

MOVING AVERAGE AS A SIMPLE INDICATOR TO PREVIEW THE TREND OF PANDEMIC CASES TO EVALUATE CONTROL INTERVENTION: STUDY FROM -ONE-YEAR COVID-19 IN INDONESIA

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Abstract. The cases of Coronavirus disease 2019 (COVID-19) in Indonesia increased exponentially and spread rapidly. The Indonesian government has made various efforts to control the spread. Several methods and mathematical models are also proposed to predict and demonstrate how COVID-19 cases will develop. This study proposes an evaluation method by utilizing the movement of the moving average (MA) around the real-time growth of case data so that it can further detect which interventions and control efforts require immediate improvement. This study employed data on daily COVID-19 cases in Indonesia from the beginning of the case until the case on 7 July 2021. Adjusted case data were employed as the main data to produce MA data and as an indicator to project future case growth. The COVID-19 cases in Indonesia occur in several phases: the delayed phase (very slow case development), the flattened phase of the curve (flat case), the exponential phase until the end of October 2020, the decline phase (downwards in all MA lines), and the return to the exponential phase with a more progressive increase from the previous phase. However, the direction of the decline case reoccurred after the first vaccination. The results of the decomposition analysis show an increasing trend and no influence of the seasonal factor on the fluctuating number of cases. The moving average can strongly detect the movement direction of cases during the COVID-19 pandemic and is applicable as an indicator to evaluate case-control efforts and other pandemic cases.

Keywords: moving average, COVID-19, pandemic, control evaluation method

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INTRODUCTION

The spread of the Coronavirus disease 2019 (COVID-19) is contagious and very fast as well as meets epidemiological principles to be called a pandemic because the virus has infected more than 100,000 people in more than 100 countries (Remuzzi and Remuzzi, 2020). Many countries have started to be overwhelmed with COVID-19 cases, and some of them have implemented a “lockdown” policy to prevent the entry of new transmissions into their country. The double burdens faced by almost all countries are the world’s limiting transmission, which has started to run out of control, and how the role of health services reduces morbidity and mortality from this disease. Moreover, economic burdens have made the G20 countries pour USD 5 trillion to maintain the global economy due to this virus (Djalante *et al*, 2020).

Indonesia’s first case was declared on 2 March 2020 with 2 cases at once (Ihsanuddin, 2020). The case has increased exponentially and spread very quickly a few days later until today; thus, Indonesia becomes the fourth-largest country with COVID-19 cases in the world (Djalante *et al*, 2020; Sasmita *et al*, 2020). Since the beginning, Indonesia was predicted to be affected by this disease for a long time (Djalante *et al*, 2020), and it was proven that the cases did not show a significant decrease. Several methods and mathematical models have been proposed to predict and demonstrate how the COVID-19 cases will develop around the world; these models aim to control the pandemic (Aldila *et al*, 2020; Annas *et al*, 2020; Cássaro and Pires, 2020; Rath *et al*, 2020; Sasmita *et al*, 2020).

Several models exhibit a forward prediction capability with excellent accuracy (Rath *et al*, 2020). Some promote a more realistic model of case growth (Cássaro and Pires, 2020). However, this model only projects cases

that will occur in the future so that the results should be proven and provide a strong relationship between assumptions and short-term projections; however, the results become uncertain in long-term projections (Naudé, 2020; Kotwal *et al*, 2020).

The MA has been used widely in various disciplines and occupations. The trend indicator of a stock's value movement (Hansun, 2013), an excellent method for forecasting activities (Barrow, 2016), and a patent system for providing data sources of internet bandwidth employ the autoregressive integrated moving average method (Aras *et al*, 1995). As an indicator, MA is frequently 'lagging' or lately predicts data movement. This indicator is more sensitive when indicating the downward or upward movement of the data. The indicator is also often used to estimate current activities and outputs data and design future projections (Johnston *et al*, 1999). This study proposed the idea of using MA to detect the direction of the data on the development of COVID-19 cases. This detection can be used as a material to evaluate and necessarily control the interventions. MA is generated from the calculation of the average case data that runs to follow data every day. The method used a simpler approach where instead of predicting how the case will be in the future, the MA indicator will determine when the trend of the case will change.

MATERIALS AND METHODS

Study site

Indonesia is a tropical archipelago country in Southeast Asia and consists of thousands of islands - its five major islands include Sumatra, Java, Kalimantan, Sulawesi, and Irian/Papua. Most of the population inhabit across the island, and the largest population is on Java Island, which has also become the center of the state government (Jakarta) as well as the center of the country's largest economic growth. Such a situation explains that the largest cases are evenly distributed across all provinces in Java, especially Jakarta and West Java. Access to domestic transportation, including sea

and air transportation, between islands has developed rapidly. Dozens of domestic flights take place every day from one region to another throughout Indonesia.

Moving average simulation

This study employed the daily case data on COVID-19 in Indonesia from the first cases until on 7 July 2021. The data were obtained from the website of the Committee for Task Force COVID-19 and National Economic Recovery (KPCPEN) [<https://covid19.go.id>]. These data include daily data on COVID-19 positive cases, recovered patients, and casualties. The data were then processed to obtain adjusted case data using the following formula:

$$Adj\ Case = Daily\ case - (Cure + Deceased) \quad (1)$$

This adjusted case data served as the main data to generate MA data with the following calculation equation:

$$MA\ n = \frac{adjC1 + adjC2 + \dots + adjCn}{n} \quad (2)$$

where: MA n = Moving average n daily
 adjC1,2,... = Daily adjusted cases
 n = Day

Then, we generated 14 days of MA data (MA14) and 50 days MA data (MA50) using the above formula. Number 14 referred to the average number of viruses that infected people, caused symptoms, and still transmitted the infection to other people (Lauer *et al*, 2020). MA50 referred to the MA standard for projecting case development in the medium-term period. MAs formula is a single method to evaluate control measure/effort only by using case data movement due to the similarity of behavioral changing such as human mobility movement, *etc*, that actually indirectly reflected to the development of the case would be in the future.

MA14 and MA50 were placed in the movement of the adj case chart and continued to follow the movement of the case in real-time every day. The MA reading served as an indicator and determinant of when a movement of case data will change its trend. The MA reading, which was below the chart, indicates that the case was likely to increase. In contrast, the MA reading, which was above the case chart, indicates that the case would tend to decrease. The analysis also investigates the density or distance of the two MAs: the distance between both MAs moved away from each other and the direction of the case movement was getting stronger in upward and downward trends, and vice versa. In advance, MAs also raises alert in real time if the smaller MA (MA14) crosses the larger MA (MA50) upward, the case trend would likely to increase. Conversely, if the larger MA crosses the smaller MA downward, the case trend would likely to decline.

Trend lines were employed to project future case growth. We employed a period of 50 days as a medium-term time projection and a trend line power type because they provided the largest R-squared value.

Seasonal decomposition

Multiplicative seasonal decomposition analysis was carried out using Statistical Package for Social Sciences (SPSS) version 21 (IBM Corporation, Armonk, NY) to break down the daily incidence of COVID-19 cases (Y_t) into combined trends (T_t), seasonal components (S_t), and errors or remaining components (E_t). The relationship between differences in terms of decomposition and the incidence of malaria was measured using the following formula: $Y_t = T_t + S_t + E_t$.

Ethical consideration

The study did not require the approval of an ethical consideration because the data are public. The data used was daily number of cases from the KPCPEN official website [<https://covid19.go.id>] and no personal data of cases were involved in the analysis.

RESULTS

The COVID-19 cases have increased since early January 2021. The cases showed a downward trend in mid-February 2021. The average increase reaches 9749,706 cases per day with a cure rate of 86.93%, a death rate of 2.71%, and a positive rate of 9.42%. The regions that contribute the most increase in the COVID-19 cases were DKI Jakarta (25.4%), West Java (16.0%), Central Java (11.5%), and East Java (9.6%) (data until 9 March 2021). Fig 1 indicates that Java region were predominantly contributed in the development of COVID-19 with 1,338,285 cases then Sumatra region (282,806 cases), Kalimantan region (160,320 cases), Sulawesi region (114,576 cases), Bali-Nusa Tenggara region (78,833 cases), and Maluku-Papua region (43,291 cases), respectively (data until 9 March 2021).

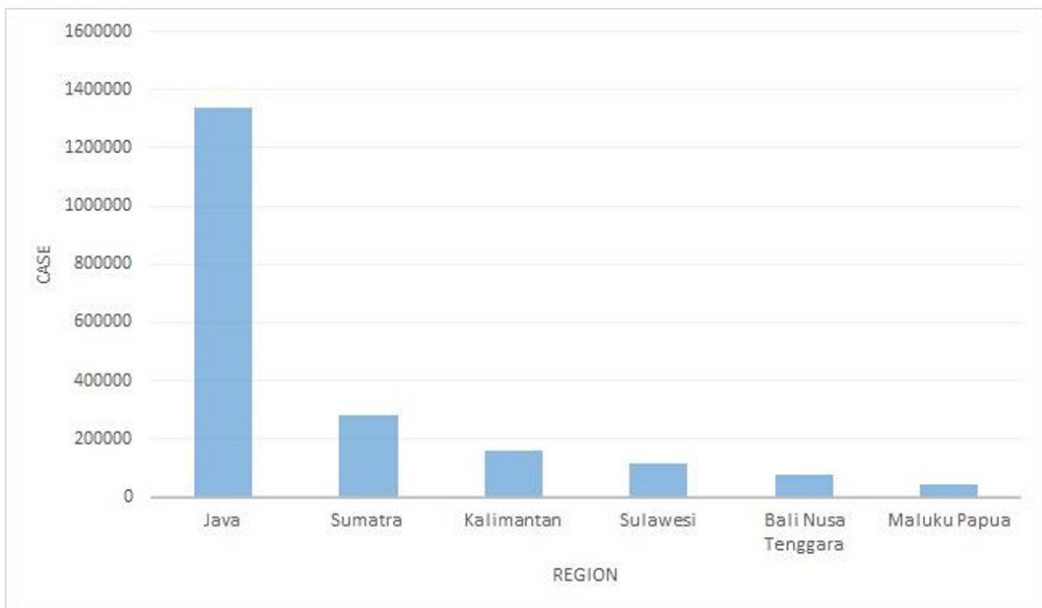


Fig 1 - Confirmed cases of COVID-19 per region
 COVID-19: Coronavirus disease 2019

Fig 2 shows that the COVID-19 cases have undergone several phases. The first few days (the first week) of the cases refer to a delayed phase when the cases developed very slowly and were only found in the Jakarta area. The case continued to grow and spread to several regions and cross Java Island; this stage refers to the exponential phase. Furthermore, in July 2020, the case graph became flat for one month; this stage refers to the flattened curve phase. The error then curved the case back to the exponential phase until the end of October 2020. Afterward, this case successfully crossed all downward MA lines and continued to decline for several days; this period refers to the decline phase. This phase lasted until early November 2020 and returned to an exponential phase with a greater increase in cases than before until 18 January 2021. A strong increase in the case started on 25 November 2020. The moving averages moved away from each other when the MA14 crossed over the MA50 lines. This condition indicates that the growth has become more progressive than before.

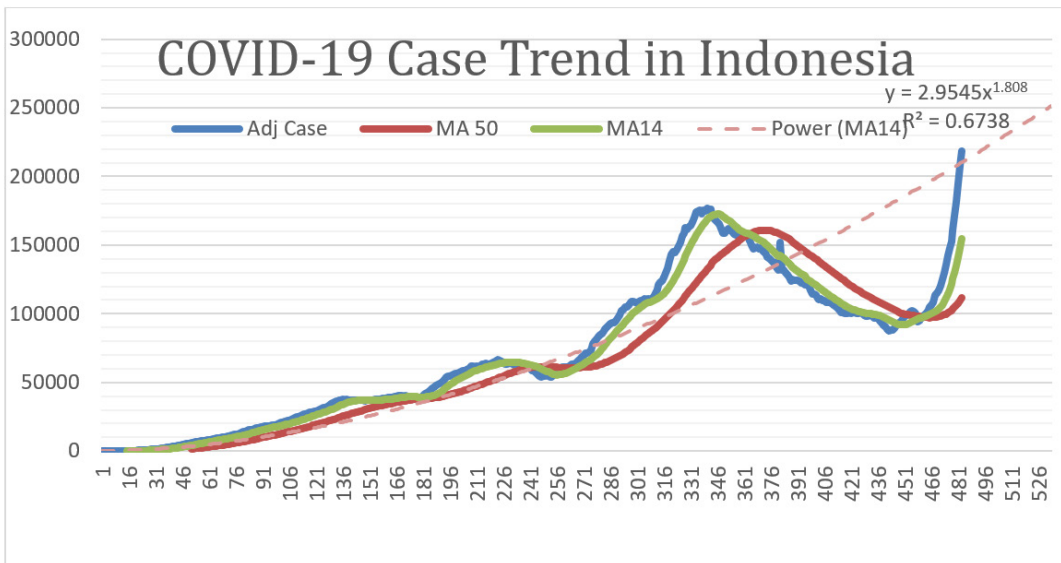


Fig 2 - COVID-19 case trend in Indonesia from 3 March 2020 to 7 July 2021

COVID-19: Coronavirus disease 2019

On Day 344 (9 February 2021), the case line showed the highest case peak and there was a downward turn until the last day when the case was updated (7 March 2021). The cases began to decline after the first vaccination for President Jokowi, health workers, public officers, and the elderly, and the vaccine target in Indonesia is 40,349,051 people. The vaccination continued gradually until the target reaches 181,554,465 vaccinated people in Indonesia. The development of vaccination included several stages. The first vaccination was on 9 March 2021 and has reached 1.84%. The second vaccination has reached 0.66% of the target of the entire Indonesians [<https://covid19.go.id>]. The MA line and the trend line are projected for the period of 50 days and have crossed over the case line. Such conditions mean that the increasing trend of cases has broken and reversed downward.

Unfortunately, on Day 472 (17 June 2021), the cases increased significantly and continued to rise exponentially until the last recording day (7 July 2021). The case line increased the MA line and the trend line again. This condition becomes an early warning to increase the necessary control activities.

The weekly pattern of COVID-19 cases in Indonesia is shown in Fig 3. The COVID-19 cases in Indonesia continued to increase for several days and rarely decreased. The results of the decomposition analysis show an upward trend. In addition, the decomposition analysis showed no tendency for the seasonal influences on the case dynamic.

DISCUSSION

The most contributing factors to the growth of the COVID-19 cases are population and human mobilization in several areas on Java Island (Aisyah *et al*, 2020). However, some major regions outside Java Island also show quite rapid progress in the case after the next period. This condition demonstrates that this virus is more contagious and spreads more rapidly than its family, such as severe acute respiratory syndrome (SARS) (Liu *et al*,

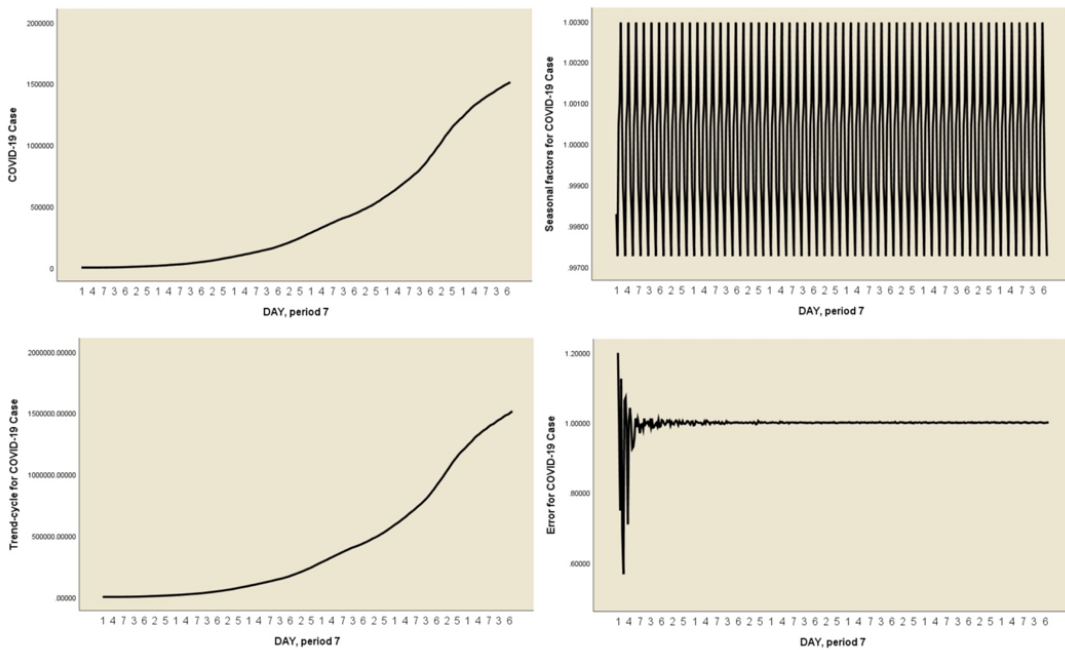


Fig 3 - Seasonal decomposition of weekly COVID-19 cases in Indonesia
 (7 March 2020-31 March 2021)
 COVID-19: Coronavirus Disease 2019

2020). The COVID-19 cases in Indonesia grow progressively at an exponential rate and last for a long time. MA is a robust choice to follow these data consistently and precisely.

In the first week, the COVID-19 cases moved slowly because Indonesia is an archipelago country that potentially delayed the disease transmission outside the epicenter of Java Island (Sasmita *et al*, 2020). However, subsequent cases were very progressive. The significant increase in the number of cases at the beginning of the pandemic encouraged the government to expand the range of screening cases using rapid tests and polymerase chain reaction (PCR) test. Moreover, this significant increase has forced the government to establish the large-scale community social distancing (PSBB) policy and

increase the capacity of health care centers to treat COVID-19-positive patients. The case chart shows that after the implementation of the PSBB in several regions, the cases still increased from day 40 (11 April 2020); however, this increase was not too progressive. From day 91 (in June 2020) the government began to loosen the PSBB policy while imposing stringent health protocols (Fajar, 2020). Unfortunately, the “herd immunity” effort resulted in increased and stronger cases, as seen from the further distance between the two MAs. In early July, the Governor of DKI Jakarta announced to extend the PSBB policy in Jakarta; this policy has resulted in a good impact on the case (Sari, 2020). On day 135, the graph of the cases flattens while the two MAs start to coincide. This policy has successfully reduced the number of daily cases, especially in the Jakarta area.

The PSBB applies to all sectors, including education. Since mid of March 2020, the Ministry of Education and Culture implemented a policy of online learning from home. This policy raises new difficulties in the learning process, mainly in areas of inadequate internet infrastructure. Finally, in August 2020 the government issued a policy allowing special face-to-face learning for schools in the green and yellow zones (Indriani, 2020). This new policy resulted in an increased case starting on day 181 (30 August 2020). The graph moved up significantly from 11 October 2020. The government of Jakarta and several other provinces reextended the PSBB transition policy on 12 October 2020. This policy could lower the chart of the cases up to the next few days. Then the cases significantly increased again with an increasingly large tilt angle until early February 2020. The surge of cases has been detected since day 268 (25 November 2020) and is visible when MA14 is crossed over and up MA50; this condition confirms that the trend of the case significantly rises.

The Indonesian government began to implement vaccinations in mid-January. The first vaccination was first given to the President of Indonesia and continued to health workers, public officials, and the elderly. Although the first vaccination program only reached about 1% of the total target vaccine

recipients, this program had a good impact on the development of cases and resulted in a downward trend. Other factors resulting a good impact are the formation of a high number of people infected by COVID-19, a high number of infected people with clinical-asymptomatic conditions (Aisyah *et al*, 2020), and herd immunity against COVID-19.

Some of the experiences above show that the implementation of control procedures, such as PSBB, and strict application of health protocols can reduce the growth of COVID-19 cases. The COVID-19 cases have significantly increased from early January 2021 to date because the availability and capacity of PCR examinations have escalated extensively throughout the regions (Sasmita *et al*, 2020). The increased cases could also occur due to the PSBB easing in several regions and the news about the vaccination program starting from mid-January with the president as the first vaccine recipient. This news has made the public psychologically expects that the crisis will end soon. This expectation could lead to euphoria and high optimism but, at the same time, lower people's awareness (Koellinger *et al*, 2007). At this stage, the government should keep educating and applying health protocols in the crowd. This incidence is different from that one month after the first phase of the vaccination for health workers; this incidence has a good impact on the development of the cases as shown by downward and crossed MA lines and trend lines. This condition shows that vaccination could increase the effectiveness of case-control.

From the mid of June to early July 2021, the COVID-19 cases in Indonesia increased rapidly, and the highest daily cases of the pandemic occurred every day. This condition was caused by homecoming activities and religious holidays in May 2021 when people went to their hometowns or vacations in several tourist attractions in Indonesia and created several crowds. The government tried to deal with these increased cases and continued to improve strict health protocols. However, it is very difficult to prevent the occurrence of new COVID-19 cases; consequently, the cases increased significantly rapidly.

The disadvantage of MA is its inability to predict real-time increases or decreases in cases because the MA indicator does not reflect current data and average case data from the previous days (Svetunkov and Petropoulos, 2018). Meanwhile, the strength of the MA is its ability to determine the movement trend of cases the next day in real-time (Patel *et al*, 2015). A trend is detected by watching the intersection of two MAs; if the larger MA (MA50) crosses the smaller MA (MA14) upward, the case trend tends to increase. Conversely, if the smaller MA crosses the larger MA downward, the case trend will tend to decline. The increasing and decreasing trend of the detected cases can be used to evaluate and control the case intervention. When the two MAs are under the case data and two MAs intersect, strict intervention on limited-social activities and health protocols is highly recommended to break the transmission chain and reduce the rate of confirmation cases that would get bigger. Likewise, the case line that crosses the two MA lines downward would provide a signal to maintain good intervention and improve the quality of more robust control. This study has interpreted that adequate and integrated interventions can reduce the number of new cases and the spread of the epidemic. The MA line can be used as one of the tools to monitor the intervention efforts.

In summary, the moving average is able to strongly detect the movement direction of cases during the COVID-pandemic and can be used as an indicator to evaluate case-control efforts. Case trends of COVID-19 are not influenced by seasonal conditions. The COVID-19 pandemic has resulted in uncertain-public health measures, fast infection rates, and a large number of asymptomatic cases. Therefore, this indicator is also applicable to other pandemic cases.

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CONFLICT OF INTEREST DISCLOSURE

The authors declare no conflict of interest.

REFERENCES

- Aisyah DN, Mayadewi CA, Diva H, Kozlakidis Z, Siswanto, Adisasmito W. A spatial-temporal description of the SARSCoV-2 infections in Indonesia during the first six months of outbreak. *PLoS One* 2020; 15: e0243703.
- Aldila D, Khoshnaw SHA, Safitri E, *et al.* A mathematical study on the spread of COVID-19 considering social distancing and rapid assessment: the case of Jakarta, Indonesia. *Chaos Solitons Fractals* 2020; 139: 110042.
- Annas S, Isbar Pratama M, Rifandi M, Sanusi W, Side S. Stability analysis and numerical simulation of SEIR model for pandemic COVID-19 spread in Indonesia. *Chaos Solitons Fractals* 2020; 139:110072.
- Aras CM, Miller JD, Scott RK. US5884037 - System for allocation of network resources using an autoregressive integrated moving average method, 1995 [cited 2020 Sep 17]. Available from: URL: <https://patentimages.storage.googleapis.com/2b/3b/1f/92f1eb9595827f/US5884037.pdf>
- Barrow DK. Forecasting intraday call arrivals using the seasonal moving average method. *J Bus Res* 2016; 69: 6088-96.
- Cássaro FAM, Pires LF. Can we predict the occurrence of COVID-19 cases? Considerations using a simple model of growth. *Sci Total Environ* 2020; 728: 138834.
- Djalante R, Lassa J, Setiamarga D, *et al.* Review and analysis of current responses to COVID-19 in Indonesia: period of January to March 2020. *Prog Disaster Sci* 2020; 6: 100091.
- Fajar WH. Getting to know the new normal concept, 2020 [cited 2020 Dec 28]. Available from: URL: <https://indonesia.go.id/ragam/komoditas/ekonomi/mengenal-konsep-new-normal> [in Bahasa]

- Hansun S. A new approach of moving average method in time series analysis, 2013 [cited 2020 Dec 23]. Available from: URL: <https://ieeexplore.ieee.org/document/6708545>
- Ihsanuddin. Complete facts of the first case of corona virus in Indonesia, 2020 [cited 2021 Jan 06]. Available from: URL: <https://nasional.kompas.com/read/2020/03/03/06314981/fakta-lengkap-kasus-pertama-virus-corona-di-indonesia> [in Bahasa]
- Indriani. Policy adjustments in learning during the COVID-19 pandemic, 2020 [cited 2021 Jan 17]. Available from: URL: <https://www.antaranews.com/berita/1917096/penyesuaian-kebijakan-dalam-pembelajaran-pada-masa-pandemi-covid-19> [in Bahasa]
- Johnston FR, Boylan JE, Shale E, Meadows M. A robust forecasting system, based on the combination of two simple moving averages. *J Oper Res Soc* 1999; 50: 1199-204.
- Koellinger P, Minniti M, Schade C. "I think I can, I think I can": overconfidence and entrepreneurial behavior. *J Econ Psychol* 2007; 28: 502-27.
- Kotwal A, Yadav AK, Yadav J, Kotwal J, Khune S. Predictive models of COVID-19 in India: a rapid review. *Med J Armed Forces India* 2020; 76: 377-86.
- Lauer SA, Grantz KH, Bi Q, *et al*. The incubation period of coronavirus disease 2019 (COVID-19) from publicly reported confirmed cases: estimation and application. *Ann Intern Med* 2020; 172: 577-82.
- Liu Y, Gayle AA, Wilder-Smith A, Rocklöv J. The reproductive number of COVID-19 is higher compared to SARS coronavirus. *J Travel Med* 2020; 27: taaa021.
- Naudé W. Artificial intelligence vs COVID-19: limitations, constraints and pitfalls. *AI Soc* 2020; 35: 761-5.
- Patel J, Shah S, Thakkar P, Kotecha K. Predicting stock and stock price index movement using Trend Deterministic Data Preparation and machine learning techniques. *Expert Syst Appl* 2015; 42: 259-68.

- Rath S, Tripathy A, Tripathy AR. Prediction of new active cases of coronavirus disease (COVID-19) pandemic using multiple linear regression model. *Diabetes Metab Syndr* 2020; 14: 1467-74.
- Remuzzi A, Remuzzi G. COVID-19 and Italy: what next? *Lancet* 2020; 395: 1225-8.
- Sari N. Transitional PSBB in Jakarta extended until 30 July 2020, 2020 [cited 2021 Jan 6]. Available from: URL: <https://www.msn.com/id-id/berita/nasional/psbb-transisi-di-jakarta-diperpanjang-sampai-30-juli-2020/ar-BB16OZAz> [in Bahasa]
- Sasmita NR, Ikhwan M, Suyanto S, Chongsuvivatwong V. Optimal control on a mathematical model to pattern the progression of coronavirus disease 2019 (COVID-19) in Indonesia. *Glob Health Res Policy* 2020; 5: 38.
- Svetunkov I, Petropoulos F. Old dog, new tricks: a modelling view of simple moving averages. *Int J Prod Res* 2018; 56: 6034-47.