indicated as outliers and the credibility of the data collection carried out by the data collection agency. The normality test was carried out in three stages, first testing all variables with the Kolmogorov-Smirnov Asymptotic at a significance of 0.05. Variables that are not normally distributed are continued to the second test stage, while those that are normally distributed are subjected to a linearity test. Second, test all variables that are not normally distributed in the first stage using Exact Monte-Carlo Kolmogorov-Smirnov. Variables that are normally distributed are subjected to a linearity test, while variables that are not normally distributed are subjected to a third-stage normality test. Third, carry out data transformation from variables that are not normally distributed in the second stage of the normality test. The transformation results show differences in the scale of the transformed data for all variables, including normal logarithm, logarithm 10, square, square-root, inverse square-root, and inverse Y. The third stage of the normality test produced 11 variables that were not normally distributed and no linearity test was carried out. Thus, 93 normally distributed variables were produced with data transformation and 40 variables without data transformation (Apendix 2). The linearity test produces 70 linear variables for the pre and resurgence regression models, as well as 83 variables for the decline model and 80 variables for the post-pandemic model (Apendix 3). The final stage is to carry out variable selection using a bivariate correlation test with the Pearson correlation criterion > 0.400 and the resulting variables for stepwise-multivariate linear regression analysis are 22 variables (pre and resurgence models), 37 variables (decline model), and 20 variables (post model) (Apendix 4).

This research passed the Faculty of Public Health of Universitas Indonesia ethical clearance number 5/UN2.F10.D11/PPM.00.02/2023 on 9 January 2023.

RESULTS

District/City Characteristics

Table 1 depicts the characteristics of 4 dependent variables and selected 25 independent variables with a significant linear regression model correlation. The COVID-19 morbidity tends to increase from pre, resurgence to decline stages. Otherwise, it tends to decrease when the COVID-19 outbreak shifts from decline to post-pandemic stages.

The Influence of SDOH Factors

Table 2 shows that the demographic factors influencing COVID-19 morbidity were people over 50 and 15 years old. The influence of people > 50 years on COVID-19 morbidity cases occurs at pre-, resurgence-, and post-pandemic stages with a positive correlation. Otherwise, the influence of people > 15 years old occurs during the resurgence pandemic with a negative correlation. These demographic factors were not correlated at the decline-pandemic stage.

For economics domain, factors that influenced the COVID-19 morbidity with positive correlation were Gini ratio (pre and resurgence-pandemic stages) and room hotel density (decline-pandemic). A negative correlation was attached for poverty ratio (pre-pandemic) and GDP for health sector (decline-pandemic). These economic factors were not correlated at post-pandemic stage (Table 2).

The social factor that influenced the COVID-19 morbidity was school duration with negative correlation at pre-pandemic stage. This social factor was not correlated at resurgence, decline, and post-pandemic stage (Table 2).

The health system factors influencing COVID-19 morbidity were healthcare facilities (pre and resurgence-pandemic stage) and herd immunity (decline-pandemic), with a positive correlation. Otherwise, a negative correlation was attached for immunity people (resurgence-pandemic), initial vaccination (decline-pandemic), and second-dose vaccination (post pandemic). These health systems factors were correlated in every stage of the pandemic (Table 2).

The quality-of-life factors, such as non-food and tobacco expenditure, were only correlated negatively with COVID-19 morbidity at the decline-pandemic stage. So, the geographic factors (the distance to the COVID-19 epicentrum area) were negatively correlated only at the post-pandemic stage (Table 2).

Table 1. Characteristics of 128 District/City in Java-Bali Area

Characteristics	Mean	95% CI	SD
Covid-19 morbidity^a (peoples)	2222.56	(1626.93 – 2818.20)	3405.49
Covid-19 morbidity^b (peoples)	5426.58	(3597.07 – 7258.09)	10471.48
Covid-19 morbidity^c (peoples)	6696.30	(5476.39 – 7916.20)	6974.68
Covid-19 morbidity^d (peoples)	95.84	(72.72 – 118.95)	132.16
Peoples >15 years^e (amount)	936358.86	(816515.95 – 1056201.77)	685190.00
Peoples > 50 years^e old (amount)	156691.09	(135054.52 – 178327.67)	123705.01
Gini ratio^e (index)	0.344	(0.337 – 0.351)	0.038
Poverty ratio^e (percent)	92.52	(85.50 – 99.54)	40.13
School duration^e (years)	8.36	(8.08 – 8.63)	0.50
Healthcare facilities^e (unit)	193.29	(173.81 – 212.77)	111.36
Immunity^a (peoples)	20427.86	(15908.55 – 24947.17)	25838.71
Immunity^b (peoples)	155539.41	(119569.83 – 191508.98)	205652.53
Immunity^c (peoples)	312417.54	(244671.40 – 380167.70)	387322.26
Herd immunity^a (percent)	2,01	(1.69 – 2.32)	1.81
Herd immunity^b (percent)	15.52	(12.61 – 18.44)	16.65
Herd immunity^c (percent)	31.03	(25.89 – 36.18)	29.41
Non-food expenditure^e (percent)	50.35	(49.29 – 51.42)	6.09
Health sector GDP^e (percent)	1.55	(1.23 – 1.87)	1.84
Tobacco expenditure^e (percent)	6.75	(6.22 – 7.29)	3.05
1st-dose vaccine density^a (per health facility)	52.21	(45.22 – 59.20)	39.95
1st-dose vaccine density^b (per health facility)	475.82	(396.61 – 555.02)	452.86
1st-dose vaccine density^c (per health facility)	1143.64	(978.29 – 1308.98)	945.35
Hotel room density^e (per 1000 km^2)	24.27	(10.59 – 37.95)	78,23
2nd-doses vaccine^a (Doses)	4985.71	(4099.76 – 5871.66)	5065.35
2nd-doses vaccine^b (Doses)	58019.17	(44058.92 – 71980.64)	78919.88
2nd-doses vaccine^c (Doses)	85672.00	(67275.00 – 104069.00)	105184.48
Distance to epicentrum^a (km)	111.51	(97.84 – 125.16)	77.99
Distance to epicentrum^b (km)	111.51	(97.84 – 125.16)	77.99
Distance to epicentrum^c (km)	117.91	(103.37 – 132.44)	83.11

Source: Primary Data, 2020 & 2021

CI = Confidence Interval; SD = Standard Deviation; a = Pre-Delta Wave Period; b = Resurgence Period, c = Decline Period, d = Post-Period; e = 2020

Table 2. Linear Regression Model of COVID-19 Morbidity as Outcome

Independent Variables	Data trans.	Domain of SDOH	Beta**	p-value
Pre-pandemic stage *(Outcome data transform = ln(Y); constant = 3.752; R-squared = 0.659)*				
Peoples>50 years (amount)	$\sqrt{Y}$	Neighborhood & physical environment	0,216	0.085
Gini ratio (index)	Y	Economic stability	0.303	<0.001
Poverty ratio (percent)	Y	Economic stability	-0.233	0.001
School duration (years)	Y^{-1}	Education	-0.227	0.003
Healthcare facilities (unit)	$\sqrt{Y}$	Healthcare system	0.317	0.012
Resurgence-pandemic stage *(Outcome data transform = ln(Y); constant = 4.758; R-squared = 0.715)*				
Peoples>50 years old	$\sqrt{Y}$	Neighborhood & physical environmental	0.238	0.036
Gini ratio (index)	Y	Economic stability	0.266	<0.001
Peoples>15 years (amount)	$1/\sqrt{Y}$	Neighborhood & physical environmental	-0.269	<0.001
Healthcare facilities (unit)	$\sqrt{Y}$	Healthcare system	0.284	0.023
Immunity peoples (amount)	$1/\sqrt{Y}$	Quality of life	-0.176	0,028
Decline-pandemic stage *(Outcome data transform = $1/\sqrt{Y}$); constant = 0.070; R-squared = 0.659)*				
Herd immunity (percent)	$1/\sqrt{Y}$	Quality of life	0.551	<0.001
Non-food expenditure (%)	Y	Quality of life	-0.178	0.022
Health sector GDP (percent)	ln Y	Healthcare system	-0,231	<0.001
Tobacco expenditure (percent)	Y	Quality of life	-0.216	0.003
First dose vaccination density	$1/\sqrt{Y}$	Quality of life	-0.392	0.003
Room hotel density	$1/\sqrt{Y}$	Economic stability	0.224	0.005
Post pandemic stage *(Outcome data transform = ln(Y)); constant = 4.808; R-squared = 0.4592)*				
Second dose vaccine (amount)	$1/\sqrt{Y}$	Quality of life	-0.451	<0.001
Peoples > 50 years old	$\sqrt{Y}$	Neighborhood & physical environmental	0.301	<0.001
Distance to epicentrum (km)	Y	Neighborhood & physical environmental	-0,216	0.001

Source: Primary data from BNPB and BPS, 2020-2021

DISCUSSION

This research proved that SDOH influenced COVID-19 morbidity at all pandemic stages and that there were no unique factors at every stage. The health system factors positively and negatively correlated at all stages; otherwise, quality-of-life and demographic factors negatively correlated at the decline and post-pandemic stages, respectively. This result is in line with previous SDOH research that influenced Covid-19 morbidity, such as (22–24), including studies specifically conducted for vulnerable groups 22–24.[25,26]

The SDOH that influenced Covid-19 morbidity encourage health authorities to prioritize health problems and allocate sufficient financial and human resources to achieve universal health coverage and health-related social protection and determine the needs of vulnerable groups.[27] Besides that, health authorities do not only focus on medical interventions to deal with the Covid-19 outbreak.[28] From this point of view We propose several recommendations to control the airborne disease outbreak as COVID-19 lessons learned.

The first recommendation is the improvement of telehealth medical consultation utilization, particularly for districts/cities with more healthcare facilities, to avoid crowding people. The study showed the novel result that the districts/cities with more healthcare facilities tend to increase COVID-19 morbidity, particularly at pre and resurgence-pandemic stages. This result is opposite to the general assumption that a healthy area (which has more healthcare facilities) is at a lower risk for COVID-19 spreading. We suggest that areas with more health facilities are more ready for COVID-19 treatment and tend to have more people density and at-risk people. This study evidenced that the correlation between the number of health facilities and the number of people > 50 years was strong (beta = 0.902), strengthening our thesis. Easy access to health facilities caused more mobility and crowded people that are at risk of Covid-19 transmission. We suggest regencies/cities residents who visit health facilities during the Covid-19 pre and resurgence-pandemic stage deal with health problems beside Covid-19, such as childbirth, mental health, gerontology and so on.[29–31] We recommend that telehealth be improved to avoid crowds and improve the mobility of asymptomatic residents undergoing COVID-19 consultations. We suggest that testing, tracing, quarantine, and isolation interventions be prioritized in districts/cities with more health facilities, particularly in DKI Jakarta provinces. The use of telemedicine in health services during the Covid-19 pandemic provides many benefits for health service providers and patients in accordance with WHO recommendations and creates simpler service operations.[32]

Second, we recommend that the intervention of testing, tracing, quarantine, isolation, and mobility restrictions during the declining pandemic be prioritized in districts/cities with higher herd immunity, especially in urban areas. Herd immunity mostly contributed to COVID-19 mobility during the pandemic, with a positive correlation. In this study, we define herd immunity as the proportion of the population that has immunity due to recovery or vaccination. This result contradicts the general thesis that areas with higher herd immunity have a more protected population, leading to reduced COVID-19 morbidity. We suggest two theses to address this result. First, herd immunity effectively protects against COVID-19 transmission, which was not in decline during the pandemic; however, when COVID-19 morbidity tends to increase or at the resurgence pandemic stage, Second, increasing herd immunity motivated people to be more mobile because of the perception that conditions are safer for carrying out activities. The correlation between herd immunity and room hotel capacity reached 0.761, strengthening this suspicion. We recommend that testing, tracing, quarantine and isolation intervention and control of mobility restriction during decline-pandemic be prioritized in districts/cities with a higher herd immunity, especially with higher density of room hotels. Jakarta Pusat, Badung (Bali), and Yogyakarta are the areas with highest density of room hotel and herd immunity in Java-Bali. Increasing recovery and providing vaccinations during the Covid-19 pandemic are crucial interventions, but the condition of natural and acquired immunity of the population needs special attention when there is a decline in cases. The results of this study still recommend vaccination intervention to improve immunity, even though theoretically immunity can be obtained after someone recovers from Covid-19. The Immunity that is only obtained from recovery without vaccination results in an increased burden on health facilities and deaths due to Covid-19.[33] Several countries, including Indonesia, are trying to achieve 70-80% herd immunity, which depends on vaccination coverage and booster doses. However, the condition of herd immunity did not reflect the effectiveness of COVID-19 eradication.[34]

This research evidently provides the theses that second-dose vaccination contributed to Covid-19 mobility during post-pandemic with negative correlation. The results of this study strengthen the hypothesis that booster vaccination provides effective protection against Covid-19 transmission.[35] A booster vaccination is needed to restore the immunity of people because of the possibility of the declining of the vaccine's efficacy.[36] The challenge faced in booster vaccination intervention is the unpleasant experience when people get the first vaccination dose.[37] The sociodemographic factors like age, education, and income.[38] High levels of booster vaccination occurred in Surabaya, DKI Jakarta and Bandung during post-pandemic. Along with efforts to increase booster vaccination coverage, third recommendation is conducting the intervention of testing, tracing, quarantine and isolation during post-pandemic be prioritized in districts/cities with a lower booster vaccination, including in Seribu island, Batu city, Sampang, Banjar city, and Cilegon city.

This research does not treat the outlier data and applies a cross-sectional design. The weakness implied by the result of this study is that it does not reflect the causal-effect relationship, and it is further necessary to carry out further studies with outlier data treatment. The bias problem arising from cross-sectional data is overcome by controlling the study result during the pandemic stage.

CONCLUSION AND RECOMMENDATION

This research provides a different perspective on epidemic control. First, epidemic control should be prioritized in districts/cities with easy access to health facilities when cases approach and experience an increase. However, this result is not related to health service capacity but the tendency of the population at risk, especially the elderly, to be more numerous in areas with adequate health facilities. Second, interventions to cure and increase immunity through vaccination must continue to be carried out. However, when the pandemic experiences a decline in cases, districts/cities with high population immunity must receive more attention in controlling the outbreak. Third, the effect of vaccination is very important when the outbreak begins to slow down through the injection of booster doses of vaccination. Booster dose vaccination is needed to restore the level of immunity against infectious diseases due to possible decreased vaccine efficacy.

The Indonesian local government should prepare the data of SDOH as district/city characteristics. These variables are the key parameters to decide the priority area that should be conducted to control the public health emergency or disease pandemic, such as the non-pharmaceutical intervention (mobility restriction) and COVID-19 vaccination. The national level government should arrange the improvement capability program to control the local government's public health emergency.

Advanced studies to address SDOH factors that influence the outbreak severity, particularly airborne transmission disease, should be organized by scholars of public health and related disciplines. We recommend applying panel study design, outbreak model simulation, and a broader area scope to investigate the pandemic policy for other outbreak potential diseases.

ACKNOWLEDGMENTS

The researcher would like thanks the Indonesia Covid-19 Task Force, the University of Indonesia, and Esa Unggul University for their material and intellectual support during the study.

AUTHOR CONTRIBUTIONS

Conceived and designed the research by WA; AH performed the experiments, analyzed the data, and contributed reagents/materials/analysis tools and wrote the manuscript. DA performed the authors read and approved the final manuscript. WA = Wiku Adisasmito; AH = Ade Heryana; DA = Dumilah Ayuningtyas.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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APENDIX-1 Outlier for Selected Individual Factor/Characteristic[e]

No	Characteristics	Outlier (Count: Districts/Cities)
1	Covid-19 morbidity [a]	5: South Jakarta, West Jakarta, East Jakarta, North Jakarta, Depok
2	Covid-19 morbidity [b]	4: South Jakarta, West Jakarta, East Jakarta, North Jakarta
3	Covid-19 morbidity [c]	7: South Jakarta, West Jakarta, East Jakarta, Bekasi city, Depok, Bantul, Surabaya
4	Covid-19 morbidity [d]	7: South Jakarta, West Jakarta, East Jakarta, North Jakarta, Bandung city, Depok, Bantul
5	Peoples>15 years	4: Tangerang, Bogor, Bandung, Bekasi
6	Peoples > 50 years old	4: Tangerang, East Jakarta, West Jakarta, Bogor
7	Gini ratio	3: Bandung, Pacitan, Bantul
8	Poverty ratio	2: Sampang, Sumenep
9	School duration	0
10	Healthcare facilities	2: South Jakarta, Bogor
11	Immunity peoples [a]	6: South Jakarta, East Jakarta, Central Jakarta, West Jakarta, Semarang city, Surabaya
12	Immunity peoples [b]	5: South Jakarta, East Jakarta, Central Jakarta, West Jakarta, Surabaya
13	Immunity peoples [c]	6: South Jakarta, East Jakarta, Central Jakarta, West Jakarta, North Jakarta, Surabaya
14	Herd immunity [a]	4: Central Jakarta, Magelang city, Surakarta, Mojokerto city
15	Herd immunity [b]	4: Central Jakarta, Yogyakarta, Bandung, Denpasar
16	Herd immunity [c]	6: Seribu island, South Jakarta, Central Jakarta, Yogyakarta, Denpasar, Bandung city
17	Non-food expenditure	1: North Jakarta
18	Health sector GDP	2: Seribu island, Pangandaran
19	Tobacco expenditure	3: Serang, Seribu island, Grobogan
20	1st-dose vaccine density [a]	3: South Jakarta, Central Jakarta, Surabaya
21	1st-dose vaccine density [b]	4: South Jakarta, East Jakarta, Central Jakarta, Surabaya
22	1st-dose vaccine density [c]	6: Central Jakarta, South Jakarta, East Jakarta, West Jakarta, North Jakarta, Surabaya
23	Room hotel density	2: Central Jakarta, Yogyakarta
24	2nd-doses vaccine [a]	6: South Jakarta, East Jakarta, Central Jakarta, West Jakarta, Bandung city, Surabaya
25	2nd-doses vaccine [b]	6: South Jakarta, East Jakarta, Central Jakarta, West Jakarta, Bandung city, Surabaya
26	2nd-doses vaccine [c]	6: South Jakarta, East Jakarta, Central Jakarta, West Jakarta, Bandung city, Surabaya
27	Distance to epicentrum [a]	2: Pangandaran, Banyuwangi
28	Distance to epicentrum [b]	2: Pangandaran, Banyuwangi
29	Distance to epicentrum [c]	1: Pangandaran

a = Pre-pandemic stage; b = Resurgence-pandemic stage; c = Decline-pandemic stage; d = Post pandemic stage; e = Z score standards (cut-off = 2.50)

APENDIX-2 Normality Test and Transforming Data Result of Selected Variables

No	Characteristics	Significantly normal[e]	Data Transformation
1	Covid-19 morbidity[a]	0,516	Logarithmic natural
2	Covid-19 morbidity[b]	0.077	Logarithmic natural
3	Covid-19 morbidity[c]	0.632	Inverse square root
4	Covid-19 morbidity[d]	0.522	Logarithmic natural
5	Peoples>15 years	0.165	Square root
6	Peoples > 50 years old	0.472	Square root
7	Gini ratio	0.343	Original data
8	Poverty ratio	0.148	Original data
9	School duration	0.610	Inverse Y
10	Healthcare facilities	0.548	Square root
11	Immunity peoples [a]	0,191	Inverse square root
12	Immunity peoples [b]	0.828	Inverse square root
13	Immunity peoples [c]	0.975	Inverse square root
14	Herd immunity [a]	0.449	Inverse square root
15	Herd immunity [b]	0.445	Inverse square root
16	Herd immunity [c]	0.397	Inverse square root
17	Non-food expenditure	0.200	Original data
18	Health sector GDP	0.239	Logarithmic natural
19	Tobacco expenditure	0.365	Logarithmic natural
20	1st-dose vaccine density [a]	0.469	Logarithmic natural
21	1st-dose vaccine density [b]	0.145	Logarithmic natural
22	1st-dose vaccine density [c]	0.977	Inverse square root
23	Room hotel density	0.195	Inverse square root
24	2nd-doses vaccine [a]	0.050	Logarithmic natural
25	2nd-doses vaccine [b]	0.442	Inverse square root
26	2nd-doses vaccine [c]	0.995	Inverse square root
27	Distance to epicentrum [a]	0.194	Original data
28	Distance to epicentrum [b]	0.194	Original data
29	Distance to epicentrum [c]	0.169	Original data

a = Pre-pandemic stage; b = Resurgence-pandemic stage; c = Decline-pandemic stage; d = Post pandemic stage; e = Exact Monte Carlo Kolmogorov-Smirnov for transformed data & Asymptotic Kolmogorov-Smirnov for original data (α=0.050)

APENDIX-3 Linearity Test Result of Selected Normal Distribution Variables

No	Characteristics	Significantly linear with COVID-19 Morbidity[e]			
		Pre-pandemic	Resurgence-pandemic	Decline-pandemic	Post-pandemic
1	Peoples>15 years	0.409	0.148	0.577	0.604
2	Peoples > 50 years old	0.454	0.170	0.090	0.065
3	Gini ratio	0.349	0.372	0.103	0.617
4	Poverty ratio	0.165	0.703	0.104	0.300
5	School duration	0.976	0.555	0.576	0.927
6	Healthcare facilities	0.167	0.496	0.241	0.616
7	Immunity peoples [a]		0.936		
8	Immunity peoples [b]			0.490	
9	Immunity peoples [c]				0.488
10	Herd immunity [a]		0.436		
11	Herd immunity [b]			0.758	
12	Herd immunity [c]				0.921
13	Non-food expenditure	0.312	0.149	0.367	0.214
14	Health sector GDP	0.445	0.004[f]	0.103	0.198
15	Tobacco expenditure	0.198	0.603	0.187	0.272
16	1st-dose vaccine density [a]		0.392		
17	1st-dose vaccine density [b]			0.416	
18	1st-dose vaccine density [c]				0.103
19	Room hotel density	0.012[f]	0.024[f]	0.492	0.014[f]
20	2nd-doses vaccine [a]		0.038[f]		
21	2nd-doses vaccine [b]			0.326	
22	2nd-doses vaccine [c]				0.860
23	Distance to epicentrum [a]		0.121		
24	Distance to epicentrum [b]			0.392	
25	Distance to epicentrum [c]				0.708

a = Pre-pandemic stage; b = Resurgence-pandemic stage; c = Decline-pandemic stage; d = Post pandemic stage; e = between groups deviation of linearity of compare means ANOVA (α=0.050); f = not linear with dependent variables

APENDIX-4 Bivariate Correlation of Selected Linear Variables

No	Characteristics	Significantly Correlate with COVID-19 Morbidity[e]			
		Pre-pandemic	Resurgence-pandemic	Decline-pandemic	Post-pandemic
1	Peoples>15 years	0.501	0.637	<0.400	0.608
2	Peoples > 50 years old	0.517	0.632	<0.400	0.610
3	Gini ratio	0.510	0.458	<0.400	<0.400
4	Poverty ratio	-0.450	<0.400	0.442	<0.400
5	School duration	-0.513	<0.400	0.575	<0.400
6	Healthcare facilities	0.535	0.652	<0.400	0.619
7	Immunity peoples [a]		-0.695		
8	Immunity peoples [b]			<0.400	
9	Immunity peoples [c]				<0.400
10	Herd immunity [a]		<0.400		
11	Herd immunity [b]			0.707	
12	Herd immunity [c]				<0.400
13	Non-food expenditure	<0.400	<0.400	-0.611	<0.400
14	Health sector GDP	<0.400	<0.400	-0.514	<0.400
15	Tobacco expenditure	<0.400	<0.400	-0.573	<0.400
16	1st-dose vaccine density [a]		<0.400		
17	1st-dose vaccine density [b]			0.558	
18	1st-dose vaccine density [c]				<0.400
19	Room hotel density	<0.400	<0.400	0.617	<0.400
20	2nd-doses vaccine [a]		<0.400		
21	2nd-doses vaccine [b]			<0.400	
22	2nd-doses vaccine [c]				-0.708
23	Distance to epicentrum [a]		<0.400		
24	Distance to epicentrum [b]			<0.400	
25	Distance to epicentrum [c]				-0.409

a = Pre-pandemic stage; b = Resurgence-pandemic stage; c = Decline-pandemic stage; d = Post pandemic stage; e = Pearson Correlation (α=0.001)