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Big data in COVID-19 prevention and control: Modeling and analysis report

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Abstract. The COVID-19 epidemic has brought great external impact to China. China is facing complex internal and external environmental challenges. SIR epidemic model is a classical partition model, which is widely used to predict the progress of COVID-19. Although the SIR model may be useful in simulating multiple epidemics, it may not be sufficient to describe the spread of COVID-19. Therefore, some modifications were made and used to study the spread and control of COVID-19 epidemic on the SIR model of COVID-19 disease. Expand it by increasing the link between tracking and other interventions. By studying the SEIR model considering the interaction between human and infectious source. In this paper, we will use the classical SIR model to simulate and predict the spread of COVID-19. By distinguishing between confirmed and undiagnosed individuals, the development of COVID-19 is characterized by phased changes. Based on the preliminary data analysis of the epidemic on various industries, the actual impact of the epidemic on society was quantitatively analyzed.

Keywords: COVID-19, SEIR Model, Simulation of Simulation, Trend Analysis, Modeling and Analysis.

1. Introduction

1.1. Research significance

COVID-19 is an acute respiratory disease caused by SARS-COV-2 virus infection. With the rapid spread of the virus to other countries and continents, on March 11, 2020, the World Health Organization classified COVID-19 as a large-scale epidemic. In terms of mortality and infection rate, COVID-19 is considered to be the most serious epidemic since the beginning of the 20th century.

Although COVID-19 pneumonia is still in the development stage in the world, its impact on development cannot be accurately assessed due to uncertain factors such as actual duration and control effect. Modeling and analysis in an uncertain environment has laid the foundation for the introduction of policy conditions for epidemic prevention and control and recovery, which is conducive to responding to the epidemic [1]. This is the practical value of learning and thinking.

1.2. Research content

The research on the identification of environmental factors, the division of level and the measurement of impact degree in the process of epidemic situation provides valuable ideas for this paper. This paper will make a preliminary analysis and modeling analysis on the basic trend of COVID-19 pneumonia

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[2]. Common infectious disease models are divided into SI, SIR, SIRS, SEIR and other models according to the types of infectious diseases. They are used to study the transmission speed, spatial range, transmission path and dynamic mechanism of infectious diseases, so as to guide the effective prevention and control of infectious diseases. Prevention and control. SEIR (Susceptible Exposed Infected Recovered) model is a classical model for the dynamic study of COVID-19.

At present, there are many studies on COVID-19 based on Sir and SEIR models. The scoring order is nonlocal, which is more suitable for describing mathematical models with complex fluid memory and genetic characteristics and the thermal conductivity of elastomers [3]. The use of fractional microcomponent modeling in various physical processes can significantly improve the modeling performance of multiple processes [4]. In this paper, the SEIR model is further analyzed and the improvement strategy is proposed.

2. Literature review

2.1. Severe situation of the development of COVID-19

COVID-19 not only seriously threatens people's lives, but also seriously hinders the development of human society [5]. Timely prediction and analysis of COVID-19 spreading trends are of great significance for the effective prevention and control and control of the epidemic. Scientific researchers often use mathematical models to derive COVID-19 non-spread conditions, predictive analysis of COVID-19 popular and infected trends. Based on this, the corresponding prevention and control measures are formulated [6]. The existing COVID-19 predicting model S model, the S model will eventually become infected with the extension of the time [7].

2.2. Blocking effect of prevention and control measures

The number of suspected cases of COVID-19 also declined, releasing positive signals for the stable control of the epidemic. In order to distinguish between infected and unintentional, the SI model was established. Only by adding new confirmed cases and suspected cases, can we gradually cure existing cases with more sufficient medical resources and reduce the epidemic until they disappear [8]. For the cure without immune ability, it may be infected again, and the SIS model is mostly used [9]. With the continuous optimization and improvement of medical care programs, and the prevention and control intervention measures adopted by localities, the prevention and control measures have given full play to the blocking role in the end of the epidemic. With the rapid spread of the global epidemic, while obtaining the results of the epidemic prevention and control, it is also facing huge investment pressure and risk.

For the healing person, the immune ability is no longer infected, and the classic SIR model is mostly adopted. The classic SIR model structure is simple and operable, and it is suitable for describing the overall trend of disease development, which is widely used. The goal of fully controlling COVID-19 pneumonia is still very arduous [10]. Therefore, while continuing to strengthen and consolidate the effectiveness of preventing and control, analyze the impact of the epidemic on society and the state and policy orientation after the outbreak, which is very important to minimize the social panic and impact brought by the epidemic situation [11]. In response to the propagation status of COVID-19, consider the dead factors, improve the classic SIR model, derive the conditions that the COVID-19 outbreak is not spread, and use the improved SIR model to predict the COVID-19.

2.3. Prediction and analysis model

The SI model did not consider the factors of the healing, and the prediction results did not meet the actual situation. On the basis of the SIR model, an unfinished infection is added, which is the same as the SEIR model. The model will be subdivided as curers and dead, so as to further analyze the trend of changes in the number of healing and death [12]. In addition, considering the excessive fitting phenomenon in the practice of data fitting, and the actual development process of the epidemic situation is divided into multiple stages, each stage of trend special sign is different [13]. Therefore, the pre-stage division is divided, and the epidemic data is then combined in stages to improve the accuracy of the analysis results.

Combining the classification and prevention and control measures of the SIR model with the growth of the epidemic growth, based on the real COVID-19 epidemic data, realized the analysis of the trend of the epidemic, the identification of the key epidemic area, the division of the epidemic stage, and prevention and control measures. The fitting method in stages can more accurately portray the changes in the epidemic data over time, and logically more in line with objective facts [14]. The analysis method is also applicable to other countries or regions, which can provide greater reference and guiding value for the prevention and control of COVID-19 epidemic prevention and control.

This article is given a score-order SIR model to predict the spread of COVID-19 diseases [15]. The text studies the impact of the scores of the model derivative on the dynamic characteristics of the model proposed. When building a modulus for COVID-19 transmission, the parameters of the model are estimated while using the genetic algorithm [16]. This model has some limitations, and the prediction of the model does not represent real data. In this case, the time-changing parameters of score-order SIR models or more complex epidemic models need to be used [17]. Nevertheless, the study shows that the model proposed is effective and may be useful for future epidemic diseases [18].

3. SEIR model

With the strict epidemic prevention measures, the overall COVID-19 has been basically suppressed. After that, although sporadic outbreaks occurred in some areas, they were quickly controlled, which benefited from the early prevention and control of the epidemic [19]. Therefore, taking effective prevention and control measures in the early stage of the outbreak plays an important role in the prevention and control of COVID-19. It is of great theoretical and practical significance to accurately predict the outbreak and decline of the epidemic and quantitatively analyze the effect of prevention and control measures, so as to study and judge the development trend of epidemic spread, scientifically implement epidemic prevention and control, and actively and steadily resume daily work and life.

These studies are mainly based on the SEIR model, and according to the pathological characteristics and transmission characteristics of the COVID-19, various improvements are made to the model to make it more consistent with the actual situation, so as to predict the epidemic development trend more accurately [20] SEIR model considers the existence of four groups: susceptible, exposed, infected and recovered. It is suitable for infectious diseases with incubation period and lifelong immunity after cure. Susceptible persons (S) become latent after being infected (E), then become ill (I), and become rehabilitated after being cured (R).

This situation is more complex and closer to the actual situation [21]. First, several important parameters of S, E, I and R are introduced:

1. S: susceptable, refers to those who do not have disease, but lack immune ability, and are vulnerable to infection after contacting infected people; In the video, if the population of a certain area is 10000, then s=n-i=9999 on the first day

2. E: exposed refers to the person who has contacted the infected person but is temporarily unable to infect others, which is applicable to infectious diseases with long incubation period; In this example, the first day is 0.

3. I: infected, refers to the infected person, which can be transmitted to class s members and become class E or class I members; In this example, the first day is 1.

4. R: recovered, refers to the person who is isolated or has immunity due to illness recovery. If the immune period is limited, members of class R can change into class s again. In this example, the first day is 0.

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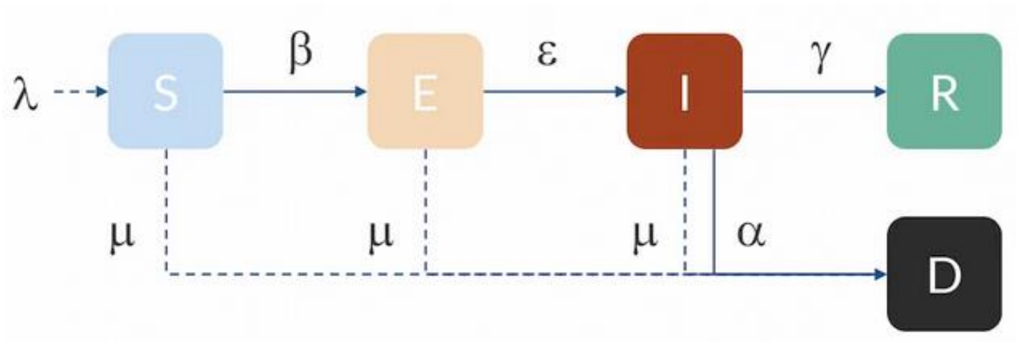

Figure 1. SEIR model.

Next, For the parameter R, β, γ, α:

1. R: number of susceptible people contacted by infected patients (I) every day, this case is 20
2. β: Infection coefficient; Determined by the transmission ability of the disease itself and the prevention and control ability of the population, this example is set to 0.03
3. γ: Coefficient of restitution; Generally, it is the reciprocal of the course of disease. For example, if the course of influenza is 5 days, then its γ It is 1/5. In this example, it is set to 0.1
4. α: Incidence probability of lurks; Generally, it is the reciprocal of the incubation period. In this case, it is 0.1

For the flow chart and formula, ds/dt can be understood as the change of s when time t is infinitely close to 0. When t=1, ds/dt is the daily change of S, and the rest of de/dt, di/dt, and dr/dt are the same. Because s is close to N at the beginning, and then slowly infected into e, showing a downward change, the right side of the first formula is with a negative sign.

How much s is reduced by the number of people exposed to the disease every day (R) and the infection coefficient(β), It is determined by the proportion of the number of patients (i/n), the proportion of susceptible people (s/n), and the total number of people (n), so ds/dt=-r* β * S/N*I/N*N=-r β SI/N。 Then the change amount of E per day, de/dt, is the number of s converted to e per day (R β Si/n) minus the number of e converted to I per day (R β SI/N- α E)。 The rest of di/dt and dr/dt are the same.

4. Improved SEIR model

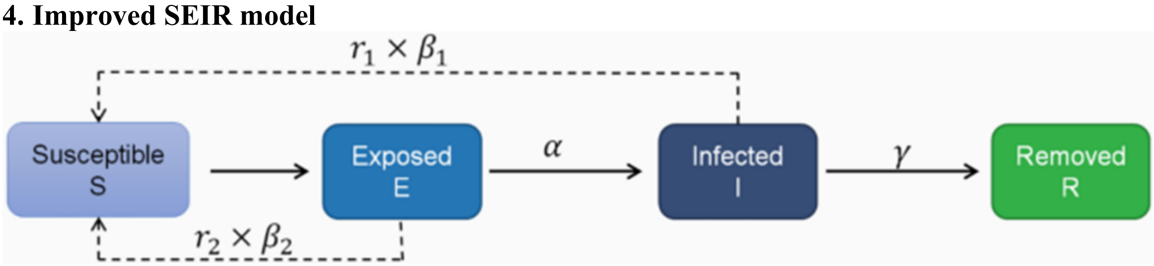

Figure 2. Improved SEIR model.

Analyzing and summarizing these papers based on SEIR model to study COVID-19, there are mainly three aspects: first, the improvement of SEIR model, second, the estimation of model parameters, and third, the prediction of epidemic spread and prevention and control measures [22]. This is also the basic path of infectious disease dynamics model for epidemic transmission research. This section mainly discusses the improvement of SEIR model.

The hypothesis of SEIR model is more complex than Si, SIS and SIR models, and it is more in line with the actual situation, so the model results are often closer to the actual data [23]. But even so, compared with the specific situation of specific infectious diseases and actual epidemic situations, the basic assumptions of SEIR model still have problems and deficiencies.

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Based on the SEIR model and considering new factors, we can improve the SEIR model by finding the specific situation of specific infectious diseases and actual epidemic situations. Generally speaking, the improvement of SEIR model mainly includes the following aspects:

4.1. Segmentation of population types

Compared with Si model, SIR model increases the number of rehabilitators (class R), and SEIR model increases the number of lurks (E). Similarly, combined with the characteristics of the spread and prevention and control of COVID-19, the population can and needs to be further subdivided [24]. The number of daily contacts and the number of contacts during the infection period can be significantly reduced by early detection of patients and latent persons who have not been infected and isolation of them. Therefore, whether the latent person is in the isolation state after detection or the normal activity state without detection has an essential difference in the impact on the spread of the epidemic, so "undiscovered" can be introduced into the SEIR model.

As long as we carefully analyze the characteristics of the pathogenesis of COVID-19, and analyze the characteristics of the investigated regions and stages, we can find the characteristic population different from SEIR, and then propose a new sub population, so as to improve the SEIR model [25]. Some sub groups have little impact on the results, or it is difficult to find the dynamic relationship between the sub group and other groups, so it does not mean that the more the group points, the better.

4.2. Add a correction term to the differential equation

SEIR model is a one-way model, which simplifies practical problems and is convenient for analysis and solution. Considering the pathogenesis and transmission characteristics of the COVID-19 epidemic, we can conduct a more scientific and detailed study on the transmission characteristics among various populations [26]. In the SEIR model, it is obviously a major defect to consider only the infection after the contact between the susceptible and the sick, and it is necessary to consider the impact of the infection after the contact between the susceptible and the latent.

In the COVID-19, it is found that the cured patients have an immune period, not lifelong immunity, so it can increase the connection path of the convalescent to the susceptible [27]. Some lurks (exposed persons) found in the epidemic are not necessarily transformed into infected persons, but may also return to susceptible persons. Therefore, the connection path between lurks and susceptible persons can be increased. Zhong Nanshan's team paper is based on the SEIR model and the data of isolation and de isolation to increase the two-way conversion path between susceptible and latent [1].

The expression of differential equation is the reflection of the dynamic relationship between all kinds of people, and it is the mathematical description of the interconnection and transformation characteristics of all kinds of people in the warehouse model [28]. Based on the improved model, a new transformation relationship between all kinds of people is proposed, which is to add a correction term to the differential equation expression to describe the dynamic relationship between the two compartments. This case will be analyzed in detail later.

4.3. Supplement or modify the original assumptions

The basic assumptions of the model are the abstraction and simplification of practical problems. As for whether simplification is reasonable, it is a matter of different opinions. Generally speaking, classical models and basic models are abstractions of general problems. Considering the characteristics of specific practical problems, they are not reasonable and perfect, so they can be supplemented or modified [29]. Combining the big data of traffic flow and considering the impact of people migration is an important part of the study of epidemic transmission. In SEIR model, the daily contact number, daily incidence rate and daily cure rate are set as constants [30]. Considering the specific situation of COVID-19, these parameters can be segmented (different populations, different stages), time-varying or some kind of function.

Some of the improvements to the SEIR model for COVID-19 are very important and have a significant impact on the results, such as the infectivity of the incubation period, the isolation of close contacts, and the impact of personnel mobility; Some will not have much impact, but make the model more complex [31]. It can only be said that it is also an exploration and attempt. From the perspective of mathematical modeling and mathematical modeling competition, as long as we observe and think carefully, we can more subdivide the crowd, give a mathematical description of a certain communication characteristic, and then put forward our own "improved SEIR model".

5. Experiment

5.1. Data set of COVID-19 cases

According to the data released by the World Health Organization, as of May 27, 2020, the number of confirmed cases of COVID-19 globally has reached 5.48 million, and the countries with more than 100000 confirmed cases [32]. With the increasing number of COVID-19 cases worldwide, the temporal and spatial transmission process of the epidemic has become more and more complex. The traditional research on the transmission process is mainly to study the overall laws or trends of infectious disease transmission from a macro perspective [33].

The data of COVID-19 cases were obtained from the Johns Hopkins University database. COVID-19 usually follows a similar growth pattern. The following update date is 11 March 2020, showing the number of days since the country reported more than 200 cases. The United States lags behind Italy by 7-10 days [34]. According to the different situations of various countries in the world, it is very important to analyze the current situation and the impact of prevention and control measures. The prototype system is constructed by graphic database and verified by experiments [35]. Through the activity map of COVID-19 cases, the transmission process reasoning, key node analysis and activity track tracking were verified. This method is more effective and feasible.

5.2. Simulation of SEIR improved model

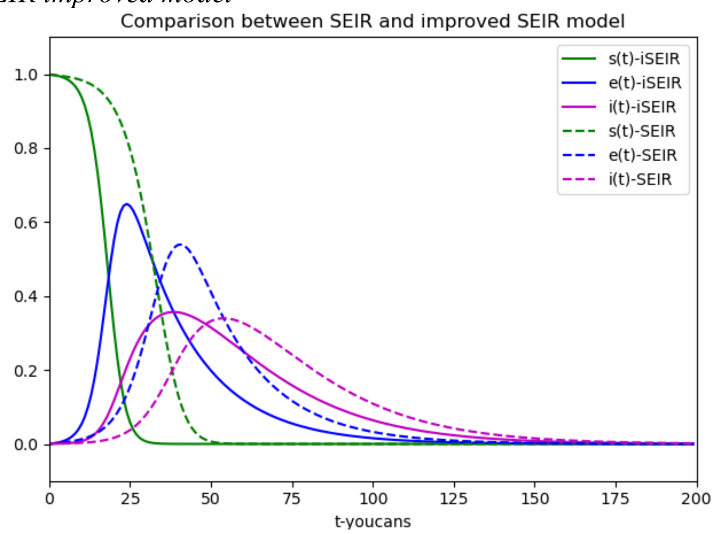

Figure 3. Comparison of the results of the improved SEIR model and the SEIR model.

The figure is a comparison of the results of the improved SEIR model and the SEIR model. The solid line in the figure is the improved SEIR model, and the dotted line is the SEIR model. Different colors represent the proportion of susceptible s(t), the proportion of latent e(t) and the proportion of sick i(t).

In the figure, the peak values of the latent ratio e(t) and the sick ratio i(t) in the improved SEIR model are earlier and stronger than those in the SEIR model, and the susceptible ratio S(t) decreases faster, but eventually both tend to stabilize [36]. This is because the SEIR improved model assumes that the number of daily contacts of lurks in the incubation period is equivalent to increasing the number of daily contacts on the whole. Therefore, the result of SEIR improved model is similar to that of increasing daily exposure rate in SEIR model.

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5.3. Result and discussion

5.3.1. Impact of isolation measures on patients. If the daily exposure rate in SEIR model is increased, a similar result can be obtained. From another point of view, if the actual epidemic data is used to fit the model parameters, the SEIR model can also achieve a good fit, but the estimated daily exposure rate parameters reflect the impact of the daily exposure number of lurks.

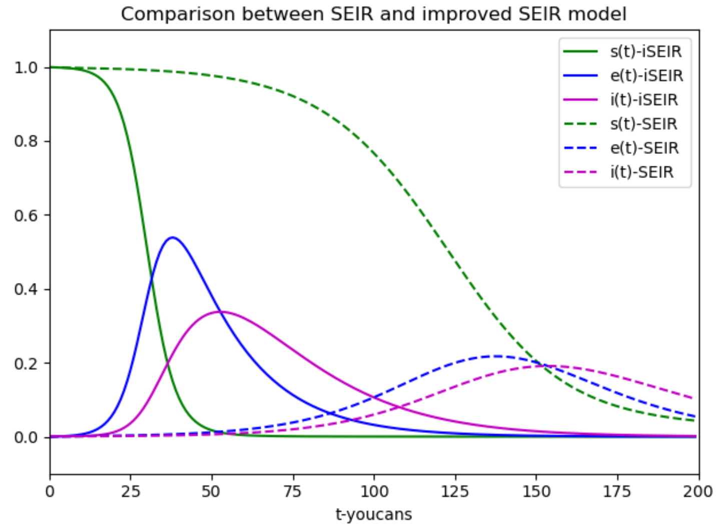

Figure 4. Increased daily exposure rate in SEIR model.

However, if the prevention and control measures of isolating the sick are considered, the situation will change greatly. Assuming that the sick are effectively isolated - this is the most basic and common infectious disease prevention and control measures, so that the daily contact rate of the sick is reduced to 20% when not isolated, while the daily contact number of the latent in the incubation period remains unchanged.

5.3.2. Impact of isolation measures on lurks. Compare the following three situations: (1) no prevention and control measures are taken; (2) Isolation measures were taken for the sick, but no isolation measures were taken for the latent; (3) Isolation measures shall be taken for the sick and the latent.

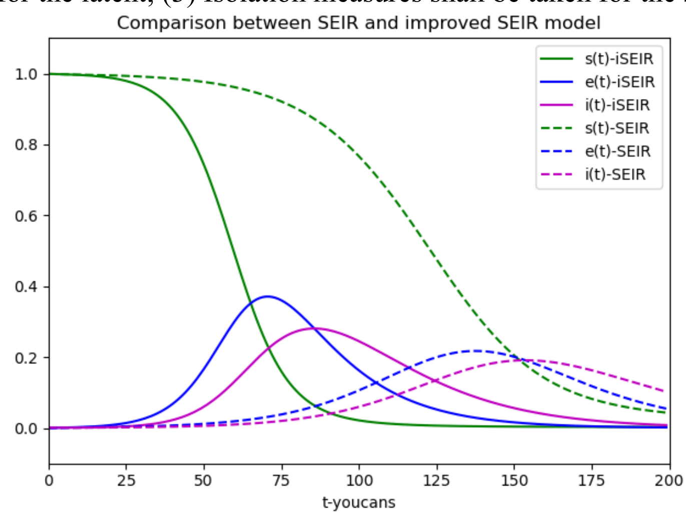

Figure 5. Impact of isolation measures on lurks.

The above figure is the simulation results of epidemic spread in three cases using the improved SEIR model considering the infectivity in the incubation period. The solid line, dotted line and dotted line in the figure represent the first, second and third cases respectively, and different colors represent the proportions of susceptible, latent and sick people respectively.

As analyzed above, the isolation measures taken for the sick reduce the daily contact number of the sick, and the epidemic situation is less than that of the uninsulated sick [37]. The start time and peak time of the peak of the ratio of the latent and the sick are postponed, and the peak height is reduced, but the epidemic situation is still very serious.

6. Conclusions

Considering the death factors of COVID-19, we improved the classical SEIR model, used the data of COVID-19 as the initial value, and used the improved model equation to predict the spread of COVID-19 using the excretion of COVID-19, so as to obtain the following main conclusions:

1) The maximum value of infected persons was predicted in the case of the maximum value of daily exposure rate and maximum value and the limit of cure and death ratio. The number of infected persons was calculated according to different daily exposure rates and compared with the actual data. Therefore, the isolation method can effectively reduce the daily contact rate.

2) COVID-19 conditions that do not spread epidemic emotional conditions were included. Using this part, COVID-19 virus will not spread under the condition of cure rate and mortality. It is concluded that reducing the daily exposure rate is the most effective measure to prevent and control the epidemic. Improve people's immunity through toilet, ventilation and exercise, so as to effectively reduce daily contact and daily contact rate.

3) In the early stage of the outbreak of COVID-19, an improved SIR model was used for prediction and analysis, which provided a useful reference for formulating epidemic prevention and control measures. Therefore, the improved SEIR model is relatively ideal and needs further improvement in the future.

References

[1] Gupta, R., Pandey, G., Chaudhary, P., & Pal, S. K. (2020). Machine learning models for government to predict COVID-19 outbreak. Digital Government: Research and Practice, 1(4), 1-6.

[2] Huang, R., Liu, M., & Ding, Y. (2020). Spatial-temporal distribution of COVID-19 in China and its prediction: A data-driven modeling analysis. The Journal of Infection in Developing Countries, 14(03), 246-253.

[3] Ding, Y., & Gao, L. (2020). An evaluation of COVID-19 in Italy: A data-driven modeling analysis. Infectious Disease Modelling, 5, 495-501.

[4] Annas, S., Pratama, M. I., Rifandi, M., Sanusi, W., & Side, S. (2020). Stability analysis and numerical simulation of SEIR model for pandemic COVID-19 spread in Indonesia. Chaos, Solitons & Fractals, 139, 110072.

[5] Ardabili, S. F., Mosavi, A., Ghamisi, P., Ferdinand, F., Varkonyi-Koczy, A. R., Reuter, U., ... & Atkinson, P. M. (2020). COVID-19 outbreak prediction with machine learning. Algorithms, 13(10), 249.

[6] Roda, W. C., Varughese, M. B., Han, D., & Li, M. Y. (2020). Why is it difficult to accurately predict the COVID-19 epidemic?. Infectious disease modelling, 5, 271-281.

[7] Shankar, S., Mohakuda, S. S., Kumar, A., Nazneen, P. S., Yadav, A. K., Chatterjee, K., & Chatterjee, K. (2021). Systematic review of predictive mathematical models of COVID-19 epidemic. Medical journal armed forces India, 77, S385-S392.

[8] Song, J., Xie, H., Gao, B., Zhong, Y., Gu, C., & Choi, K. S. (2021). Maximum likelihood-based extended Kalman filter for COVID-19 prediction. Chaos, Solitons & Fractals, 146, 110922.

[9] Abuhasel, K. A., Khadr, M., & Alquraish, M. M. (2022). Analyzing and forecasting COVID-19 pandemic in the Kingdom of Saudi Arabia using ARIMA and SIR models. Computational intelligence, 38(3), 770-783.

[10] Santosh, K. C. (2020). COVID-19 prediction models and unexploited data. Journal of medical

systems, 44(9), 1-4.
[11] Mohamadou, Y., Halidou, A., & Kapen, P. T. (2020). A review of mathematical modeling, artificial intelligence and datasets used in the study, prediction and management of COVID-19. Applied Intelligence, 50(11), 3913-3925.
[12] Yang, Z., Zeng, Z., Wang, K., Wong, S. S., Liang, W., Zanin, M., ... & He, J. (2020). Modified SEIR and AI prediction of the epidemics trend of COVID-19 in China under public health interventions. Journal of thoracic disease, 12(3), 165.
[13] Karaçuha, E., Önal, N. Ö., Ergün, E., Tabatadze, V., Alkaş, H., Karaçuha, K., ... & Nu, N. V. N. (2020). Modeling and prediction of the COVID-19 cases with deep assessment methodology and fractional Calculus. Ieee Access, 8, 164012-164034.
[14] Chen, L. P., Zhang, Q., Yi, G. Y., & He, W. (2021). Model-based forecasting for Canadian COVID-19 data. PLoS One, 16(1), e0244536.
[15] Ma, C., Li, X., Zhao, Z., Liu, F., Zhang, K., Wu, A., & Nie, X. (2022). Understanding the dynamics of pandemic models to support predictions of COVID-19 transmission: Parameter sensitivity analysis of the SIR-type model. IEEE Journal of Biomedical and Health Informatics.
[16] Zareie, B., Roshani, A., Mansournia, M. A., Rasouli, M. A., & Moradi, G. (2020). A model for COVID-19 prediction in Iran based on China parameters. MedRxiv.
[17] Weissman, G. E., Crane-Droesch, A., Chivers, C., Luong, T., Hanish, A., Levy, M. Z., ... & Halpern, S. D. (2020). Locally informed simulation to predict hospital capacity needs during the COVID-19 pandemic. Annals of internal medicine, 173(1), 21-28.
[18] Tan, S. X., & Chen, L. (2020). Real-time differential epidemic analysis and prediction for COVID-19 pandemic. arXiv preprint arXiv:2004.06888.
[19] He, S., Peng, Y., & Sun, K. (2020). SEIR modeling of the COVID-19 and its dynamics. Nonlinear dynamics, 101(3), 1667-1680.
[20] Cooper, I., Mondal, A., & Antonopoulos, C. G. (2020). A SIR model assumption for the spread of COVID-19 in different communities. Chaos, Solitons & Fractals, 139, 110057.
[21] Ghostine, R., Gharamti, M., Hassrouny, S., & Hoteit, I. (2021). An extended SEIR model with vaccination for forecasting the COVID-19 pandemic in Saudi Arabia using an ensemble Kalman filter. Mathematics, 9(6), 636.
[22] Moein, S., Nickaeen, N., Roointan, A., Borhani, N., Heidary, Z., Javanmard, S. H., ... & Gheisari, Y. (2021). Inefficiency of SIR models in forecasting COVID-19 epidemic: a case study of Isfahan. Scientific reports, 11(1), 1-9.
[23] Singh, P., & Gupta, A. (2022). Generalized SIR (GSIR) epidemic model: An improved framework for the predictive monitoring of COVID-19 pandemic. ISA transactions, 124, 31-40.
[24] Kotwal, A., Yadav, A. K., Yadav, J., Kotwal, J., & Khune, S. (2020). Predictive models of COVID-19 in India: a rapid review. Medical journal armed forces India, 76(4), 377-386.
[25] Kozioł, K., Stanisławski, R., & Bialic, G. (2020). Fractional-order sir epidemic model for transmission prediction of COVID-19 disease. Applied Sciences, 10(23), 8316.
[26] Mustafa, S. K., Ahmad, M. A., Sotnik, S., Zeleniy, O., Lyashenko, V., & Alzahrani, O. (2020). Brief review of the mathematical models for analyzing and forecasting transmission of COVID-19.
[27] Shi, Y., Huang, R., & Cui, H. (2021). Prediction and analysis of tourist management strategy based on the SEIR model during the COVID-19 period. International Journal of Environmental Research and Public Health, 18(19), 10548.
[28] Ndiaye, B. M., Tendeng, L., & Seck, D. (2020). Comparative prediction of confirmed cases with COVID-19 pandemic by machine learning, deterministic and stochastic SIR models. arXiv preprint arXiv:2004.13489.
[29] Harjule, P., Tiwari, V., & Kumar, A. (2021). Mathematical models to predict COVID-19 outbreak: An interim review. Journal of Interdisciplinary Mathematics, 24(2), 259-284.

DOI: 10.54254/2755-2721/6/20230403

[30] Anirudh, A. J. I. D. M. (2020). Mathematical modeling and the transmission dynamics in predicting the COVID-19-What next in combating the pandemic. Infectious Disease Modelling, 5, 366-374.

[31] Bherwani, H., Gupta, A., Anjum, S., Anshul, A., & Kumar, R. (2020). Exploring dependence of COVID-19 on environmental factors and spread prediction in India. npj Climate and Atmospheric Science, 3(1), 1-13.

[32] Singhal, A., Singh, P., Lall, B., & Joshi, S. D. (2020). Modeling and prediction of COVID-19 pandemic using Gaussian mixture model. Chaos, Solitons & Fractals, 138, 110023.

[33] Kounchev, O., Simeonov, G., & Kuncheva, Z. (2020). The TVBG-SEIR spline model for analysis of COVID-19 spread, and a Tool for prediction scenarios. arXiv preprint arXiv:2004.11338.

[34] Piccolomini, E. L., & Zama, F. (2020). Preliminary analysis of COVID-19 spread in Italy with an adaptive SEIRD model. arXiv preprint arXiv:2003.09909.

[35] Waqas, M., Farooq, M., Ahmad, R., & Ahmad, A. (2020). Analysis and prediction of COVID-19 pandemic in Pakistan using time-dependent SIR model. arXiv preprint arXiv:2005.02353.

[36] Biswas, K., Khaleque, A., & Sen, P. (2020). COVID-19 spread: Reproduction of data and prediction using a SIR model on Euclidean network. arXiv preprint arXiv:2003.07063.

[37] Tutsoy, O., Çolak, Ş., Polat, A., & Balikci, K. (2020). A novel parametric model for the prediction and analysis of the COVID-19 casualties. Ieee Access, 8, 193898-193906.