RESEARCH ARTICLE

Forecasting COVID-19 in Morocco

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ABSTRACT

The COVID-19 has become a public health emergency of international concern. As of April 26, 2020, this pandemic has caused in Morocco more than 4065 confirmed infections and more than 161 reported deaths. To mitigate this epidemic threat and act quickly, it is very important to monitor and analyze changing trends and predict what might happen in the future. The main objective of this paper is to develop a successful prediction. We used in this study at the end of each week the TBATS model to forecast confirmed cases. This model is calculated on the basis of the daily historical data. From the results obtained we can conclude that the predictions obtained are close to reality and for the peak of this epidemic is not yet identified. The obtained results shows that this epidemics will continue to grow. For our forecast from 04/27/2020 to 05/03/2020 we estimate that the number of affected cases will achieve 4367 cases.

Keywords: Coronavirus, COVID-19, forecasting, TBATS, Morocco

INTRODUCTION

The novel coronavirus named " COVID-19" is started from Wuhan city in China, in November 17, 2019, and has now spread all over the planet. The World Health Organization (WHO) alert at first the Chinese Republic and its other Member States. On January 30, 2020 the WHO declares a Public Health Emergency of international Concern [1]. There are to date April 26, 2020, 2 804 796 confirmed cases and 193 710 deaths worldwide [2].

Although there are some similarities in epidemiology and clinical features between COVID-19, SARS-CoV, MERS-CoV and pandemic influenza viruses [3,4]. The zoonotic origin of COVID-19 is not confirmed by researchers. Historically, the Middle East respiratory syndrome coronavirus (MERS-CoV) infection has been approved for transmission from dromedary camels to humans [5], and bats are the group of mammals that harbor the largest number Coronaviruses [6,7]. That's why for COVID-19, the Human-Animal interaction has been questioned by researchers as a likely risk factor for COVID-19 [7,8].

Morocco has also been exposed to the spread of the virus, given its proximity to Europe where the virus is already widespread. Morocco knows its first case of Coronavirus on March 02, 2020 and it registered until the date of April 26, 2020, 4065 of contamination with COVID-19, including 539 people healed and 161 deaths, while 2334 cases have excluded following negative tests in the laboratory (According to the Official Portal of the Coronavirus in Morocco www.covidmaroc.ma).

To control this epidemic and limit its spread. Morocco has implemented several actions and measures : (1) in March 13, 2020: Suspension of air flights and maritime links to and from countries considered to be epidemic centers, and access to Moroccan ports is suspended for all pleasure, cruise and transport vessels; (2) in March 15, 2020: the King orders the government to immediately create a special fund for the management of the pandemic; (3) in March 19, 2020: the health emergency declared in Morocco ; (4) in March 12, 2020: Establishment of field hospitals and private clinics made available to the COVID-19; (5) April 7, 2020: Mandatory wearing of the
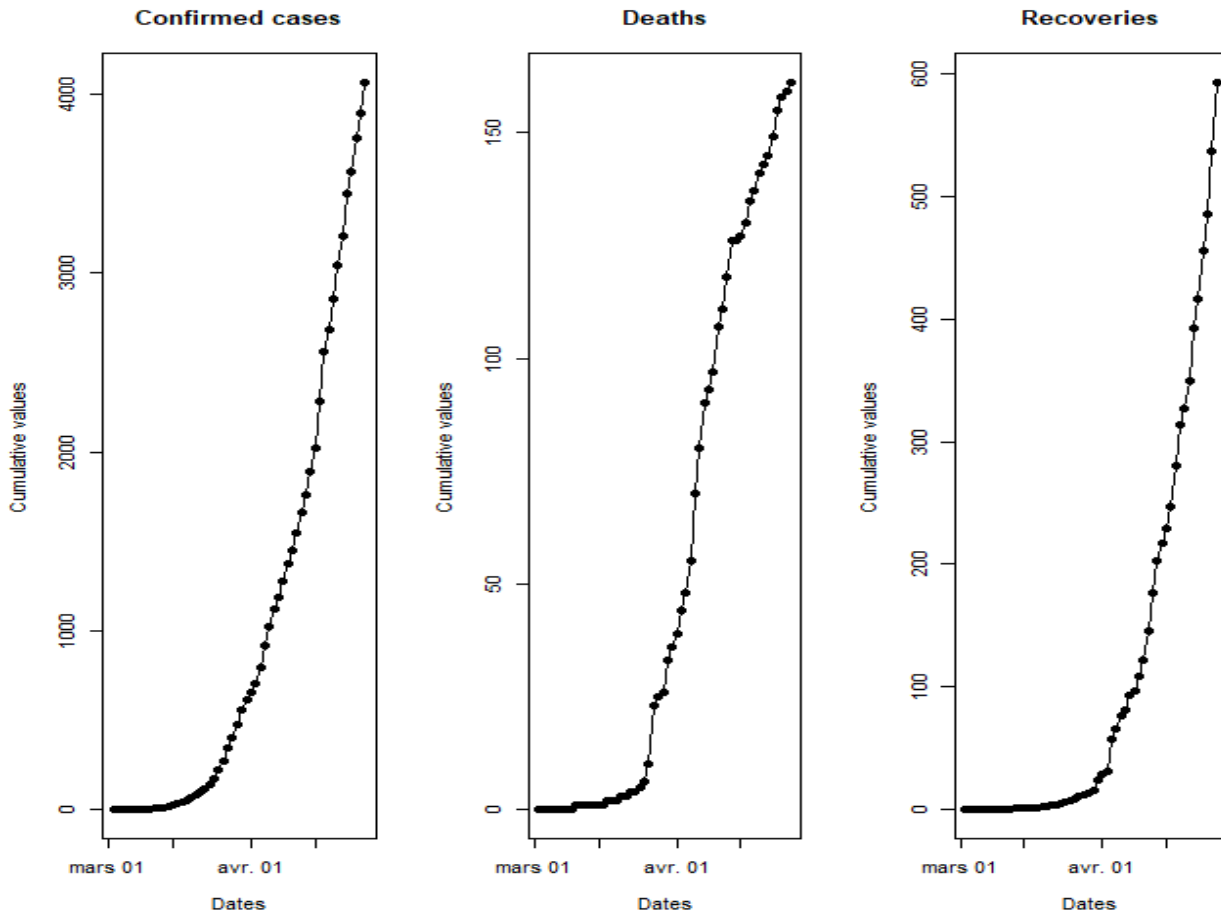
Figure 1. Daily cumulative confirmed, deaths and recovered cases from COVID-19 in Morocco (March 02 to April 26, 2020)

mask for the whole country.

Given the economic and social impacts of this pandemic, statistical studies can be used to predict the number of infected cases. During this study and to get an idea on the possible scenarios in the near future in order to take the necessary measures, and educate people and decision-makers about the consequences of this epidemic, we have developed a model based on the TBATS method to predict the daily recorded cases of the COVID-19 epidemic.

METHODS AND ANALYZES

Data Source

The developed model was built and tested on the data provided by the Moroccan Ministry of Health. This data presents the daily values since the appearance of the first case of COVID-19 in Morocco (March 02, 2020 to April 26, 2020). For this period the **Figure 1** shows the daily cumulative confirmed, deaths and recovered cases from COVID-19 in Morocco.

Model

The TBATS (Trigonometric seasonality, Box-Cox transformation, ARMA errors, Trend and Seasonal) is used in this study. TBATS is a forecasting method to model time series data. Each seasonality is modeled by a trigonometric representation based on Fourier series. One major advantage of this approach is that it requires only two seed states regardless of the length of period [9].

The main aim of this is to forecast time series with complex seasonal patterns using exponential smoothing [10]. This method can be described by the following equations :

$$
\begin{aligned}
y_t^{(\lambda)} &= l_{t-1} + \phi b_{t-1} + \sum_{i=1}^{T} S_{t-m_i}^{(i)} + d_t \\
l_t &= l_{t-1} + \phi b_{t-1} + \alpha d_t \\
b_t &= \phi b_{t-1} + \beta d_t \\
d_t &= \sum_{i=1}^{p} \varphi_i d_i + \sum_{i=1}^{q} \theta_i e_{t-1} + e_t
\end{aligned}
\tag{1}
$$

Where

$y_t^{(\lambda)}$: Time series at moment t (Box-Cox transformed)

$S_t^{(i)}$: Seasonal component

l_t : Local level

b_t : Trend with damping

d_t : ARMA (p, q) process for residuals

e_t : Gaussian white noise

Table 1. The percentage of coincidence between prediction intervals and the eight forecasting

| TBATS Model	Daily interval for used data	Forecasting period	Prediction intervals	
			80 %	95 %
1	02/03 - 08/03/2020	09/03 - 15/03/2020	0,14 %	14,29 %
2	02/03 - 15/03/2020	16/03 - 22/03/2020	100 %	100 %
3	02/03 - 22/03/2020	23/03 - 29/03/2020	0 %	28,57 %
4	02/03 - 29/03/2020	30/03 - 05/04/2020	57, 14 %	100 %
5	02/03 - 05/04/2020	06/04 - 12/04/2020	100 %	100 %
6	02/03 - 12/04/2020	13/04 - 19/04/2020	57, 14 %	100 %
7	02/03 - 19/04/2020	20/04 - 26/04/2020	100 %	100 %
8	02/03 - 26/04/2020	27/04 - 03/05/2020		
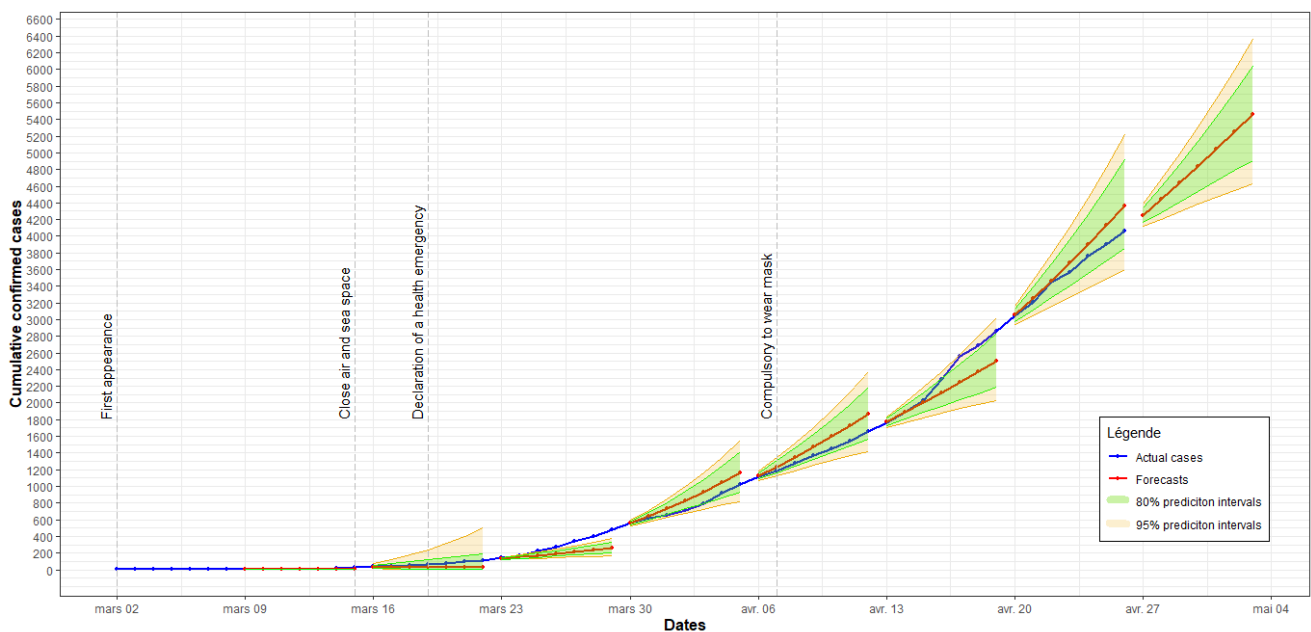
Figure 2. Cumulative actual confirmed cases of COVID-19 in Morocco, together with forecast and prediction intervals produced over several origins

In this study we use the TABAS model to produce seven-days-ahead point forecasts and prediction intervals and update our forecasts.

RESULTS

Since the appearance of this epidemic in Morocco, we have built the TBATS model to predict the number of confirmed cases each Sunday. The prediction interval presented in **Table 1** has been computed to check the performances for the eight forecasting. A prediction interval is an estimate of an interval in which a future observation will fall, with a certain probability, given what has already been observed.

In this paper we calculate two predictions intervals 95% and 80%. For the 95% interval we find just two periods when the prediction comes out of this interval (Models 1 and 3). But for 80% we find four periods (Models 1, 3, 4 and 6). Predictions were done with 100 % in 80 % interval for the model 2, 5 and 7 (**Table 1**).

We decided to use a TBATS smoothing model. We first started at the March 02, 2020 and only had seven actual data points in hand. The forecasts produced at all periods, 80 % and 90% prediction intervals are presented in **Figure 2**. In this figure, we have put the key actions that the government of Morocco under the leadership of King Mohammed 6 have been taken to reduce and control this epidemic.

From the results obtained we can conclude that the predictions obtained are close to reality and for the peak of this epidemic is not yet identified. The obtained results shows that this epidemics will continue to grow. For our forecast from 04/27/2020 to 05/03/2020 we estimate that the number of affected cases will achieve 4367 cases.

To analyze and discuss the results we present in **Figure 3** a zoom on the eight prediction periods with their intervals.
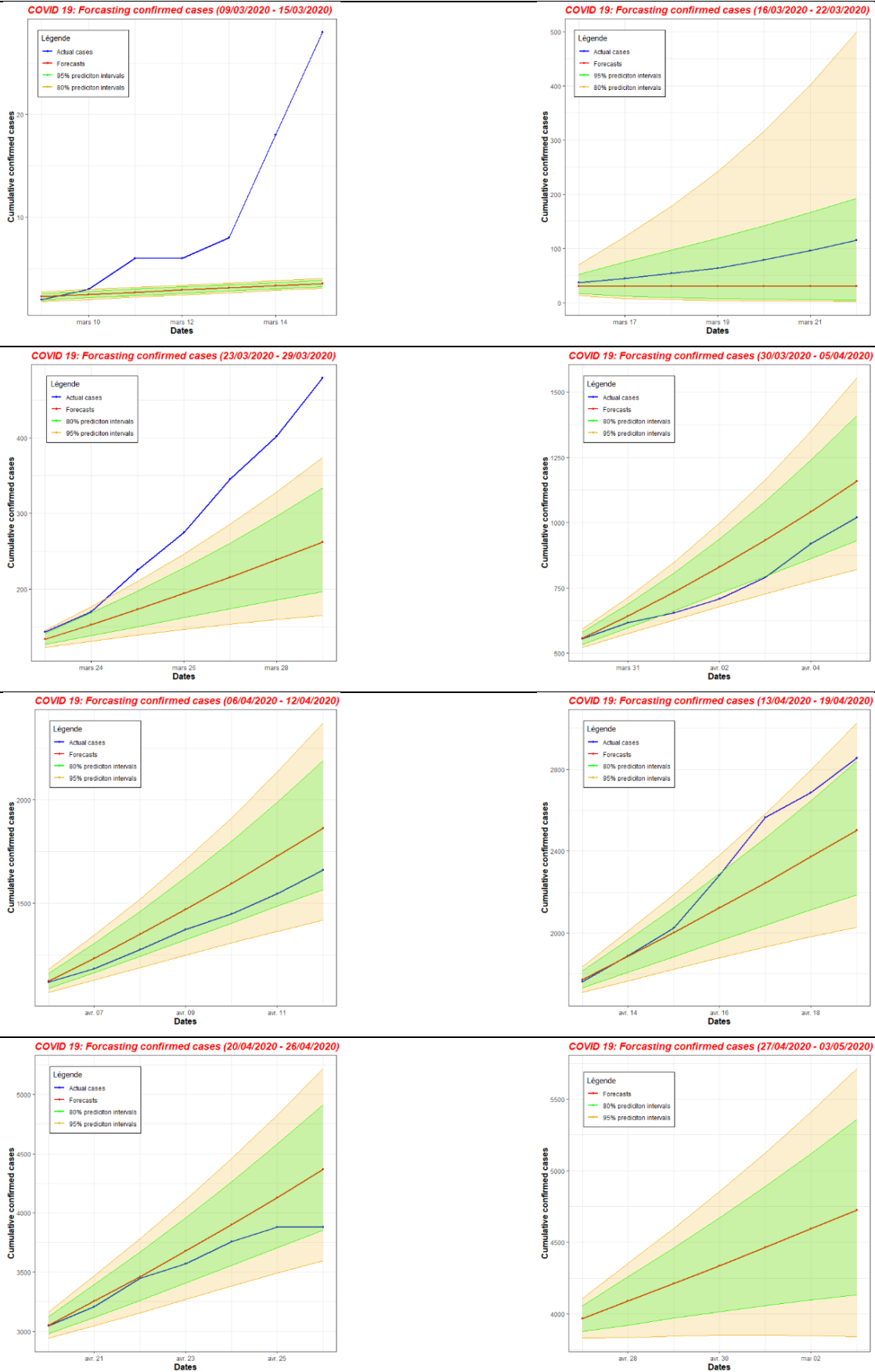
Figure 3. A zoom on the eight results for forecasting confirmed cases of COVID-19 in Morocco (Between March, 02 and April, 26 2020)

DISCUSSION AND CONCLUSION

After the appearance of the first case of COVID-19 in Morocco on March 02, 2020. The Moroccan government has faced various challenges. In one part, find the actions that need to be taken to control and reduce the rapid spread of COVID-19. In other part, the difficult task to aware people about the critic situation [11].

When we look at the evolution of the infected cases in Morocco we notice that the actions taken are not random but are made in good moments. According to the Moroccan authorities, the passage from one stage to another of an epidemic starts from a field observation. And this evolution changes the level of health alert and the strategy to follow. Despite the measures taken, Morocco has declared the transition to stage 2, where the country begins to develop local cases arising from cases of transmission in the family, factories and some administrations.

To date, there is no effective vaccine against the COVID-19, but researchers have proposed several remedies that can be effective for the treatment of infected patients:

- BCG: is a tuberculosis vaccine and given its known impact on the reduction of respiratory viral infections, its use during the COVID-19 pandemic could prove to be beneficial [12];

- Convalescent plasma: is effective method which is based on administration of antibodies against a given agent to a susceptible individual for the purpose of preventing or treating the COVID-19 [13,14];

- Drugs : Several drugs are tested for their potential activity against COVID-19 such as Chloroquine / Hydroxychloroquine, Lopinavir-Ritonavir, Remdesivir, Tocilizumab and Camostat Mesilate [15].

Despite the fact that treatment with Chloroquine / Hydroxychloroquine has undesirable cardiovascular effects: Conduction abnormalities, Long QT / Torsades de pointes, and Cardiomyopathy [16]. Morocco has adopted this solution in its treatment protocol and has generalized this treatment without waiting for test results [11].

When looking at the forecast results obtained by our TBATS method **Figures 2** and **3**, we notice that the observed cases follow the forecast in most weeks except the first and third week. For the first week this is justified by the appearance of cases from abroad. After the border closure and the application of containment the curve will become correlated with our predictions. But during the third week another deviation is observed. During this week we have gone from 28 to 143 cases. After this evolution the government of Morocco decided to implement the action of the obligation of masks. What justifies the deviation during the third week is the development of local cases and the end of the incubation period which is defined by the WHO at 14 days [17].

The statistical technique used in this study shows that they can contribute in the prediction of COVID-19 infected cases in Morocco. During this epidemic several researchers have tried to predict the future using mathematical model [17-23]. But unfortunately to have more precision this type of prediction requires a lot of historical data.

In the fight against COVID-19, in addition to forecasting techniques, new technology, data science and artificial intelligence can help curb this epidemic. During this period, several innovations have emerged around the world: (1) Doctors and police robots [24]; (2) Mobile application that tracks virus carriers [25]; (3) Thermal cameras [25]; (4) Application delivering a color QR code indicating the level of risk assumed by the person [25]; (5) Chatbots to share information [25]; (6) Drones to disinfect the streets and bring medication [26].

It is possible to limit the spread of this serious disease, with the cooperation of all the citizens in respect of the measures of containment and individual protection [11], but also with cooperation between all countries. To succeed in this cooperation, it is necessary to share data and results of studies between all countries in real time. In our opinion, what is blocking studies and research to deal with this epidemic is that the available data are limited and cooperation with countries which have already overcome this virus is not sufficient

In conclusion, we want to signal that at the moment of writing this article the origin of COVID-19 and its treatment are not yet known, that's why it is advisable to carry out urgent research in the following areas: (1) what exactly is the composition of COVID-19? (2) Is there only one type of COVID-19 or does it depending on the human person? (3) Does heat slowly down the development of COVID-19 and its spread? (4) What are the after-effects that can occur once the patient is cured of the COVID-19? (5) Can the virus be carried by air or animals?

REFERENCES

1. WHO. Statement on the second meeting of the International Health Regulations (2005) Emergency Committee regarding the outbreak of novel coronavirus (2019-nCoV) [Internet]. 2020 Jan [cited 2020 Apr 28]. Available at: https://www.who.int/news-room/detail/30-01-2020-statement-on-the-second-meeting-of-the-international-health-regulations-(2005)-emergency-committee-regarding-the-outbreak-of-novel-coronavirus-(2019-ncov)

2. WHO. COVID-19 situation reports - 97 [Internet]. 2020 Apr [cited 2020 Apr 26]. Available at: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports

3. Riou J, Althaus CL. Pattern of early human-to-human transmission of Wuhan 2019 novel coronavirus (2019-nCoV), December 2019 to January 2020. Eurosurveillance. 2020; 25(4). doi: 10.2807/1560-7917.ES.2020.25.4.2000058.

4. Xu J, Zhao S, Teng T, Abdalla AE, Zhu W, Xie L, et al. Systematic Comparison of Two Animal-to-Human Transmitted Human Coronaviruses: SARS-CoV-2 and SARS-CoV. Viruses. 2020; 12(2). doi: 10.3390/v12020244

5. Killerby ME, Biggs HM, Midgley CM, Gerber SI, Watson JT. Middle East Respiratory Syndrome Coronavirus Transmission - Volume 26, Number 2—February 2020 - Emerging Infectious Diseases journal - CDC. 2020. doi: 10.3201/eid2602.190697

6. Shereen MA, Khan S, Kazmi A, Bashir N, Siddique R. COVID-19 infection: Origin, transmission, and characteristics of human coronaviruses. J Adv Res. 2020; 24: 91-8. doi: 10.1016/j.jare.2020.03.005.

7. Decaro N, Lorusso A. Novel human coronavirus (SARS-CoV-2): A lesson from animal coronaviruses. Vet Microbiol. 2020; 244: 108693. doi: 10.1016/j.vetmic.2020.108693.

8. Li H, Mendelsohn E, Zong C, Zhang W, Hagan E, Wang N, et al. Human-animal interactions and bat coronavirus spillover potential among rural residents in Southern China. Biosaf Health. 2019; 1(2): 84-90. doi: 10.1016/j.bsheal.2019.10.004.

9. Brożyna J, Mentel G, Szetela B, Strielkowski W. Multi-Seasonality in the TBATS Model Using Demand for Electric Energy as a Case Study. 2018. doi: 10.24818/18423264/52.1.18.14

10. De Livera AM, Hyndman RJ, Snyder RD. Forecasting Time Series With Complex Seasonal Patterns Using Exponential Smoothing. J Am Stat Assoc. 2011; 106(496): 1513-27. doi: 10.1198/jasa.2011.tm09771.

11. Addi RA, Benksim A, Amine M, Cherkaoui M. COVID-19 Outbreak and Perspective in Morocco. Electron J Gen Med. 2020; 17(4): 1-2. doi: 10.29333/ejgm/7857.

12. Sharquie IK. BCG is a Good Immunotherapeutic Agent for Viral and Autoimmune Diseases: Is it a New Weapon against Coronavirus (COVID-19)? Electron J Gen Med. 2020; 17(6): 229. doi: 10.29333/ejgm/7892.

13. Roback JD, Guarner J. Convalescent Plasma to Treat COVID-19: Possibilities and Challenges. JAMA. 2020; 323(16): 1561-2. doi: 10.1001/jama.2020.4940.

14. Hachim SK. The Convalescent Serum for Treatment of COVID-19 Infection: Review. Eur J Med Educ Technol. 2020; 13(1): 2005. doi: 10.30935/ejmets/8016.

15. Aljofan M, Gaipov A. COVID-19 Treatment: The Race Against Time. Electron J Gen Med. 2020; 17(6): 227. doi: 10.29333/ejgm/7890.

16. Dakhil ZA, Farhan HA. Cardiovascular Impacts of COVID-19 Pandemic: From Presentation to Management: Current and Future Perspectives. J Clin Exp Investig. 2020; 11(3): 739. doi: 10.5799/jcei/7941.

17. Chintalapudi N, Battineni G, Amenta F. COVID-19 virus outbreak forecasting of registered and recovered cases after sixty day lockdown in Italy: A data driven model approach. J Microbiol Immunol Infect. 2020. doi: 10.1016/j.jmii.2020.04.004

18. Perc M, Gorišek Miksić N, Slavinec M, Stožer A. Forecasting COVID-19. Front Phys. 2020; 8. doi: 10.3389/fphy.2020.00127

19. Petropoulos F, Makridakis S. Forecasting the novel coronavirus COVID-19. PLOS ONE. 2020; 15(3): e0231236. doi: 10.1371/journal.pone.0231236.

20. Wu JT, Leung K, Leung GM. Nowcasting and forecasting the potential domestic and international spread of the 2019-nCoV outbreak originating in Wuhan, China: a modelling study. The Lancet. 2020; 395(10225): 689-97. doi: 10.1016/S0140-6736(20)30260-9.

21. Zahiri A, Rafiee Nasab S, Roohi E. Prediction of Peak and Termination of Novel Coronavirus Covid-19 Epidemic in Iran. medRxiv. 2020;2020. 03.29. 20046532. doi: 10.1101/2020.03.29.20046532.

22. Chakraborty T, Ghosh I. Real-time forecasts and risk assessment of novel coronavirus (COVID-19) cases: A data-driven analysis. 2020. doi: 10.13140/RG.2.2.20428.36489

23. Al Hasan SM, Saulam J, Kanda K, Hirao T. The novel coronavirus disease (COVID-19) outbreak trends in mainland China: a joinpoint regression analysis of the outbreak data from January 10 to February 11, 2020. nCoV; 2020. doi: 10.2471/BLT.20.253153

24. Yang G-Z, Nelson BJ, Murphy RR, Choset H, Christensen H, Collins SH, et al. Combating COVID-19—The role of robotics in managing public health and infectious diseases. Sci Robot. 2020 Mar;5(40). doi: 10.1126/scirobotics.abb5589

25. Kohler K, Scharte B. L'intégration de l'IA dans la protection de la population. Polit Sécurité Anal CSS. 2020 [cited 2020 Apr 30].; 260. Available at: https://www.research-collection.ethz.ch/handle/20.500.11850/408270

26. Estrada R, Arturo M. The Uses of Drones in Case of Massive Epidemics Contagious Diseases Relief Humanitarian Aid: Wuhan-COVID-19 Crisis. Rochester, NY: Social Science Research Network; 2020. doi: 10.2139/ssrn.3546547