

Impact of PM_{2.5} and Climate conditions on Mortality of COVID-19 in Jakarta, Indonesia



Nurfanida Librianty^{1,*}, Bambang Wispriyono¹, Haryoto Kusnoputranto¹, Anna Rozaliyani²
Department of Environment Health, Faculty of Public Health, University of Indonesia¹
Department of Parasitology, Faculty of Medicine, University of Indonesia²

Abstract— Coronavirus disease 2019 (COVID-19) has been linked to exposure to air pollutants and climate conditions. The purpose of this study was to examine the correlation between COVID-19 mortality in Jakarta, Indonesia and fine particulate matter (PM_{2.5}), carbon monoxide (CO) exposure, and climate variables (temperature, sunlight hours, humidity, precipitation, and wind speed). Meteorology station measurements of PM 2.5, CO concentrations, and climate conditions from May to August 2021. The second peak of COVID-19 infections happened in Indonesia at that time. Using COVID-19 daily mortality data and meteorology data, the linear regression test was used to evaluate the impact of ambient temperature and PM_{2.5} on COVID-19 mortality. Temperature and PM_{2.5} have been linked to COVID-19 mortality. An increase of 1 µg/m³ in PM_{2.5} concentration will result in an increase of 1.57 deaths. A minimum temperature increases of 1°C reduces 11.8 death cases. These variables may be taken into consideration when creating policy intended to regulate and stop the spread of new coronavirus chains in tropical nations.

Keywords: PM_{2.5}, temperature, climate, COVID-19

1. Introduction

Since the initial case of coronavirus disease 2019 (COVID-19) was recognized in Wuhan, China and the World Health Organization (WHO) declared a pandemic, nearly three years have passed.(1)Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2) has spread worldwide, including in Indonesia.(1,2) Globally, there were 6,6 million deaths and 641 million confirmed cases as of December 7, 2022.(3)Virus variants are also a component in the transmission raise.(4)The first case was discovered in Depok on 2 March 2021, and it has since spread to all provinces in Indonesia.(2)Jakarta, the capital city of Indonesia, has the highest number of COVID-19 reported cases. There was a total of 1,528,544 confirmed cases. It accounts for 22,8% of all national cases and 9.9% of all national deaths.(5)

In order to implement restrictive measures, it is crucial to comprehend the factors that contribute to the spread of the disease. Exposure to air pollutants such as PM_{2.5} can increase transmission, leading to an elevate in COVID-19 cases and mortality.(6) One of the non-human factors that can have an effect on coronavirus transmission is the climate.(7) Since the start of the COVID-19 pandemic, almost all studies have found that PM_{2.5} exposure is directly related to the spread of the virus. and other environmental parameters, such as air ambient temperature, are significant contributors to the spread of the virus and its associated mortality rates.(8–11) COVID-19 transmission may also be influenced by factors in the environment, such as climate, moisture, air,

sewage, food, insects, inanimate surfaces, and hygiene practices. Viruses like SARS and the flu spread more easily in the winter than in the summer.(12)

Additionally, the many countries that have been impacted by the pandemic each have their own unique environmental factors, such as air pollution, temperature, and humidity. There are only two distinct seasons in the tropical nation of Indonesia: the summer season and the rain season. The initial pandemic peak in Indonesia happened in either January or February, which was a time of year when the country experienced a lot of rain. The months of June and July in 2021 would therefore constitute the second peak during the summer season. Jakarta is a highly populated metropolis with high levels of vehicle usage and air pollution. As the seasons change and more pleasant climate arrives, it is important to raise awareness about the importance of preventing illness by learning how environmental factors affect viral transmission. In this article, examine the connection between COVID-19 mortality and PM2.5 exposure, CO exposure and climate condition was evaluated in Jakarta.

2. Method

2.1 Study region

Province of DKI Jakarta has an area of 661.5 km² and a population of 10,609,681 as of the 2020 census. Jakarta is located astronomically between 6°12' south latitude and 106°48' east longitude. In Jakarta the climate is typically warm, with daytime temperatures between 32.7°C and 34°C and especially at night lows between 23.8°C and 25.4°C.(13)

2.2 Data collection

The Government of DKI Jakarta Province's database was used to compile the number of daily COVID-19 mortality cases. The required COVID-19 data was delivered by Jakarta Smart City.(14) Meteorological information was obtained from the Nations' Meteorological, Climatological, and Geophysical Agency. Data were collected between 1 May and 31 August 2021. The data included of PM2.5 concentration (µg/m³), CO concentration (mg/m³), minimum temperature (°C), average temperature (°C), maximum temperature (°C), duration of solar radiation (hour), humidity average (%), rainfall (mm), wind speed average (m/s), wind speed maximum (m/s), and wind direction at maximum speed (°).

2.3 Analysis of statistics

The data's normality was evaluated using the Kolmogorov-Smirnov test. The data on daily cases of COVID-19 mortality displayed a non-normal distribution, so the relation between PM2.5, CO, climate, and COVID-19 mortality was analyzed using the Spearman rank correlation test.. The significance level was set at 0.01. After fulfilling the assumptions, multiple *linear regression* is used to study the linear relationship between daily of death, PM2.5 concentration, and temperature at 5% level of significance using SPSS 24 software.

3. Result

During the evaluation period of 123 days, it was determined that the highest daily mortality rate occurred in July 2021. A total of 268 deaths on 20 July. With an average daily death rate of 54

during the months of May to August 2021. The highest concentration of PM2.5 was 89,26 $\mu\text{g}/\text{m}^3$ on 15 July and the lowest was 20,17 $\mu\text{g}/\text{m}^3$, and the mean was 49,15 $\mu\text{g}/\text{m}^3$. The mean of CO concentration was 0,87 mg/m^3 . Fig.1 shows the number of deaths, PM2.5, and CO concentrations over time.

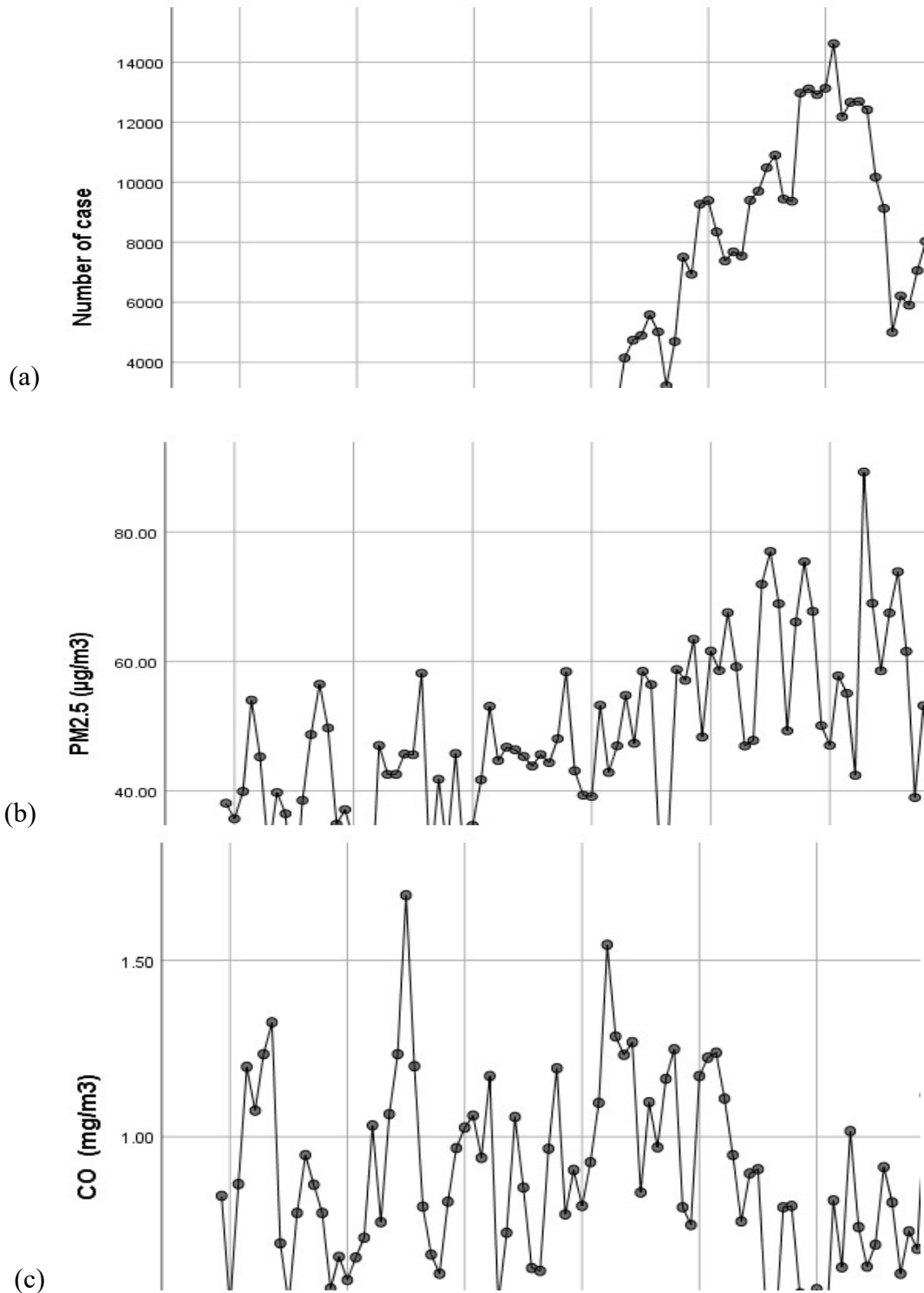
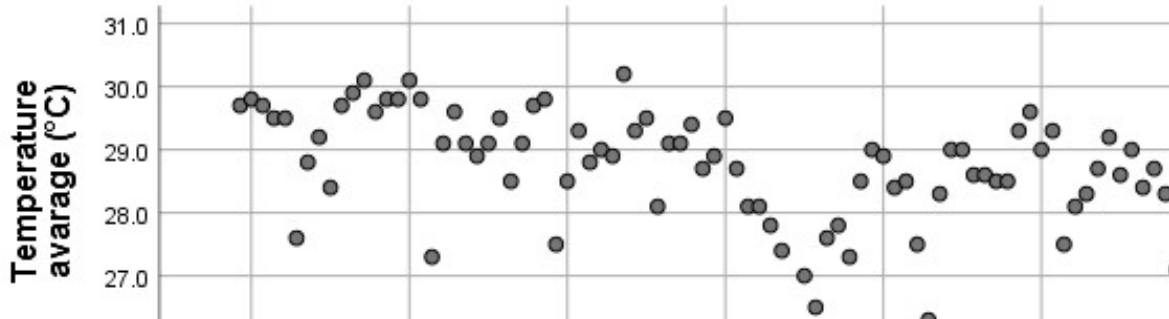


Fig. 1. Daily death of the COVID-19 (a), PM2.5 concentration (b), and CO concentration (c) in Jakarta between May 1, 2021 and August 31, 2021

The climate reports indicated that the lowest temperature was 22.0 degrees Celsius, the highest temperature was 34.8 degrees Celsius, the average temperature was 30.2 degrees Celsius, the average humidity was 92.0 percent, and the highest temperature was 34.8 degrees Celsius. The highest average temperature was 30.2 degrees Celsius; the lowest average temperature was 26.09 degrees Celsius. Fig.2 shows the climate conditions over time.

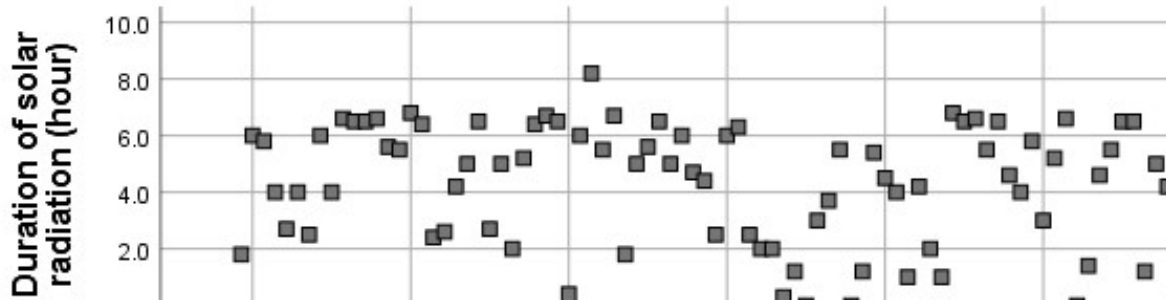
(a)



(b)



(c)



(d)

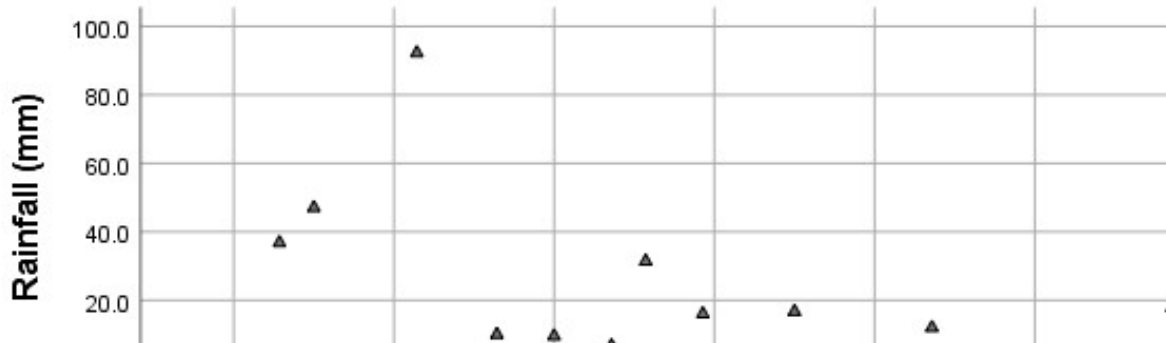


Fig. 2. (a) average temperature (°C), (b) average wind speed (m/s), (c) duration of sunlight (hour), (d) rainfall (mm) (e) in Jakarta between May 1, 2021 and August 31, 2021

Table 1 displays the result of spearman correlation test. There was a significant correlation found between four of the ten environmental parameters (PM2.5, minimum temperature, maximum temperature, and average temperature) that were investigated in this study. Other variables are not significant. There is a positive relationship between PM2.5 levels and mortality rates. The number of deaths is inversely related to all statistically significant temperature variable. Evans defined a weak correlation as a value between 0.0 and 0.19, a moderate correlation as 0.4 to 59, a strong correlation as 0.6 to 79, and a very strong correlation as 1.0 or higher.(15) In general, there was a moderate correlation between the average temperature and the number of deaths from COVID-19. Weak correlation between PM2.5 and minimum and maximum temperatures.

Table 1. The Spearman correlation test between mortality COVID-19 and climate variables.

Environment Variables	SpearmanCorrelationcoefficient	Sig.
Minimumtemperature (°C)	- 0,372	0,000
Maximum temperature (°C)	- 0,235	0,009
Average temperature (°C)	- 0,418	0,000
Average humidity (%)	0,033	0,718
Duration of sunlight (hour)	- 0,103	0,253
Rainfall (mm)	0,053	0,560
Average wind speed (m/s)	- 0,078	0,389
Maximum wind speed (m/s)	- 0,043	0,639
Wind direction at maximum speed (°)	- 0,022	0,805
PM2.5 (µg/m ³)	0.350	0.000
CO (mg/m ³)	-0.053	0.558

The linear regression test was developed in order to evaluate the impact of PM2.5, minimum temperature, maximum temperature, and average temperature on COVID-19 mortality. Results showed in Table 2 demonstrates that, 1 µg/m³ in PM2.5 the number of deaths significantly increased by 1.57. Whereas 1 °C increase in minimum temperature the number of deaths significantly recused by 11.8. Other variables (average and maximum temperature) were not significant.

Table 2. Linear regression test between PM2.5, temperature, and mortality COVID-19.

Environment Variables	B	Coefficients Std. Error	StandardizedCoefficientsBeta	t	Sig
Minimumtemperature (°C)	- 11.86	5.62	-0.20	-2.11	0,000
Maximum temperature (°C)	- 4.256	7.11	-0,08	-0.59	0,009

Average temperature (°C)	-	10.56	-0.62	-0.62	0,000
PM2.5 ($\mu\text{g}/\text{m}^3$)	6.569	0.34	0.37	4.57	0.000

4. Discussion

PM2.5 concentration and temperature play a significant role in COVID-19 mortality in Jakarta, Indonesia, based on this study. A $1 \mu\text{g}/\text{m}^3$ increase in PM2.5 concentration will cause increase the number of deaths 157%. Similarity, In the United States, an increase in PM2.5 exposure of $1 \mu\text{g}/\text{m}^3$ increases COVID-19 mortality by 10%.(11) COVID-19 mortality in Italy is twice as high in areas with high levels of PM2.5.(16) In London, $1 \mu\text{g}$ increase in PM2.5 the number of deaths significantly increased by 2.3% respectively.(17) In France showed that a $1 \mu\text{g}/\text{m}^3$ increase in the annual average PM2.5 concentration was associated with a statistically significant increase in the COVID-19 mortality rate.(18) PM exposure can trigger an inflammatory response through oxidative stress and surface toxic components which will cause inflammation in the respiratory tract, causing respiratory complaints and lung disease. SARS-CoV-2 induces inflammation by inhibiting the renin-angiotensin system (RAS), through binding to the angiotensin converting enzyme 2 receptor (ACE2). ACE2 is widely found in the human body. In the lungs there are type 2 alveolar cells that function in repairing the lung after injury. ACE2 is a receptor on SARS-CoV-2 so it can enter host cells. SARS-CoV-2 infection increases angiotensin II levels and decreases ACE2 protein levels. This shows the downregulation of ACE2 after viral infection.(19)

CO concentration was not significantly associated with COVID-19 mortality in this study. This is different from study in London that showed 1 unit increase in CO level the number of deaths significantly increased by 21.8%.(17) Also in San Francisco showed 1 part per million (ppm) increase in carbon monoxide level, the cumulative deaths increased by 5.3%, but CO and daily deaths had no significant association.(20)

In this study, temperature presented negative correlation between the number of deaths of COVID-19. A temperature minimum increases of 1°C reduces 11.8 death cases. Previous studies showed that there was a link between the climate and COVID-19's death. The link between temperature and new cases, new deaths, total cases, and total deaths was strongest in Bagdad and Kuwait. A 1°C rise in temperature was linked to a 0.6%, 0.3% increase in day to new cases and a 0.03%, 0.003% increase in daily new deaths.(21) Similarly, Tapia-Munoz et al. (22) showed 1°C increase in ambient temperature reduces the number of COVID-19 deaths and the possibility of high-level COVID-19 mortality over time. High-income northern countries had colder temperatures and higher mortality rates from COVID-19. Meo et al. (23) study in 16 African countries found that a decrease in the number of daily COVID-19 cases and deaths was associated with an increase in relative humidity and temperature.

An increase in COVID-19-related deaths is observed in Brazil during the winter. (24) During the winter, COVID-19 deaths in Brazil ramp up, and the temperature and the spread of SARS-CoV-2 were discovered to have a weakly negative association by Ogaugwu et al. (25) in Lagos, Nigeria. Similar results were found in Rio de Janeiro, Brazil, in which maximum and average temperatures,

wind speed, and the incidence of COVID-19 all had a negative correlation.(7)Yuan et al.(26) also observed that the number of new cases of COVID-19 that occurred each day had a negative correlation with the average temperature, wind speed, and relative humidity. Shi et al. [9] also noticed that the temperature rises as the incidence of COVID-19 lower.

In France, temperature was observed to have a significant effect on the COVID-19 mortality rate by Tchicaya et al.(18). According to negative binomial regression models, for every 1 degree Celsius above average temperature, the COVID-19 mortality rate dropped by 1%; this equates to 9.7%, 13.3%, and 14.5% on November 1, 2020, December 1, 2020, and December 31, 2020. Although some social norms may have loosened, the development of the second wave in France coincided with a gradual drop in temperature, lending credence to the theory that temperature is significantly related to the incidence and mortality rate of COVID-19. (18)

On the other hand, Sobral et al. (27) found no connection between temperature and COVID-19 mortality rates. Twenty days after initial infection with COVID-19, a minimum temperature increase of 18 degrees Fahrenheit was associated with a 1.9% (95% CI, 0.2% to 3.6%) increase in deaths, according to research by Karimi et al.It was found by Holtman et al. (9) that low temperatures aid the survival of COVID-19 in the environment, thereby contributing to the virus's spread.

Based on our findings, we can conclude that cold climate contributes to an increase in the incidence of COVID-19. The rate of death from COVID-19 declines as the temperature rises. Increased temperatures may reduce the deadly intensity of COVID-19 because of the increased virus inactivation caused by high temperatures (28,29)At 25 degrees Celsius, the SARS-CoV-2 has a possible 9-day lifetime, but at 30 degrees Celsius, it might not fare so well.(30)There was a decrease in both temperature and mortality risk during COVID-19, and then an increase in mortality risk when the temperature rose to around 10.0 °C and stayed there. These results are comparable to those found for noncommunicable diseases.(31) Respiratory illness deaths are significantly affected by low temperatures. Factors such as red blood cell count, blood viscosity, peripheral blood vessel constriction, plasma cholesterol, plasma fibrinogen, and inflammatory response can all contribute to the cardiovascular stress that can occur when humans are exposed to cold temperatures.(32)

Average levels of humidity, sunshine duration, wind velocity, and rainfall were not found to be related to each other in this study. Although Halos et al.(21) found a negative correlation between relative humidity and both daily and overall mortality, our data show the opposite. A 0.01%, 0.002% increase in daily new deaths were observed in regions where relative humidity dropped by 1%.Temperature and humidity, as found by Qi et al. (33), are inversely associated with the death rate from COVID-19. Study from Turkey, which shows that low humidity can be fatal for viral infections, contradicts these findings.(34) In Rio de Janeiro presented solar radiation and wind speed had relation with incidence of COVID-19.(7) Similarly, according to Hachim et al.(35), patients who required hospitalization on days with higher temperatures, lower humidity, and greater solar radiation had a higher mortality rate. As a result of the sun's rays, tropical virus

populations can be drastically reduced. Conversely, vitamin D, which can be used to treat or prevent COVID-19 infection, is produced in large part due to exposure to sunlight.(7)

A positive but weak correlation was found between wind speed and daily new cases, daily new deaths, cumulative cases, and cumulative deaths, as determined by Halos et al. (21). Zhu et al. reported no significant association between daily COVID-19 cases and wind speed.(36) In Australia Abraham et al. reported no significant correlation was found for rainfall. (37) It turns out that other studies have also found the same thing. To minimize the effects of environmental variables such as sunshine, wind, and rainfall, this study was carried out during the summer.

5. Conclusion

PM2.5 exposure and temperature have an effect on COVID-19 mortality in Jakarta, Indonesia. The number of COVID-19 mortalities was significantly correlated with the concentration of PM2.5 and the minimum temperature. As an example of an environmental factor, consider the possibility that prolonged exposure to high temperatures will have a dampening effect on the pandemic. Policymakers, medical professionals, and public health professionals can better understand the spatial distribution of the pandemic and adjust intervention plans for ongoing or future pandemics by conducting analyses at the provincial level. A third or even fourth wave of SARS-CoV-2 transmission is still possible. To better understand the role of climate and air pollution in future pandemics and how this knowledge can aid in the implementation of preventative measures, more study into the COVID-19 pandemic is required.

Declaration of competing interest

Authors declared no conflict of interest in this study.

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