The Impact of Large-Scale Social Restriction and Odd-Even Policies During COVID-19 Pandemic to Traffic Congestion and Air Pollution in Jakarta

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***Abstract*—The COVID-19 pandemic has had a global impact on transportation mobility and air pollution, including Jakarta as the capital and busiest city in Indonesia. This paper reports the impact of two policies imposed by the Governor of Jakarta, namely the odd-even and the large-scale social restriction (PSBB) transitional phase-1, against the traffic congestion and air pollution quality in Jakarta during the COVID-19 pandemic. This paper investigates the odd-even and PSBB policy impact using paired T-Test. Moreover, this study assesses the relationship between traffic congestion and air pollution using the Pearson correlation. The result shows that the odd-even policy does affect significant only on MH Thamrin Street. Furthermore, the odd-even policy does not significantly affect air pollution reduction in Jakarta. This study also found that there is no meaningful relationship between traffic congestion and air pollution. These results can be used to reference future data-driven policy improvement on traffic congestion and air pollution management in Jakarta and other cities.**

Keywords—* *odd-even policy, large-scale social restriction, traffic congestion, air quality, covid-19, Jakarta

I. Introduction

The COVID-19 pandemic has influenced transportation mobility and air pollution in many countries, including Indonesia. This pandemic has affected the air quality in Jakarta, the largest city and capital city of Indonesia [1]. Lockdown or social restriction policy in many countries in Asia, Europe, South America, and North America led to significant air quality improvements [2], [3]. Traffic congestion is a severe problem in Jakarta, which has often occurred before the pandemic. Jakarta occupied the top ten congested cities globally, consecutively from 2017 to 2019 [4]. Jakarta has been deemed the second largest world pollution contributor, reported on June 26th, 2020 [5].

Traffic congestion and air pollution in Jakarta are significant problems that must be addressed in sustainable ways. Several cities in the world have implemented odd-even policies, the limitation of the motor vehicle - referring to the last two numbers on the license plate number of the vehicle, to reduce vehicle mobility and air pollution [6]. They are Rome, Paris, Mexico, New Delhi [7], and Beijing [8], [9]. In Beijing, during the 2008 Summer Olympic Games, the Odd-Even policy successfully reduced traffic congestion and increased travel speed [8]. Odd-Even's definition in the Jakarta context is a policy that limits the most rear police plate or number based on odd and even numbers [10]. The Provincial Government of Jakarta has implemented this policy on several roads since August 30th, 2016, to replace the ineffective *3-in-1 system* [11].

Literature studies have reported the effect of the Odd-Even policy [12]–[14]. The Odd-Even policy implementation shows a change in vehicles' volume on roads in Jakarta, with people tending to choose public transportation as an alternative option [12]. The Odd-Even policy application also increases the vehicle's average speed on several roads in Jakarta [13]. During the COVID-19 pandemic, the Provincial Government of Jakarta implemented an Odd-Even policy in conjunction with the PSBB Transitional Phase 1 [15]. This policy runs from August 3rd to September 13th, 2020 [16]. The Odd-Even policy is enforced on 25 roads with application times from 6-10 am and 4-9 pm at Jakarta time on weekdays.

This paper analyses the effectiveness of the odd-even policy during the COVID-19 pandemic on MH Thamrin, Neli Anggrek, and Merdeka Perintis streets. The results are obtained by conducting data exploration, testing them using the Paired-Test [17], [18], and analyzing the correlation between traffic congestion and air quality using the Pearson test [19].

The rest of this paper is organized as follows. Section 2 describes the methodology used to analyze the data. The following section shows the analysis and findings of the study.

In Section 4, we discuss the odd-even effect on traffic congestion and air pollution and their correlation. Finally, we present the conclusion, recommendation, and future works.

II. Related Work

A. *PSBB Transitional Phase Policy and Odd-Even Policy to Traffic Congestion*

A recent study from Nissa et al. [20] about PSBB Transitional Phase Policy revealed an improved average vehicle speed in Jakarta due to the policy. The study compared the average vehicle speed before PSBB and during PSBB [20]. During PSBB Transitional Phase 1 Policy, the Provincial Government of Jakarta implemented the odd-even policy that could influence the average vehicle speed.

In the previous research from Supriana et al. [13], before the PSSB Policy was implemented, the Odd-Even policy increased the vehicle's average speed on several streets in Jakarta. The study was conducted using descriptive statistical analysis for average speed [13]. Other studies are about the impact of the odd-even policy on the vehicle's average speed in Beijing, China [8], [9]. The study from Ren et al. used a Nonparametric Wilcox test that shows that the odd-even policy can reduce traffic congestion [9].

B. *PSBB Transitional Phase Policy and Odd-Even Policy to Air Quality*

Recent studies from Pardamean et al. [21] about PSBB Transitional Phase Policy enhance the air quality of Jakarta. The study conducted by the statistical test used a chi-squared test to the AQI every location and PSBB Transitional Phase. It also used paired one-sided *t*-test for the seasonal trend [21]. Other related studies about the effect of a similar policy, which is a lockdown, on the air quality in several countries in the world [2]. The study from Ghosh and Ghosh [2] compares the mean of the air quality index between pre and post-lockdown period with the parameters PM_{10}, $PM_{2.5}$, CO, NO, NO_2, NH_3, NO_x, SO_2, and O_3.. This study concluded that the lockdown significantly improved the air quality of the world [2].

The study from Ren et al. [9] about the odd-even policy effect on air quality in Beijing, China. The study was conducted by a Nonparametric Wilcox test [9]. This study shows that the effect of the odd-even policy is little or limited to the air quality [9]. This study also shows that air quality is not very relevant to traffic congestion [9]. Other related studies in India from Goyan and Gabdhi [22] about air quality when the odd-even policy was implemented. The objective of this policy implementation is to reduce the air pollution problem [22]. This study uses the average Air Quality Index and meteorological conditions each day [22]. The result shows that the pollution levels were high when the odd-even policy was implemented [22]. This result can happen because of meteorological conditions like 'low daily temperatures' and 'low wind speeds' [22].

C. *Research Group*

Therefore, this study concludes that there has been no report or analysis of PSBB Policy and the odd-even policy effectiveness on traffic congestion and air pollution simultaneously in Jakarta during the COVID-19 pandemic.

III. Methodology

In this study, the analysis was performed using Data Exploration, Hypothesis Testing with Paired T-Test, and Correlation Testing with Pearson Correlation.

A. *Datasets*

Dataset was obtained from the Jakarta Environment Office for air quality and the *Waze Application* for traffic information. The Waze application is a navigation tool created for the local driver community to share traffic jams from the average speed of vehicles and traffic alerts from accident reports [23].

The data includes daily air quality data from three streets in Jakarta, namely Bundaran HI (DKI1), Kelapa Gading (DKI2), and Kebun Jeruk (DKI5). The air quality dataset can be seen in Table I. As shown in Table II, the transportation data includes traffic congestion data in daily average speeds on MH Thamrin, Anggrek Nelimurni, and Perintis Kemerdekaan streets. Dataset was collected during the PSBB Transitional Phase 1, which is June 5th to September 10th, 2020, on weekdays and when the Odd-Even policy was applied or not. On August 3rd, the Odd-Even policy was used until the end of PSBB Transitional Phase 1 on September 10th, 2020.

TABLE I. Air quality data in several streets in Jakarta

Date	Location	ISPU Max Value
05/03/20	Bundaran HI(DK1)	74
05/06/20	Kelapa Gading(DKI2)	91
…	…	…
10/09/20	Kebun Jeruk(DKI5)	97

TABLE II. Traffic congestion in several streets in Jakarta

Date	Street	Avg Speed
05/03/20	Jl. MH Thamrin	5.72
05/06/20	Jl. Perintis Kemerdekaan	6.72
…	…	…
10/09/20	Jl Anggrek Nelimurni	3.43

B. *Data Collection and Analysis*

The traffic congestion data contains the date, road, average speed, average congestion, and amount of traffic congestion. Air pollution data has start date, end date, *Indeks Standard Pencemar Udara* (hereafter referred to as the ISPU) value parameter ($PM_{2.5}$. PM_{10}, CO, SO_2, NO_2, and O_3), maximum ISPU value, location, and dominant ISPU parameter. These datasets were analyzed in several stages, as shown in Figure 1. First, in the pre-processed stage, the data were selected for specific variables. Next, data cleaning and data integration were performed. Data cleaning is part of the pre-processing stage to clean the data according to our particular study. Meanwhile, data integration is part of combining data after the data is cleaned. There are two focuses on data: the maximum ISPU value and average speed of vehicles per day.

The dataset was then filtered when the PSBB Transition Phase 1 policy came into effect due to an odd-even policy change. Subsequently, the dataset was filtered according to the time and day the odd-even policy was applied. The filter is dedicated to the location of the road we want to analyze. The locations of the streets analyzed are MH Thamrin, Neil Anggrek, and Merdeka Perintis streets. These three roads were chosen because they are the closest to the ISPU sensors and implemented odd-even policies. Following this stage, data exploration, T-test, and correlation test were carried out.

In hypothesis testing, the null hypothesis [17], *H0*, is assumed that the Odd-Even policy has no significant effect on traffic congestion and air pollution. Meanwhile, the alternative hypothesis [17], *H1*, is considered that the odd-even policy significantly impacts traffic congestion and air quality. Subsequently, the T-test was used to test for significant differences by comparing the two means [17], [18]. We chose the *Paired T-Test* due to the normally distributed data, sample size <30, and the conditions of observation (pre-post) [18]. Paired T-Test was chosen by testing the same sample under one different condition [24], namely when the odd-even policy was applied and not. With the *Paired T-Test*, we can determine the Odd-Even policy's significant effect in those areas. Following this step, we conducted a correlation test between two variables: the vehicle's average speed (described traffic congestion) and the maximum value of the ISPU (defined air quality).

A correlation test was performed as a statistical method to determine a linear relationship between two continuous variables [25]. The correlation coefficient values are in the range of -1 to 1 [25]. If the coefficient value is "0", then there is no relationship. We use the *Pearson Correlation* to assess how strong the relationship is between these two continuous variables (numeric value).

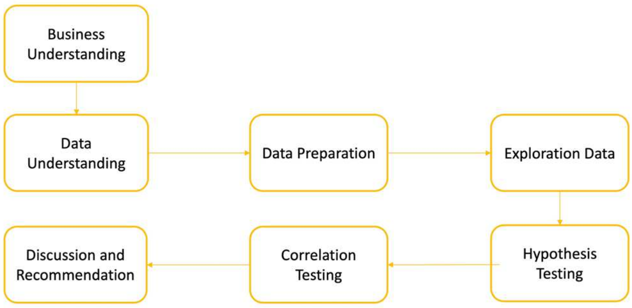

Fig. 1. Research Workflow

IV. RESULT

A. Data Exploration

We visualize and analyze the Odd-Even policy's application on traffic congestion and air pollution on MH Thamrin, Neil Anggrek, and Merdeka Perintis streets in data exploration. As shown in Figure 2, the lowest average speed occurs when the Odd-Even policy is not applied. Meanwhile, the fastest average speed only occurs when the odd-even policy is applied on MH Thamrin Street. It shows that the odd-even policy is only effective on MH Thamrin Street.

Figure 3 indicates that the three roads shown have the same pattern for air quality values, even when there are differences in sensor locations. The highest and the lowest air pollution value occurs when the Odd-Even policy is not enforced. The value of air pollution tends to decrease when the Odd-Even policy is started. However, if we look thoroughly, the Odd-Even policy's impact is not significant to air pollution on the road.

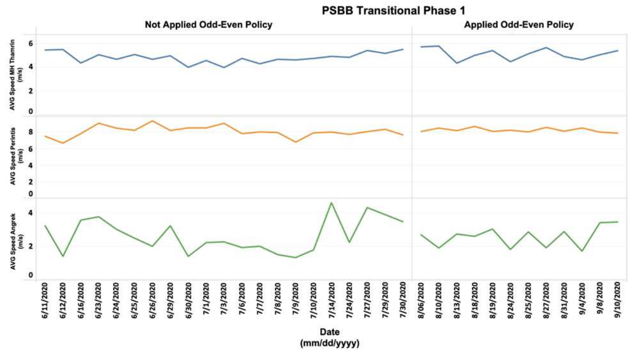

Fig. 2. Daily vehicles' average speed related to MH Thamrin (blue), Merdeka Perintis (Orange), and Neil Anggrek (Green) streets. The Odd-Even policy effect when applied (right) and not (left).

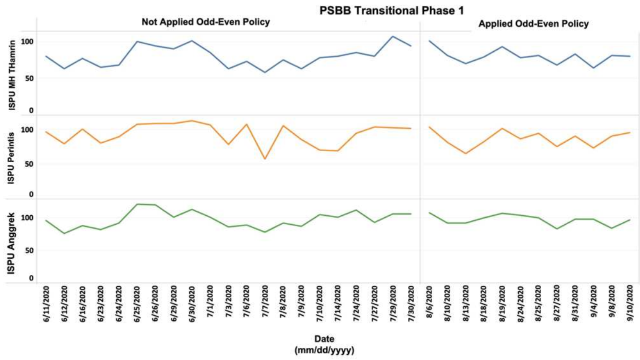

Fig. 3. Daily air pollution to MH Thamrin (blue), Merdeka Perintis (Orange), and Neil Anggrek (Green) streets. The Odd-Even policy effect when applied (right) and not (left).

B. Hypothesis Testing with Paired T-Test

The Paired T-Test was conducted to determine the significant differences when the Odd-Even policy was applied and not towards traffic congestion and air pollution during the COVID-19 pandemic. The Paired T-Test resulted in the p-value, as shown in Table 3 and Table 4. The *p-value* can determine the significant difference in the effect when the Odd-Even policy was applied rather than traffic congestion and air pollution. If the test results give a *p-value* <α, the odd-even application significantly impacts the street. If it provides a significant positive impact, the odd-even policy can be applied too on other roads.

TABLE III. THE PAIRED T-TEST RESULTS FOR ASSESSMENT OF ODD-EVEN POLICY IN TERMS OF VEHICLE'S AVERAGE SPEED

Street	**Mean (Average Speed)**		**p-value**	**α**
	Not Apply	***Apply***		
Jl MH Thamrin (DKI1)	4.834	5.398	0.000	0.05
Jl Perintis Kemerdekaan (DKI2)	8.153	8.188	0.794	0.05
Jl Anggrek Nelimurni (DKI5)	2.619	2.572	0.906	0.05

Table 3 shows that from the three streets, only one road has a *p-value* <α, namely MH Thamrin Street. The Odd-Even policy significantly affects only one road, where the average vehicle speed changes significantly. The other chosen streets that apply the Odd-Even policy show no significant effect.

TABLE IV. THE PAIRED T-TEST RESULTS FOR ASSESSMENT OF ODD-EVEN POLICY IN TERMS OF AIR QUALITY

Street	Mean (Air Quality)		p-value	α
	Not Apply	*Apply*		
Jl MH Thamrin (DKI1)	80.750	82.125	0.736	0.05
Jl Perintis Kemerdekaan (DKI2)	94.042	90.875	0.506	0.05
Jl Anggrek Nelimurni (DKI5)	96.333	96.917	0.890	0.05

As shown in Table 4, the *p-value*> α, suggesting that the mean value is the same. There is no significant effect of the Odd-Even policy on air pollution on MH Thamrin, Neil Anggrek, and Merdeka Perintis streets during the COVID-19 pandemic with the same mean value. However, when looking at the *p-value* for each sensor, the DKI2 sensor result is relatively low compared to the other sensors. It shows that the Odd-Even policy in DKI2 has a minor effect in reducing air pollution than other areas.

C. Relationship between Traffic Congestion and Air Pollution

This test aims to see the relationship between traffic congestion and air pollution using *Pearson Correlation*. Congestion indicator is obtained from the vehicle's average speed. For air pollution, the maximum ISPU value is taken. Average traffic congestion acts as the independent variable, while air pollution is the dependent variable. Variable values were obtained daily during working days, during odd-even implementation times, and within the PSBB Transitional Phase 1.

The results show that traffic congestion has a slight impact on air quality during the COVID19 pandemic. The MH Thamrin street shows the strongest relationship between the vehicle's average speed (congestion) and air pollution. However, the relationship is positive, which shows that the faster the vehicle's average speed, the greater the air pollution. Ideally, the relationship is inversely proportional, where the slower the vehicle's average speed, the higher the air pollution should be. This result indicates that traffic congestion is not the leading cause of air pollution during the COVID-19 pandemic in DKI1.

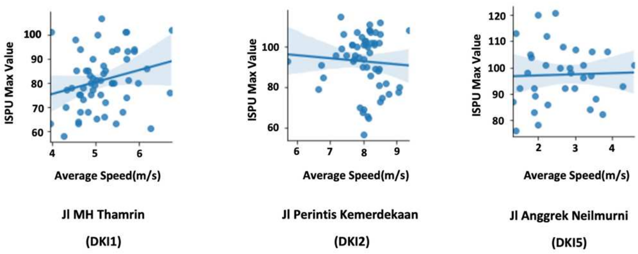

Fig. 4. Relationship between the vehicle's average speed and air quality.

As shown in Figure 4, the three streets show different results; only MH Thamrin (DKI1) has a stronger relationship. Perintis Kemerdekaan (DKI2) street has the right relationship, where the higher the vehicle's average speed, the less air pollution. On the other hand, the relationship on Anggrek Neilmurni (DKI5) street is the weakest. These three streets have a different relationship, which means that traffic congestion in Jakarta slightly impacts air quality during the COVID-19 pandemic. The three roads in Jakarta that have been analyzed demonstrate that Jakarta's primary source of air pollution did not come from traffic congestion during the COVID-19 pandemic.

V. DISCUSSION

In this study, we selected three streets since only three out of five air quality sensors in those streets apply the Odd-Even policy. The selected streets are closest to the air quality sensors that can represent Jakarta overall. The dataset was obtained from the Jakarta Environment Office and the Waze application. Data exploration was carried out to analyze the impact before and after implementing the Odd-Even policy on Jakarta's traffic congestion and air quality [26].

There was a similar air quality pattern on three roads in each sensor in the data exploration stage. It means that the air quality in several areas in Jakarta is the same. It also points to the same possible leading cause affecting air pollution in Jakarta. The highest and lowest ISPU value occurred when the Odd-Even policy was not applied. It means that the Odd-Even policy did not impact Jakarta's air quality during the COVID-19 pandemic. In terms of traffic congestion, it was found that the lowest vehicle's average speed occurs when the Odd-Even policy is not applied. Only one road had the highest vehicle average speed when the Odd-Even policy was applied, suggesting that the Odd-Even policy is not very useful on the other streets. Therefore, the Provincial Government of Jakarta needs to review the road choice to use this Odd-Even policy effectively.

We assessed the significance of the Odd-Even policy impact on traffic congestion and air quality with Paired T-Test. The result showed that only one of the three streets was significantly affected by the Odd-Even policy during the COVID-19 pandemic. The Odd-Even policy application is not very practical on many other streets in Jakarta. It means that the air quality in Jakarta is also not strongly affected by the number of vehicles in Jakarta, as in agreement with other reports [9], [27]. The nominal value of the correlation factor between traffic congestion and air quality in Jakarta also suggests that air quality in Jakarta can be affected by more significant factors, most likely energy and industry [28].

The Provincial Government of Jakarta needs to consider further study in improving air quality apart from restricting transportation mobility through the Odd-Even policy. Moreover, this policy can cause people to switch from private/personal to public transportations [12]. During this pandemic, the Odd-Even policy could increase the spread of COVID-19 in the public transportation cluster. However, the authors acknowledged some limitations in this study: the number of datasets due to a limited number of available sensors surrounding Jakarta.

This study is the first to analyze the impact of large-scale social restriction and the Odd-Even policies on traffic congestion and air pollution in Jakarta during the COVID-19 pandemic. We choose Jakarta because this city is the largest city and capital city in Indonesia with a huge problem in traffic congestion and air pollution. The result of this paper can be a reference for other cities in Indonesia to know the impact of large-scale social restriction and odd-even policies to solve air pollution and traffic congestion problems.

VI. Conclusion and Future Work

This paper explains the effectiveness of the Odd-Even policy in solving traffic congestion and air pollution in Jakarta, especially on MH Thamrin, Neil Anggrek, and Merdeka Perintis streets during the COVID-19 pandemic. The result shows that the traffic congestion on MH Thamrin Street is affected significantly. For air pollution, the Odd-Even Policy does not have a significant impact. The result indicates an insignificant correlation between traffic congestion and air pollution, where the leading cause of air pollution in Jakarta is not from the increase in vehicle volume. In conclusion, the Provincial Government of Jakarta needs to consider the implementation of the existing Odd-Even policy. Future works need to accommodate other sources of the dataset for transport and air pollution in Jakarta. For example, more streets can gain a deeper understanding of traffic congestion and air pollution. On the other hand, the Odd-Even policies can increase the number of people to switch from private/personal to public transportations and potentially increase the spread of COVID-19.

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References

[1] "Daerah Khusus Ibukota Jakarta." https://indonesia.go.id/province/daerah-khusus-ibukota-jakarta (accessed Jan. 21, 2021).

[2] S. Ghosh and S. Ghosh, "Air quality during COVID-19 lockdown: Blessing in disguise," *Indian J. Biochem. Biophys.*, vol. 57, pp. 420--430, 2020.

[3] S. Muhammad, X. Long, and M. Salman, "COVID-19 pandemic and environmental pollution: A blessing in disguise?," *Sci. Total Environ.*, vol. 728, no. 4, p. 138820, 2020, doi: https://doi.org/10.1016/j.scitotenv.2020.138820.

[4] N. F. Shalihah, "Survei 2019, Jakarta Masuk Peringkat 10 Kota Termacet di Dunia," *Kompas.com*, 2020. https://www.kompas.com/tren/read/2020/01/31/052816565/survei-2019-jakarta-masuk-peringkat-10-kota-termacet-di-dunia (accessed Jan. 21, 2020).

[5] "Hari 11 PSBB Transisi, Senin Pagi Polusi Udara DKI Terburuk," *CNN Indonesia*, 2020. https://www.cnnindonesia.com/nasional/20200615105713-20-513363/hari-11-psbb-transisi-senin-pagi-polusi-udara-dki-terburuk (accessed Jan. 21, 2020).

[6] P. Singhal, G. Tan, K. Basak, and B. Marimuthu, "Visualization of Urban Traffic for the Management of Smart Cities," in *Proceedings of the 9th EAI International Conference on Simulation Tools and Techniques*, 2016, pp. 96–103.

[7] K. Singhania, G. P. Girish, and N. Emodi, "Impact of Odd-Even Rationing of Vehicular Movement in Delhi on Air Pollution Levels," *Low Carbon Econ.*, vol. 7, pp. 151–160, 2016, doi: 10.4236/lce.2016.74014.

[8] R. Li and M. Guo, "Effects of odd–even traffic restriction on travel speed and traffic volume: Evidence from Beijing Olympic Games," *J. Traffic Transp. Eng. (English Ed.*, vol. 3, no. 1, pp. 71–81, 2016, doi: https://doi.org/10.1016/j.jtte.2016.01.002.

[9] X. Ren, J. Liu, and J. Wen, "Effects of Odd-Even Traffic Restriction on Traffic Congestion and Air Quality," in *2018 5th International Conference on Industrial Economics System and Industrial Security Engineering (IEIS)*, Aug. 2018, pp. 1–6, doi: 10.1109/IEIS.2018.8597909.

[10] "Peraturan Gubernur (PERGUB) Provinsi Daerah Khusus Ibukota Jakarta Nomor 164 Tahun 2016," *Legal Documentation and Information Provincial Government of Jakarta*, 2016. https://jdih.jakarta.go.id/uploads/default/produkhukum/PERATURAN_GUBERNUR_NO.164_TAHUN_.2016__.pdf (accessed Feb. 15, 2020).

[11] R. A. Yori, A. Fuad, and A. Atto'ullah, "IMPLEMENTASI PERATURAN GUBERNUR DKI JAKARTA NO. 164 TAHUN 2016 TENTANG PEMBATASAN LALU LINTAS GANJIL-GENAP DI PROVINSI DKI JAKARTA," Universitas Sultan Ageng Tirtayasa, 2018.

[12] M. E. Fadhli and H. Widodo, "Analisis Pengurangan Kemacetan Berdasarkan Sistem Ganjil-Genap," *Planners Insight Urban Reg. Plan. J.*, vol. 2, no. 2, pp. 36–41, 2020.

[13] F. J. R. Supriana, M. L. Siregar, E. S. W. Tangkudung, and A. Kusuma, "Evaluation of Odd-Even Vehicle Registration Number Regulation Before and After Expansion of the Rule in Jakarta," in *Proceedings of the 2nd International Symposium on Transportation Studies in Developing Countries (ISTSDC 2019)*, 2020, pp. 151–156, doi: https://doi.org/10.2991/aer.k.200220.032.

[14] M. H. Yudhistira, R. Kusumaatmadja, M. F. Hidayat, and others, "Does Trafic Management Matter? Evaluating Congestion Effect of Odd-Even Policy in Jakarta," *Inst. Econ. Soc. Res.*, 2019.

[15] "Ganjil – Genap Diberlakukan kembali mulai 3 Agustus 2020," *Department of Transportation of DKI Jakarta Province*, 2020. https://dishub.jakarta.go.id/ganjil-genap-diberlakukan-kembali-mulai-3-agustus-2020/.

[16] "Pemprov DKI Jakarta resmi menerapkan kembali Pembatasan Sosial Berskala Besar (PSBB)," *Department of Transportation of DKI Jakarta Province*, 2020. https://dishub.jakarta.go.id/pemprov-dki-jakarta-resmi-menerapkan-kembali-pembatasan-sosial-berskala-besar-psbb/.

[17] K. R. Sundaram, S. N. Dwivedi, and V. Sreenivas, *Medical Statistics: Principles & Methods*. Anshan, 2010.

[18] P. Mishra, U. Singh, C. M. Pandey, P. Mishra, and G. Pandey, "Application of student's t-test, analysis of variance, and covariance," *Ann. Card. Anaesth.*, vol. 22, no. 4, pp. 407–411, 2019, doi: 10.4103/aca.ACA_94_19.

[19] H. Akoglu, "User's guide to correlation coefficients," *Turkish J. Emerg. Med.*, vol. 18, no. 3, pp. 91–93, Aug. 2018, doi: 10.1016/j.tjem.2018.08.001.

[20] N. K. Nissa, Y. Nugraha, C. F. Finola, A. Ernesto, J. I. Kanggrawan, and A. L. Suherman, "Evaluasi Berbasis Data: Kebijakan Pembatasan Mobilitas Publik dalam Mitigasi Persebaran COVID-19 di Jakarta," *J. Sist. Cerdas*, vol. 3, no. 2, pp. 84–94, 2020.

[21] B. Pardamean, R. Rahutomo, T. W. Cenggoro, A. Budiarto, and A. S. Perbangsa, "The Impact of Large-Scale Social Restriction Phases on the Air Quality Index in Jakarta," *Atmosphere (Basel).*, vol. 12, no. 7, 2021, doi: 10.3390/atmos12070922.

[22] P. Goyal and G. Gandhi, "Assessment of Air Quality during the 'Odd-Even Scheme' of Vehicles in Delhi," *Indian J. Sci. Technol.*, vol. 9, Dec. 2016, doi: 10.17485/ijst/2016/v9i48/105801.

[23] Z. Lenkei, "Crowdsourced traffic information in traffic management : Evaluation of traffic information from Waze," KTH, Transport Planning, Economics and Engineering, 2018.

[24] E. Whitley and J. Ball, "Statistics review 5: Comparison of means," *Crit. Care*, vol. 6, no. 5, pp. 424–428, Oct. 2002, doi: 10.1186/cc1548.

[25] M. M. Mukaka, "Statistics corner: A guide to appropriate use of correlation coefficient in medical research," *Malawi Med. J.*, vol. 24, no. 3, pp. 69–71, Sep. 2012, [Online]. Available: https://pubmed.ncbi.nlm.nih.gov/23638278.

[26] "Pergub No 88 Tahun 2019 tentang Ganjil Genap," *Jakarta Transportation Office*, 2019. https://dishub.jakarta.go.id/download/pergub-no-88-tahun-2019-tentang-ganjil-genap/.

[27] S. Chowdhury, S. Dey, S. N. Tripathi, G. Beig, A. K. Mishra, and S. Sharma, "'Traffic intervention' policy fails to mitigate air pollution in megacity Delhi," *Environ. Sci. Policy*, vol. 74, pp. 8–13, 2017, doi: https://doi.org/10.1016/j.envsci.2017.04.018.

[28] R. H. T. Lauri Myllyvirta, Isabella Suarez, Erika Uusivuori, "Transboundary Air Pollution in the Jakarta, Banten, and West Java provinces," *Center for Research on Energy and Clean Air*, 2020. https://energyandcleanair.org/wp/wp-content/uploads/2020/08/Jakarta-Transboundary-Pollution_FINALEnglish.pdf (accessed Feb. 17, 2020).