Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.

Science of the Total Environment 725 (2020) 138436

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Correlation between weather and Covid-19 pandemic in Jakarta, Indonesia

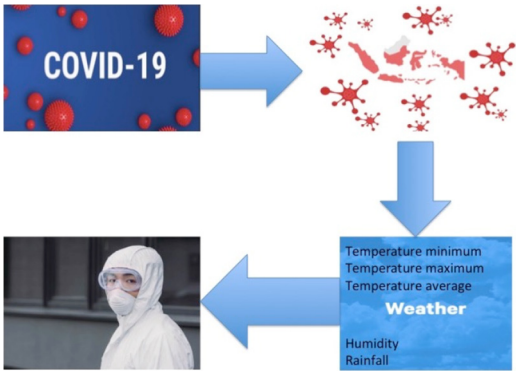
Ramadhan Tosepu [a,*], Joko Gunawan [b], Devi Savitri Effendy [c], La Ode Ali Imran Ahmad [d], Hariati Lestari [e], Hartati Bahar [f], Pitrah Asfian [g]

[a] Deparment of Environmental Health, Faculty of Public Health, University of Halu Oleo, Indonesia
[b] Poltekkes Kemenkes Pangkal Pinang, Bangka Belitung, Indonesia
[c] Deparment of Health Nutrition, Faculty of Public Health, University of Halu Oleo, Indonesia
[d] Deparment of Health Administration, Faculty of Public Health, University of Halu Oleo, Indonesia
[e] Deparment of Epidemiology, Faculty of Public Health, University of Halu Oleo, Indonesia
[f] Deparment of Health Promotion, Faculty of Public Health, University of Halu Oleo, Indonesia
[g] Deparment of Occupational Health, Faculty of Public Health, University of Halu Oleo, Indonesia

HIGHLIGHTS

- Covid-19 is a pandemic disease
- The weather factor is one of the factors that triggered the spread of Covid-19
- The spread of covid-19 in Indonesia is very fast, so the results of this study will be useful in efforts to prevent the spread of covid-19 disease

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 2 April 2020
Accepted 2 April 2020
Available online 4 April 2020

Editor: Damia Barcelo

Keywords:
Covid-19
Coronavirus
Temperature
Humidity
Rainfall
Indonesia

ABSTRACT

This study aims to analyze the correlation between weather and covid-19 pandemic in Jakarta Indonesia. This study employed a secondary data analysis of surveillance data of covid-19 from the Ministry of Health of the Republic of Indonesia and weather from the Meteorological Department of the Republic of Indonesia. The components of weather include minimum temperature (°C), maximum temperature (°C), temperature average (°C), humidity (%), and amount of rainfall (mm). Spearman-rank correlation test was used for data analysis. Among the components of the weather, only temperature average (°C) was significantly correlated with covid-19 pandemic ($r = 0.392$; $p < .01$). The finding serves as an input to reduce the incidence rate of covid-19 in Indonesia.
© 2020 Elsevier B.V. All rights reserved.

* Corresponding author at: Faculty of Public Health, University of Halu Oleo, Southeast Sulawesi Province, Indonesia.
E-mail address: ramadhan.tosepu@uho.ac.id (R. Tosepu).

https://doi.org/10.1016/j.scitotenv.2020.138436
0048-9697/© 2020 Elsevier B.V. All rights reserved.

1. Introduction

World Health Organization (WHO) reported that there have been pneumonia cases in Wuhan City, Hubei Province, China (Zhu et al., 2019), but the etiology was unknown (Sohrabi et al., 2020). The case was developed very fast (Anderson et al., 2020), until January 7, 2020, the Chinese government said that pneumonia was a new type of coronavirus or covid-19 (Li et al., 2020).

Common signs and symptoms of covid-19 infection include symptoms of acute respiratory disorders such as fever, coughing and shortness of breath. The average incubation period is 5–6 days with the longest incubation period of 14 days. In severe cases, covid-19 can cause pneumonia, acute respiratory syndrome, kidney failure, and even death. The clinical signs and symptoms reported in the majority of cases are fever, with some cases having difficulty breathing, and X-rays show extensive pneumonia infiltrates in both lungs (Holshue et al., 2020; Perlman, 2020). The clinical symptoms of severe and critical patients with covid-19 are likely similar with the clinical symptoms of SARS and MERS (Wang et al., 2020b).

In Indonesia, on March 2, 2020, Indonesia has reported 2 confirmed cases of covid-19. As of March 29, 2020, it has increased to 1285 cases in 30 provinces. The five highest provinces in the covid-19 cases are Jakarta (675), West Java (149), Banten (106), East Java (90), and Central Java (63) (Kementerian Kesehatan Republik Indonesia, 2020). The increase in the number of cases took place quite quickly and there has been a spread between countries. In response to that, WHO set covid-19 as a pandemic (Cucinotta and Vanelli, 2020).

The extreme weather conditions that accompany long-term climate change may also contribute to the spread of the West Nile virus in the United States and Europe (Epstein, 2001). Certain climatic conditions can be considered as the top predictors of respiratory diseases such as SARS. Climate variables can also be a direct cause of biological interactions between SARS-CoV and humans. Optimal temperature, humidity, and wind speed are variables that can determine the survival and transmission of the SARS virus (Yuan et al., 2006). Changes in weather are very significantly correlated with changes in mortality rates due to pneumonia (Bull, 1980).

Viruses can be transmitted by being influenced by several factors, including climatic conditions (such as temperature and humidity), and population density (Dalziel et al., 2018). Research on climate change and covid-19 is still very limited so this research will contribute to efforts to prevent covid-19 disease.

2. Methods

2.1. Study area

Jakarta is the Capital of the Republic of Indonesia. Jakarta lies between 6° 12′ South latitude and 106° 48′ East longitude. The area of Jakarta consists of a land area of 662.33 km^2 and a sea area of 6977.5 km^2. The population of Jakarta in 2017 based on projections of results of the 2010 Population Census population was 10.374.235 (Mawarni, 2019) inhabitants with the population growth rate of 0.94% per year.

2.2. Data collection

The computerized data set on daily covid-19 in Jakarta for the period of January – March 29, 2020 were obtained from the Ministry of Health of Republic of Indonesia, while the weather data for the period of February 2020 were obtained from the Meteorological Department of the Republic of Indonesia. The data consist of temperature minimum (°C), temperature maximum (°C), temperature average (°C), humidity (%), and amount of Rainfall (mm).

2.3. Data analysis

As data were not normally distributed, Spearman rank correlation test was used to examine the relationship between weather and daily covid-19.

3. Results and discussion

Fig. 1 shows that covid-19 that occurred in Jakarta experienced a rapid increase. The first finding numbered 177 cases, the next report found 40 cases, and on 29 March 2020 the total number of covid-19 cases numbered 678. With an average of 61 cases, the weather data showed temperature minimum of 24.6 °C (with the highest temperature minimum of 27.5 °C), the lowest maximum temperature of 28.6 °C (with the highest maximum temperature of 31.4 °C), the lowest average temperature of 26.1 °C (with the highest average temperature of 28.6 °C), the lowest humidity of 75% (with the highest humidity of 93%), and the lowest rainfall of 1.1 mm (with the highest of 88 mm).

Table 1 shows that, among five weather variables, only temperature average (°C) was significantly correlated with covid-19 ($r = 0.392$; $p < .001$), with medium level. Temperature minimum, temperature maximum, humidity, and rainfall were not significantly correlated with covid-19.

In this study, the pattern of climate change provides a picture of the occurrence of covid-19 e in Jakarta. We found only temperature average was correlated with Covid-19, with the lowest average temperature of 26.1 °C and the highest temperature of 28.6 °C. This correlation is in line with previous research that shows the relationship between weather transmission and Syncytial Virus Respiration (RSV) (Vandini et al., 2013), SARS (Tan et al., 2005). Temperature is also the environmental driver of the covid-19 outbreak in China (Shi et al., 2020). The regression equation shows how temperature, relative humidity, and wind speed affected SARS transmission (Yuan et al., 2006).

In spite of the weather, the high covid-19 cases in Jakarta is also caused by the very high mobility of the people. As the capital city of Indonesia, Jakarta is the main economic destination for job seekers who come from various regions in Indonesia. Jakarta's population density is also very high and this allows covid-19 transmission to be very fast.

Another cause is that Jakarta is a very densely populated area. The majority of the population is residents from outside Jakarta, generally they choose the location of residence in the area because of the affordable price factor (Fitria and Setiawan, 2014). According to the results of the last national census, Jakarta is inhabited by almost 9.6 million people, exceeding the projected population of 9.2 million for 2025. Jakarta's population is 4% of the country's total population, 237.6 million people (Widiarso, n.d.). This means Jakarta's population has grown 4.4% over the past 10 years, up from 8.3 million in 2000 (Surjadi and Surja, 2019). With population growth like this allows covid-19 to spread rapidly (Zu et al., 2020).

In China, Wang et al. (2020a) found that temperature and relative humidity have a strong influence on the R value, with a significant level of 1% for both. Temperature and humidity have a significant and consistent distribution of seasonal behavior of respiratory viruses (Sajadi et al., 2020). Meteorological variables can predict worldwide outbreaks with high correlations ($r^2 > 0.6$) with real data (Chen et al., 2020). In Wuhan, covid-19 transmission is very important to be associated with transmission, there is a correlation between weather and disease spread, and weather factors will suppress disease when the weather warms up (Guo et al., n.d.).

Meteorological factors such as humidity, visibility, and wind speed can affect environmental stability, or affect the viability of viruses. As well as air temperatures have an impact on the transmission of the epidemic. Besides, absolute air temperature and humidity have been indicated to significantly affect covid-19 transmission (Chen et al., 2020). Temperature and humidity variations may be important factors that

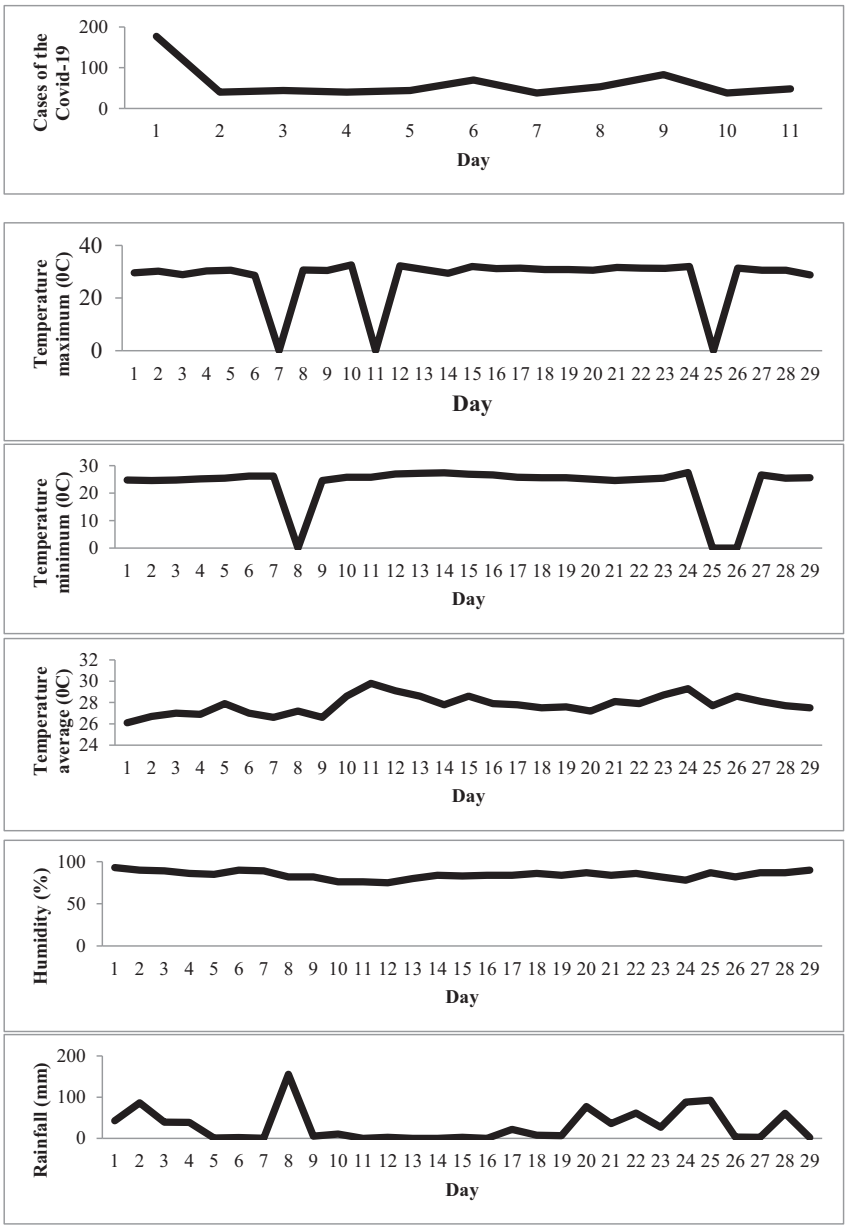


Fig. 1. (a) Cases of the Covid-19, (b) the amount of temperature maximum (°C), (c) temperature minimum (°C), (d) temperature average (°C), (e) humidity (%), and (f) rainfall (mm) in Jakarta Indonesia from January to March 29, 2020.

influence covid-19 mortality (Ma et al., 2020). There is a correlation between the spread of covid-19 on temperature and climate latitude (Poole, 2020).

Despite the significant finding of the weather on covid-19, this study has limitations: First, as the disease is caused by the virus, many factors are needed to be investigated such as virus resistance, population mobility, and population endurance. Second, individual health factors such as hand washing habits, personal hygiene, and use of hand sanitizers may be the other related factors of covid-19 that are necessary to be explored. However, this study is just the preliminary analysis. The strong conclusion requires time and a long data set.

Table 1
Spearman correlation coefficients between covid-19 and weather variables.

Weather variables	Spearman correlation coefficient
Temperature minimum/Tn (°C)	.128
Temperature maximum/Tx (°C)	0.238
Temperature average/Tavg (°C)	0.392*
Humidity (%)	0.002
Rainfall (mm)	0.139

* Correlation is significant at the 0.01 level (2-tailed).

4. Conclusion

The weather is an important factor in determining the incidence rate of covid-19 in Jakarta. Temperature average was significantly correlated with covid-19. Our findings can be used as an input in suppressing covid-19 disease in Indonesia.

Declaration of conflicts of interest

The authors declared that they have no conflict of interests.

References

Anderson, R.M., Heesterbeek, H., Klinkenberg, D., Hollingsworth, T.D., 2020. How will country-based mitigation measures influence the course of the COVID-19 epidemic? Lancet 395, 931–934.

Bull, G., 1980. The weather and deaths from pneumonia. Lancet 315, 1405–1408.

Chen B, Liang H, Yuan X, Hu Y, Xu M, Zhao Y, et al. Roles of meteorological conditions in COVID-19 transmission on a worldwide scale. medRxiv 2020.

Cucinotta, D., Vanelli, M., 2020. WHO declares COVID-19 a pandemic. Acta bio-medica: Atenei Parmensis 91, 157.

Dalziel, B.D., Kissler, S., Gog, J.R., Viboud, C., Bjørnstad, O.N., Metcalf, C.J.E., et al., 2018. Urbanization and humidity shape the intensity of influenza epidemics in U.S. cities. Science 362, 75–79.

Epstein, P.R., 2001. West Nile virus and the climate. J. Urban Health 78, 367–371.

Fitria, N., Setiawan, R., 2014. Identifikasi Karakteristik Lingkungan Permukiman Kumuh di Kelurahan Kapuk, Jakarta Barat. Jurnal Teknik ITS 3, C240–C244.

Guo X-J, Zhang H, Zeng Y-P. Transmissibility of COVID-19 and its Association with Temperature and Humidity.

Holshue, M.L., DeBolt, C., Lindquist, S., Lofy, K.H., Wiesman, J., Bruce, H., et al., 2020. First case of 2019 novel coronavirus in the United States. N. Engl. J. Med.

Kementerian Kesehatan Republik Indonesia, 2020. Pedoman Pencegahan dan Pengendalian Corona Virus Diaseases (COVID-19).

Li, Q., Guan, X., Wu, P., Wang, X., Zhou, L., Tong, Y., et al., 2020. Early transmission dynamics in Wuhan, China, of novel coronavirus–infected pneumonia. N. Engl. J. Med.

Ma Y, Zhao Y, Liu J, He X, Wang B, Fu S, et al. Effects of temperature variation and humidity on the mortality of COVID-19 in Wuhan. medRxiv 2020.

Mawarni, V., 2019. Kajian Evaluasi Kinerja Komite Sekolah di Provinsi DKI Jakarta. Prosiding Seminar Nasional Pendidikan STKIP Kusuma Negara.

Perlman, S., 2020. Another decade, another coronavirus. Mass Medical Soc.

Poole, L., 2020. Seasonal Influences on the Spread of SARS-CoV-2 (COVID19), Causality, and Forecastabililty (3-15-2020). Causality, and Forecastabililty (3-15-2020). (March 15, 2020).

Sajadi, M.M., Habibzadeh, P., Vintzileos, A., Shokouhi, S., Miralles-Wilhelm, F., Amoroso, A., 2020. Temperature and Latitude Analysis to Predict Potential Spread and Seasonality for COVID-19. Available at SSRN 3550308.

Shi, P., Dong, Y., Yan, H., Li, X., Zhao, C., Liu, W., et al., 2020. The Impact of Temperature and Absolute Humidity on the Coronavirus Disease 2019 (COVID-19) Outbreak-Evidence from China. medRxiv.

Sohrabi, C., Alsafi, Z., O'Neill, N., Khan, M., Kerwan, A., Al-Jabir, A., et al., 2020. World Health Organization declares global emergency: a review of the 2019 novel coronavirus (COVID-19). Int. J. Surg.

Surjadi, C., Surja, S.S., 2019. Kesehatan perkotaan di Indonesia: Penerbit Unika Atma Jaya Jakarta.

Tan, J., Mu, L., Huang, J., Yu, S., Chen, B., Yin, J., 2005. An initial investigation of the association between the SARS outbreak and weather: with the view of the environmental temperature and its variation. J. Epidemiol. Community Health 59, 186–192.

Vandini, S., Corvaglia, L., Alessandroni, R., Aquilano, G., Marsico, C., Spinelli, M., et al., 2013. Respiratory syncytial virus infection in infants and correlation with meteorological factors and air pollutants. Ital. J. Pediatr. 39 (1).

Wang J, Tang K, Feng K, Lv W. High temperature and high humidity reduce the transmission of COVID-19. Available at SSRN 3551767 2020a.

Wang, Y., Wang, Y., Chen, Y., Qin, Q., 2020b. Unique epidemiological and clinical features of the emerging 2019 novel coronavirus pneumonia (COVID-19) implicate special control measures. J. Med. Virol.

Widiarso T. Rekayasa Gaya Hidup Menuju Kota Masa Depan Yang Berkelanjutan Di Indonesia.

Yuan, J., Yun, H., Lan, W., Wang, W., Sullivan, S.G., Jia, S., et al., 2006. A climatologic investigation of the SARS-CoV outbreak in Beijing, China. Am. J. Infect. Control 34, 234–236.

Zhu, N., Zhang, D., Wang, W., Li, X., Yang, B., Song, J., et al., 2019. A novel coronavirus from patients with pneumonia in China. N. Engl. J. Med. 2020.

Zu, Z.Y., Jiang, M.D., Xu, P.P., Chen, W., Ni, Q.Q., Lu, G.M., et al., 2020. Coronavirus disease 2019 (COVID-19): a perspective from China. Radiology, 200490.