Correlation of public mobility and Covid-19 incidence in Indonesia during six phases of restriction policy implementation

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Abstract. Public mobility is considered one of the factors thought to impact the transmission of SARS-CoV2. The Indonesian government has imposed six mobility restriction policies since the beginning of the COVID-19 pandemic to cope this situation, however there has been no comprehensive evaluation of this program. This study aimed to examine the correlation between mobility and the incidence of COVID-19 during the implementation of this policy in Indonesia. Secondary data on public mobility, acquired through the Google Community Mobility Reports, and data on COVID-19 new cases, recorded on the COVID Task Force website, were utilized from 2 March 2020 to 20 July 2021.The analysis in this study was carried out using the Pearson correlation test with an alternative Spearman correlation test. The result reported a positive correlation between COVID-19 cases and mobility in certain places, such as in Grocery Store and Transit Station ($r = 0.75$; p-value <0.001; $r = 0.62$ p-value <0.001) while there was negative correlation in residential area ($r= - 0.276$ p-value < 0.001). Public mobility is found to be correlated with an increase in COVID-19 cases during the six phases of restriction policy implementation. In conclusion, regulating public mobility is important to minimize the risk of COVID-19 transmission.

1 Introduction

Indonesia is among the largest nations impacted by the COVID-19 pandemic. The cumulative count of confirmed positive COVID-19 cases continues to rise. As of 18 February 2022, the tally in Indonesia reached 5,089,637, with 59,635 new cases reported.[1] Numerous factors are contributing to the rise in COVID-19 cases in Indonesia, with one of them being highlighted as mobility. In the initial stages of the COVID-19 pandemic, elevated population mobility heightened the risk of virus transmission and significantly influenced the increase

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in COVID-19 cases. Higher public mobility in today's globalization era challenges the prevention and control of pandemics.[2, 3]

The Indonesian government responded to emerging cases of COVID-19 by applying mobility restriction policies. Policies limiting social activities, such as : working, studying, praying and all activities that require large numbers of people, are believed to reduce the spread of COVID-19.[4] During that time vaccine and specific drugs for covid-19 infection were not well developed.[5], [6] Despite the urge for mobility restriction, the government issued a gradual restriction policy instead of total mobility restriction such as a lockdown.[7] Due to various considerations, lockdown had not been the choice in tackling the pandemic in Indonesia. Enforcing the implementation of the total lockdown may lead to greater consequences, concerning the economic sector.[8] There were several phases of mobility restriction policy recorded since the COVID-19 outbreak, started from first case confirmation phase, Large-Scale Social Restriction (PSBB), New Habit Adaptation (AKB), Public Activity Restriction Enforcement (PPKM), Micro PPKM, and Emergency PPKM. Each phase poses a different level of restriction and affect the mobility trend in Indonesia.

Amid the policy implementation, the Google Community Mobility Reports COVID-19 website was utilized to provide information on public mobility. The reports depict the trends in movement across diverse categories of locations, encompassing retail and recreation, grocery stores and pharmacies, parks, transit stations, workplaces, and residential areas. Mobility data is generated daily by Google based on Google Maps data records of the user. The data summary illustrates alterations in mobility within specific locations throughout the pandemic in contrast to the pre-pandemic period. For example, during the enforcement of the restriction policy, there was a significant change in mobility in the workplace and residential areas. In residential areas, the curve increases, showing positive changes because of people staying at home, while in the workplace, the curve decreases, meaning negative changes because of residents working from home.[9–11]

Considering the importance of COVID-19 control and the available access to the Google Community Mobility Reports COVID-19 website, the objective of this study is to examine the relationship between public mobility and the incidence of COVID-19 cases. Investigations carried out in Italy substantiated the significant influence of public mobility on the dissemination of the COVID-19 virus.[12] Similarly, a study conducted in Indonesia demonstrated the impact of mobility patterns and government policies on the propagation of COVID-19.[13] Numerous investigations have explored the association between mobility and COVID-19 cases; however, no research has systematically analyzed the correlation of mobility with COVID-19 cases across the six phases of restriction policy implementation.[14, 15] The findings of this study are expected to furnish additional data for scrutinizing the factors responsible for the rise in COVID-19 cases and formulating an appropriate restrictive policy for managing the pandemic scenario.

2 Method

This research employed secondary data encompassing public mobility and recorded new COVID-19 cases during the initial stage of the COVID-19 pandemic, spanning from 2 March 2020 to 20 July 2021. Public mobility data were obtained through the Google Community Mobility Reports COVID-19 website: “https://www.google.com/covid19/mobility/”, whilst the data on COVID-19 new cases were observed through the COVID Task Force website: ”https://dashboardcovid19.kemkes.go.id/”. The objective of this study is to examine the correlation between each variable and identify the mobility restriction policy type that exerts the most pronounced impact on the control of COVID-19 cases in Indonesia.

This study has obtained approval from the Research Ethics Commission of the Faculty of Medicine at Padjadjaran University, as indicated by ethical letter number

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672/UN6.KEP/EC/2021. The study's variables comprise newly reported cases of COVID-19 (denoted as Y), Google Community Mobility Reports for COVID-19 categorized into six specific types of locations, and the restriction policy segmented into six phases (refer to Table 1).

Table 1. Variable of study

Code	Variable
X1	Mobility in grocery store and pharmacies
X2	Mobility in retail and recreation
X3	Mobility in garden
X4	Mobility in transit station
X5	Mobility in workplace
X6	Mobility in residential area
F1	first case confirmation phase (F1) on 2 March 2020 to 9 April 2020
F2	Large Scale Social Restriction (F2) on 10 April 2020 to 4 June 2020
F3	New Habit Adaptation (F3) on 5 June 2020 to 10 January 2021
F4	Public Activity Restriction Enforcement (F4) on 11 January 2020 to 8 February 2021
F5	Micro Public Activity Restriction Enforcement (F5) on 9 February to 2 July 2021
F6	Emergency Public Activity Restriction Enforcement (F6) on 3 July 2021 to 20 July 2021

The data were collected and analyzed using “R” and “R Studio” version 4.3.0. The normality test was done using the Shapiro-Wilk test, then the analysis was carried out using the Pearson correlation test with an alternative Spearman correlation test. Correlation values, ranging from -1 to 1, indicate that a higher correlation value denotes a more intimate relationship between the variables.

3 Results

COVID-19's first case in Indonesia was confirmed at the beginning of March 2020. Because of its rapid transmission, the reported number of COVID-19 cases continued to increase, causing an increase in mortality and morbidity rate. The Indonesian government implemented various mobility restriction policies as essential measures to mitigate the dissemination of the COVID-19 virus.[16] The examination of COVID-19 cases across various phases of restriction policies is depicted in Figure 1. The figure illustrates an inclination of an increase in the number of COVID-19 cases from F1 to the F4 period, followed by a marginal decline during the F5 period, and a substantial increase during the F6 period.

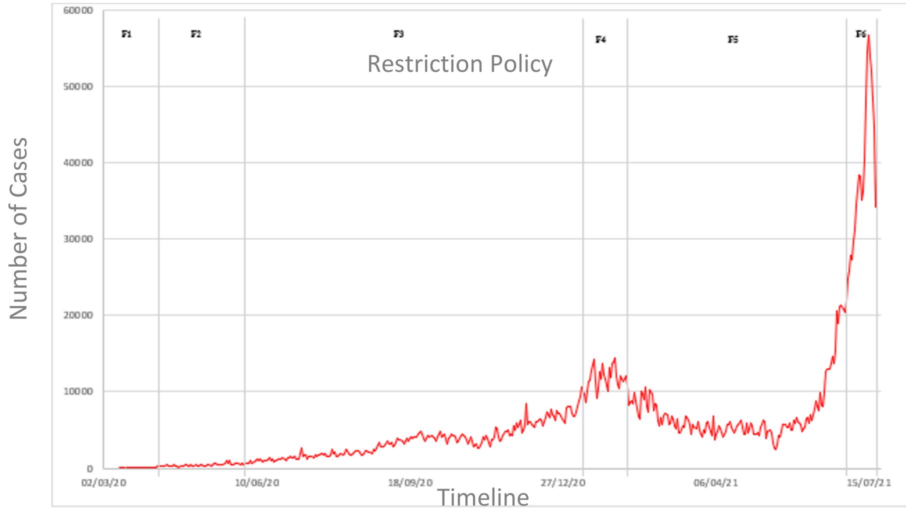

Figure 1. The pattern of COVID-19 occurrences in Indonesia. (2020 – 2021). The curve shows the increased number of COVID-19. F: Restriction Policy;

The mobility of Indonesians during the COVID-19 pandemic, as observed across various phases of mobility restriction policies, is illustrated in Figure 2.The highest mobility during first case confirmation (F1) to PSBB (F2) was seen in residential areas, while lower mobility was seen at grocery and pharmacy, retail and recreation, workplaces, and public facilities such as parks, and transit stations. However, the curve of the resident's mobility at the end of PSBB (F2) started to increase and remain constant during the AKB (F3) period despite a peaked curve of mobility at parks and a significant decline of mobility at workplaces seen at a certain time during AKB (F3). Observing the places, residential areas were still the center of residents' mobility, while other places experienced fluctuating changes. A volatile change also resided at the end of AKB (F3).

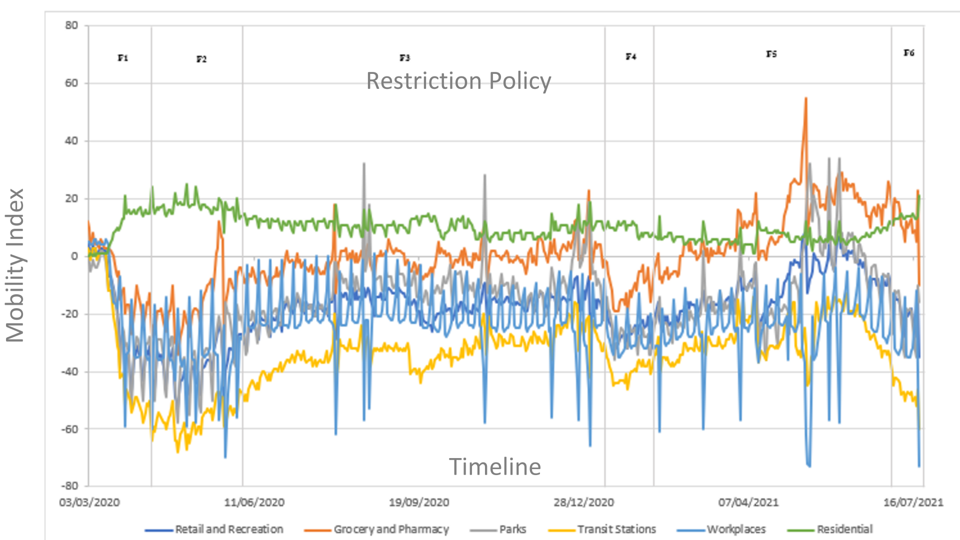

Figure 2. Indonesian Mobility Report. (2020 – 2021). Each curve shows the public mobility rate at several public places during the COVID-19 pandemic. F: Restriction Policy; F1: First case

confirmation phase, F2: Large-Scale Social Restriction (PSBB), F3: New Habit Adaptation (AKB), F4: Public Activity Restriction Enforcement (PPKM), F5: Micro PPKM (F5), F6: Emergency PPKM.

The mobility trend in public spaces, encompassing parks, retail and recreational areas, transit stations, grocery and pharmacy facilities, workplaces, and transit stations, exhibited a notable decline during the initial phase of PPKM (F4), whereas the mobility trend in residential areas remained constant. The decline did not last and started to increase again entering the micro PPKM (F5) period. During this period, there was a change in policy with a lenient restriction named micro PPKM. Compare to four restriction period before this policy was loose than the others. At that time the public places are opened just the same like before pandemic. Compare to the F2 period (Large Scale Social Restriction), this is a reverse condition. One thing that makes this condition different is the new cases of covid19 was low and more than 75 percent of the people had been vaccinated. It showed that the residents' mobility started returning to normal, and the mobility curve at grocery stores, pharmacies, and parks jumped sharply beyond residential areas accompanied by a sharp decline in the workplace's mobility curve. Transiting to the Emergency PPKM (F6) period, the mobility was suppressed, with the mobility of residential areas began to increase. The mobility to grocery stores and pharmacies experienced a modest reduction, whereas the mobility to parks, retail and recreational areas, workplaces, and transit stations exhibited a more substantial decline.

The correlation test result between public mobility and COVID-19 cases during six restriction policy phases was carried out using the Pearson Correlation test depicted in Table 2. There were discrepancies in the correlation outcomes across distinct restriction policies. Upon the initial confirmation of a COVID-19 case in Indonesia, the majority of correlation indices indicated a negative correlation. Notably, the correlation for mobility in residential areas stood out with a positive correlation of 0.9, accompanied by a p-value of <0.001.
However, during the F2 or PSBB phase and F3 or AKB phase there were a vice versa condition. Where most of the mobility area such as grocery, retail and recreation, park, transit station, and workplace shows a positive correlation. With the greater value support by Grocery and Transit Station (r= 0.749, p-value=<0.001; r=0.62, p-value <0.001).

Table 2. The correlation of public mobility and COVID-19 cases in Indonesia

Variable (p-value)	First Confirmation	PSBB	AKB	PPKM	Micro PPKM	Emergency PPKM
Grocery Store and Pharmacy	-0.71** (<0.001)	0.749** (<0.001)	0.501** (<0.001)	-0.394* (0.05)	-0.164* (0.05)	-0.202 (0.421)
Retail and Recreation	-0.858** (<0.001)	0.497 (0.09)	0.257* (<0.001)	-0.265 (0.165)	-0.157 (0.06)	-0.287 (0.248)
Park	-0.821** (<0.001)	0.356* (0.009)	0.392* (<0.001)	-0.500* (0.005)	-0.136 (0.102)	-0.167 (0.508)
Transit Station	-0.916** (<0.001)	0.620* (0.007)	0.585* (<0.001)	-0.241 (0.201)	-0.228* (0.006)	-0.423 (0.08)
Workplace	-0.853** (<0.001)	0.050 (0.71)	-0.143* (0.04)	0.112 (0.675)	-0.035 (0.675)	-0.239 (0.341)
Residential Area	0.902** (<0.001)	-0.276* (0.04)	-0.254* (<0.001)	-0.050 (0.795)	0.358* (<0.001)	0.587* (0.01)

Description: * significant value. ** significant value and strong correlation, the Pearson correlation value (r) is divided into several value interval: 0.1 – 0.39 (weak correlation); 0.4 – 0.69 (medium correlation); 0.7 – 0.89 (strong correlation); and 0.9 – 1.0 (very strong correlation).

During the PPKM phase or F4 through the F6 or Emergency PPKM the were a huge variation in correlation index direction. Sometime it shows a positive correlation and in the others its show a negative correlation. However, the significance level was low and could not be intervened. In the PSBB-PPKM phase, mobility in residential areas exhibits a negative correlation with the number of new cases, whereas in the Micro PPKM and emergency PPKM phases, a positive correlation is observed. Another noteworthy discovery pertains to the PPKM and Micro PPKM phases, where residential areas exclusively demonstrate a weak negative correlation with new cases.

4 Discussion

Public mobility in Indonesia has undergone alteration due to the swift proliferation of COVID-19 cases and the implementation of numerous restriction policies. The study result depicted in Table 2 showed that each phase of restriction policy implementation has a different direction of correlation with COVID-19 cases. In the F1 phase, residential areas stood out as the sole location demonstrating a positive correlation with new cases of COVID-19. The notably strong correlation implies that the increase in COVID-19 cases coincided with a rise in the number of individuals staying at home. Conversely, other variables such as grocery stores and pharmacies, retail and recreation, parks, transit stations, and workplaces exhibit a negative correlation with COVID-19 new cases. This suggests that an increase in the number of new cases corresponds to a decrease in public mobility for these locations. At the time F2 was implemented, the mobility to public facilities also decreased drastically, while in residential areas it increased. Consistent with a investigation by Setia Pramana et al., in the initial 2.5 months of the pandemic, individuals curtailed their engagements in public spaces and exhibited a preference for staying at home.[17] Another investigation encompassing 41 cities across 22 countries disclosed that, at the onset of the COVID-19 pandemic, diminished mobility was observed in all the Asian cities under scrutiny. Numerous policy constraints, including the closure of workplaces, cancellation of public events, suspension of public transport services, restrictions on internal movement, and regulations pertaining to international travel, were correlated with a reduction in mobility.[18] A study conducted in the United States also documented a swift surge in individuals opting to stay at home, coinciding with the emergency declaration of COVID-19. This declaration heightened public awareness and prompted a larger portion of the population to curtail mobility during the initial phase of the pandemic.[19]

This study concluded that during the implementation of the government regulations at the beginning of the pandemic, mobility decreased in public facilities, while mobility in residential areas increased (Figure 2). The reduced mobility contributed to the decrease in positive COVID-19 case numbers. A research study conducted in Italy substantiated a comparable observation, demonstrating that human mobility exerted a significant influence on the virus's spread prior to the implementation of health protocols.[20] A study in France also concluded that mobility could contribute to 52-92% of deaths related to COVID-19, while a study in Spain found a high correlation (p-value >75%) between some people with positive IgG test results with human mobility.[21]In addition, research in India reported that social isolation and lockdown had an impact on reducing the transmission of the virus.[22]

Another finding of this study (Table 2) revealed a medium to weak correlation strength during AKB, PPKM, micro PPKM, and emergency PPKM phases, revealing that public mobility at all observed places other than residential areas was not greatly affected by COVID-19 new cases. One variable that was found to have a positive correlation with COVID-19 is the mobility in residential areas during micro PPKM and Emergency PPKM. In response to a notable surge in COVID-19 case numbers, individuals opted to remain at home, demonstrating compliance with government policies aimed at mitigating the spread of

COVID-19. The measures instituted during the micro PPKM and emergency PPKM are perceived as effective in diminishing the number of confirmed cases. [23], [24]

This study then suggests that mobility during the pandemic (Figure 2) increased in residential areas because public facilities were closed and all public activities were done from home, such as work, study, and business. However, when this policy became more lenient, people returned to their activities as usual and began to visit public facilities. The risk of contracting COVID-19 increased as people crowded in restaurants or parks and ignored the health protocols. As depicted in Figure 1, the early stages of the pandemic exhibited a relatively low number of COVID-19 cases, indicating a gradual spread. However, over time, there was an escalation in the number of COVID-19 cases, particularly marked during the F4 and F6 periods. This study also identified a modest correlation between the number of positive cases and the mobility of residents to specific locations, as evident in the final two phases. Anticipating this finding, the government issued restriction policies and established a COVID-19 emergency hospital. However, the increase in cases occurred due to several other factors such as changes in government policies causing public mobility out of control, or lack of public compliance with health protocols.[25] The health facilities and health workers were still overwhelmed to treat infected patients in this phase. Considering this discussion, the government needs to put more attention to the society aspect as a target group. The government should provide continuous education regarding the restriction policy along with the implementation of the restriction policy itself. A better understanding of the importance of mobility restriction hopefully can raise the public’s awareness and ability to obey the policy properly.[26]

In conclusion, the government regulated public mobility during the pandemic by implementing several restriction policies such as PSBB, AKB, PPKM, micro PPKM, and emergency PPKM. The objective of the policy is to restrict public mobility and diminish the incidence of positive COVID-19 cases. A study conducted by Arie Wahyu at the National Bureau of Statistics affirms the significant impact of travel restrictions and social distancing as among the most effective mitigation strategies to curb the spread of the pandemic in Indonesia. This effectiveness is evident in various cities, including Jakarta, Bekasi, and Surabaya, where the implementation of the PSBB policy is believed to have effectively reduced COVID-19 cases.[27–30] However, several aspects are still needed to be considered. The government needs to improve public knowledge to make them comply with health measures and obey the restriction policies as research in the United States reported that the public's compliance with policies could decrease over time because people become anxious.[31] An appropriate strategy for controlling the pandemic also should be done by identifying the distribution of COVID case numbers across provinces. It was reported that Java and Bali has a higher number of cases than other islands. In summary, the restriction policy needs to be implemented at the right time, place, and situation.

5 Conclusion

This study draws the conclusion that the transmission of COVID-19 in Indonesia is influenced by the mobility patterns of the public during the implementation of restriction policies. The variables of mobility of residential areas and mobility of transit stations have a very strong correlation with the spread and increase in COVID-19 cases in Indonesia. This study proposes the necessity of modifying the arrangement of restriction policies to regulate public mobility, aiming to mitigate the risk of COVID-19 transmission.

Limitations

This study only observed the implementation of the six restriction policies imposed by the government and retrieved mobility data from pages of Google Community Mobility Reports COVID-19 governed by the security and privacy of its users. Google's understanding of different categories of places could change, causing the mobility curve to fluctuate up or down over long periods of time. In addition, the mobility data was obtained from people who have google service on their phone, therefore, the data could not represent all the Indonesian population who do not have cell phones or access to the internet.

References

1 Komite Penanganan COVID-19 dan Pemulihan Ekonomi Nasional, "Data Vaksinasi COVID-19 (Update per 31 Juli 2021) - Berita Terkini | Covid19.go.id."

2 K. Khoirunurrofik, F. Abdurrachman, and L. A. M. Putri, "Half-hearted policies on mobility restrictions during COVID-19 in Indonesia: A portrait of large informal economy country," *Transp. Res. Interdiscip. Perspect.*, vol. 13, p. 100517, 2022, doi: 10.1016/J.TRIP.2021.100517.

3 M. Zhang *et al.*, "Human mobility and COVID-19 transmission: a systematic review and future directions," *medRxiv*, pp. 2021.02.02.21250889-2021.02.02.21250889, 2021, doi: 10.1101/2021.02.02.21250889.

4 "WHO Coronavirus (COVID-19) Dashboard | WHO Coronavirus (COVID-19) Dashboard With Vaccination Data." [Online]. Available: https://covid19.who.int/

5 P. A. Ilhami, M. N. Adisasmita, D. Agustian, and B. Sujatmiko, "COVID-19 Vaccination Program Data Analysis Based on Regional Status and Day Type: A Study from West Java Province, Indonesia," in *Healthcare*, 2023, p. 772.

6 B. Sujatmiko, "Mencari Cakupan Ideal Vaksinasi RI," *https://www.cnnindonesia.com/teknologi/20210208180211-200-603812/mencari-cakupan-ideal-vaksinasi-ri*. 2022.

7 S. S. Andriani Apt, M.Sc, Ph.D, Helen, "Effectiveness of Large-Scale Social Restrictions (PSBB) toward the New Normal Era during COVID-19 Outbreak: a Mini Policy Review," *J. Indones. Heal. Policy Adm.*, vol. 5, no. 2, pp. 61–65, 2020, doi: 10.7454/ihpa.v5i2.4001.

8 P. S. J. Kennedy, "Analisis Strategi Lockdown Atau Pembatasan Sosial Dalam Menghambat Penyebaran COVID-19: Sebuah Tinjauan Teoritis," 2020.

9 "COVID-19 Community Mobility Reports." [Online]. Available: https://www.google.com/covid19/mobility/

10 "Laporan Mobilitas Masyarakat Selama Pandemi COVID-19." [Online]. Available: https://www.google.com/covid19/mobility/

11 "COVID-19: Google Mobility Trends - Our World in Data." [Online]. Available: https://ourworldindata.org/covid-google-mobility-trends

12 M. Gatto *et al.*, "Spread and dynamics of the COVID-19 epidemic in Italy: Effects of emergency containment measures," *Proc. Natl. Acad. Sci. U. S. A.*, vol. 117, no. 19, pp. 10484–10491, 2020, doi: 10.1073/PNAS.2004978117/-/DCSUPPLEMENTAL.

13 G. A. Alawy, A. Wicaksono, and A. Suharyanto, "Correlation Between Mobility and COVID-19 Cases in Surabaya City , Indonesia," vol. 4, no. 2, pp. 154–162, 2021.

14 I. Suraya, M. I. Nurmansyah, E. Rachmawati, B. Al Aufa, and I. I. Koire, “The Impact of Large-scale Social Restrictions on the Incidence of COVID-19 : A Case Study of Four Provinces in Indonesia,” *Kesmas J. Kesehat. Masy. Nas. (National Public Heal. Journal)*, vol. 0, no. 0, pp. 49–53, 2020, doi: 10.21109/KESMAS.V15I2.3990.

15 S. F. Auliya and N. Wulandari, “The Impact of Mobility Patterns on the Spread of the COVID-19 in Indonesia,” *J. Inf. Syst. Eng. Bus. Intell.*, vol. 7, no. 1, p. 31, 2021, doi: 10.20473/jisebi.7.1.31-41.

16 A. Roziqin, S. Y. F. Mas’udi, and I. T. Sihidi, “An analysis of Indonesian government policies against COVID-19”, doi: 10.1108/PAP-08-2020-0039.

17 S. Pramana, Y. Yuniarti, D. Y. Paramartha, and S. B. Panuntun, “Mobility Pattern Changes in Indonesia in Response to COVID-19,” *Econ. Financ. Indones.*, vol. 67, no. 1, p. 75, 2021, doi: 10.47291/efi.v67i1.924.

18 M. Vannoni, M. McKee, J. C. Semenza, C. Bonell, and D. Stuckler, “Using volunteered geographic information to assess mobility in the early phases of the COVID-19 pandemic: A cross-city time series analysis of 41 cities in 22 countries from March 2nd to 26th 2020,” *Global. Health*, vol. 16, no. 1, pp. 1–9, 2020, doi: 10.1186/S12992-020-00598-9/TABLES/1.

19 M. Lee *et al.*, “Human mobility trends during the early stage of the COVID-19 pandemic in the United States,” *PLoS One*, vol. 15, no. 11, pp. e0241468–e0241468, 2020, doi: 10.1371/JOURNAL.PONE.0241468.

20 E. Pepe *et al.*, “COVID-19 outbreak response, a dataset to assess mobility changes in Italy following national lockdown,” *Sci. Data*, vol. 7, no. 1, pp. 3–9, 2020, doi: 10.1038/s41597-020-00575-2.

21 S. M. Iacus, C. Santamaria, F. Sermi, S. Spyratos, D. Tarchi, and M. Vespe, “Human mobility and COVID-19 initial dynamics,” *Nonlinear Dyn.*, vol. 101, no. 3, pp. 1901–1919, 2020, doi: 10.1007/s11071-020-05854-6.

22 A. Tomar and N. Gupta, “Prediction for the spread of COVID-19 in India and effectiveness of preventive measures,” *Sci. Total Environ.*, vol. 728, p. 138762, 2020, doi: 10.1016/J.SCITOTENV.2020.138762.

23 R. Y. YAKHAMID and N. A. R. ZAQI, “Efektivitas PPKM Darurat Dalam Penanganan Lonjakan Kasus Covid-19,” *Semin. Nas. Off. Stat.*, vol. 2021, no. 1, pp. 235–244, 2021, doi: 10.34123/semnasoffstat.v2021i1.848.

24 N. Ruhyana, “Implementasi Nilai Ketaatan Hukum Pada Masa Pemberlakuan Pembatasan Kegiatan Masyarakat (PPKM) Darurat Dalam Rangka Menurunkan Penyebaran Corona Virus Desease-2019 (COVID-19).pdf.”

25 A. Aleta *et al.*, “Modeling the impact of social distancing, testing, contact tracing and household quarantine on second-wave scenarios of the COVID-19 epidemic,” *medRxiv Prepr. Serv. Heal. Sci.*, 2020, doi: 10.1101/2020.05.06.20092841.

26 D. Herdiana, “Implementasi Kebijakan Pembatasan Sosial Berskala Besar (Psbb) Sebagai Upaya Penanggulangan Corona Virus Disease 2019 (Covid-19),” *Decis. J. Adm. Publik*, vol. 2, no. 2, 2020, doi: 10.23969/decision.v2i2.2978.

27 R. T. Handayanto and H. Herlawati, “Efektifitas Pembatasan Sosial Berskala Besar (PSBB) di Kota Bekasi Dalam Mengatasi COVID-19 dengan Model Susceptible-Infected-Recovered (SIR),” *J. Kaji. Ilm.*, vol. 20, no. 2, pp. 119–124, 2020, doi: 10.31599/jki.v20i2.119.

28 Z. Li *et al.*, “IOP Conference Series: Earth and Environmental Science Modeling the

effectiveness of the PSBB based on COVID-19 case in Greater Surabaya Area The Evolution of the Interstellar Medium in Post-starburst Galaxies Modeling the effectiveness of the PSBB based ", doi: 10.1088/1755-1315/778/1/012021.

29 Z. F. Firdaus and A. W. Wijayanto, "Tinjauan Big Data Mobilitas Penduduk Pada Masa Social Distancing dan New Normal Serta Keterkaitannya Dengan Jumlah Kasus COVID-19," *Semin. Nas. Off. Stat.*, vol. 2020, no. 1, pp. 265–272, 2020, doi: 10.34123/SEMNASOFFSTAT.V2020I1.502.

30 A. I. Vecino-Ortiz, J. Villanueva Congote, S. Zapata Bedoya, and Z. M. Cucunuba, "Impact of contact tracing on COVID-19 mortality: An impact evaluation using surveillance data from Colombia," *PLoS One*, vol. 16, no. 3, p. e0246987, 2021.

31 Y. Li *et al.*, "The impact of policy measures on human mobility, COVID-19 cases, and mortality in the US: A spatiotemporal perspective," *Int. J. Environ. Res. Public Health*, vol. 18, no. 3, pp. 1–25, 2021, doi: 10.3390/ijerph18030996.