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Solution of SEIRD Mathematical Model for the COVID-19 Transmission Using Microsoft Excel

at International Conference on Biospheric Harmony Advanced Research (ICOBAR) 2021

"Sustainable Innovation: Science and Technology to Foster and Empower the Society"



Archipelagic & Island States Forum



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Volume 2594 A

#### 3rd International Conference on Biospheric Harmony Advanced Research (ICOBAR) 2021

Jakarta, Indonesia • 24–25 June 2021 Editors • Christian Harito, Elicenai Sitepu and Noerlina

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![](_page_1_Picture_6.jpeg)

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### INTERNATIONAL CONFERENCE ON BIOSPHERIC HARMONY 2021

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## Preface: International Conference on Biospheric Harmony Advanced Research (ICOBAR) 2021

On behalf of Bina Nusantara University and the organizing committee of the ICOBAR, I am delighted to have the opportunity to share the accomplishment of our conference. Due to the extraordinary situation produced by COVID-19, our conference was prepared in a virtual format on 24th - 25th of June 2021, to best keep you physically safe while still profiting from the stimulating, intellectual developments that we have in store.

In ICOBAR 2021, the main theme of this conference is focused on "Sustainable Innovation: Science and Technology to Foster and Empower the Society". As we realized the continuous growth in research activities around the world, we would like to propose a movement to rethink the purpose of the research. Sustainable innovation means doing research that considers the sustainability factor such as environmental, social, financial aspects in their proposed technology, which is integrated from ideation to commercialization and its use in the society. Such innovation may be incremental, redesign, alternative, or even disruptive technology which help us to attain the same goal that we proposed in the first and second ICOBAR, "biospheric harmony".

This is the third ICOBAR series held by Bina Nusantara University since 2019. This year, the committee had received 492 submitted manuscripts. Through double-blind peer-review process, the committee carefully selected 202 research papers that were presented during the conference. There were 4 distinguished keynote speakers, 4 plenary sessions, and 5 parallel sessions (each parallel session consists of 8 sessions). The total number of participants were 315 from 8 different countries: Malaysia, Philippines, China, Singapore, France, Australia, Japan, and Indonesia. I believe that during those two days, we have all had insightful, interactive discussions and great chance to share the outcomes of our research.

I would like to thank our distinguished keynote speakers as well as CORIS (Cooperation Computer Research Inter University) and the Archipelagic & Islands States (AIS) as our sponsor. More than that, I also express my heartfelt thanks to the committee, reviewers, presenters, authors, and all people who have given their time and assistance to support this event.

I do hope that the ICOBAR 2021 is able to impact all of us to greatly foster and empower the society through science and technology from sustainable innovation. Through the discussion and knowledge sharing sessions, the conference brought positive contribution and impact to the academic society, policy makers and key stakeholders in our society. To conclude, thank you for the great contribution and looking forward to seeing you in the ICOBAR 2022.

See you again next year!

Jakarta, 25 June 2021 Christian Harito, S.T., Ph.D. Chair of the ICOBAR 2021

> 3rd International Conference on Biospheric Harmony Advanced Research (ICOBAR) 2021 AIP Conf. Proc. 2594, 010001-1-010001-1; https://doi.org/10.1063/12.0012823 Published by AIP Publishing. 978-0-7354-4420-1/530.00

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#### PRELIMINARY

Preface: International Conference on Biospheric Harmony Advanced Research (ICOBAR) 2021

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#### SUSTAINABLE INFRASTRUCTURE AND TRANSPORTATION

Seismic performance evaluation of steel structures designed using SNI 1726-2019 ₽

R. Suwondo; A. Nugraha; I. Hidayat
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Abstract ✓ View article DDF

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#### A. B. Putra

AIP Conf. Proc. 2594, 020002 (2023) https://doi.org/10.1063/5.0109740

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Structure behaviour of inclined column building to earthquake load based on SNI 1726-2019 ₽

#### I. Hidayat; R. R. Harland

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## Solution of SEIRD Mathematical Model for the COVID-19 Transmission Using Microsoft Excel

### D. P. W. Putra<sup>1</sup>, M. A. Rudhito<sup>1</sup>, D. Sudigyo<sup>2</sup>, T. Suparyanto<sup>2</sup> and B. Pardamean<sup>3, a)</sup>

<sup>1</sup> Department of Mathematics Education, Faculty of Teacher Training and Education, Sanata Dharma University, Yogyakarta, Indonesia 55281

<sup>2</sup> Bioinformatics & Data Science Research Center, Bina Nusantara University, Jakarta, Indonesia 11480

<sup>3</sup> Computer Science Department, BINUS Graduate Program - Master of Computer Science, Bina Nusantara

University, Jakarta, Indonesia 11480

<sup>*a*</sup>)Corresponding author: bpardamean@binus.edu

Abstract. Mathematical modeling in the epidemiology study can be applied to describe the current transmission of viruses, one of which is compartments. However, this simulation model is rigorous to understand, especially in interpreting the parameter values in influencing the solution. Therefore, it is necessary to present a coherent mathematical model solution. This study aims to determine the SEIRD model solution in the COVID-19 transmission using Microsoft Excel with three conditions (normal, new normal, and lockdown) to facilitate the interpretation of data. The SEIRD model used in this study considers natural population growth, namely natural births and deaths. Three stages to evaluate the model solution in this study are constructing a mathematical model, deciding the parameter intervals, and creating an applet in Microsoft Excel. The system of differential equations is converted into a system of difference equations to obtain numerical model solutions. The results showed that the differences in the infection rates for old normal, new normal, and lockdown conditions were 24%, 4%, and 3%, respectively.

#### **INTRODUCTION**

The COVID-19 pandemic has spread in 216 countries around the world. Until now, the COVID-19 pandemic is still spreading, which is marked by more and more people who are infected. Various parties have taken several steps to anticipate the COVID-19 transmission, including the health policy implementation also predictions made by academics and epidemiologists. It is necessary to predict the COVID-19 transmission so that interested parties can take appropriate action to control this pandemic [1, 2].

Mathematical modeling can be used in the field of epidemiology to describe the COVID-19 transmission. The compartment model is one of the mathematical models that can be applied. Compartment models have been used to model the COVID-19 transmission in China [3], Italy [4], and India [5]. The compartment model divides the population into compartments with specific characteristics. The compartments commonly used in modeling the spread of disease are Susceptible-Infectious-Recovered (SIR) [6]. Exposed [3, 4] and Quarantine [5] are two more compartments that can be introduced based on the disease's characteristics. These characteristics of the COVID-19 virus require time for incubation before it can infect other individuals. Therefore, a compartment is needed to see how the dynamics of the population are at this stage. Furthermore, because the COVID-19 virus is still relatively new, a separate compartment is required to study the dynamics of individual deaths caused by this virus. Finally, the demographic conditions of an area also need to be considered to distinguish the disease death rate from the natural death rate. As a result, we require a mathematical model that can account for the dynamics of a given area. As a result, we require a mathematical model that can account for the dynamics of a given area.

3rd International Conference on Biospheric Harmony Advanced Research (ICOBAR) 2021 AIP Conf. Proc. 2594, 090006-1–090006-6; https://doi.org/10.1063/5.0109176 Published by AIP Publishing. 978-0-7354-4420-1/\$30.00 In real-time, a function represents each compartment. A system of differential equations reveals in this compartment model. Solving the model is obtained by solving systems of differential equations analytically or numerically. The solution to this model will provide an overview of the transmission and prediction of COVID-19 in this population.

The compartment model simulation results are not always easy to understand, especially in interpreting the parameter values in influencing the solution. We have used mathematical modeling in many studies such as agroindustry [7, 8], environment [9–16], healthcare [17,18], and electricity [19, 20]. Therefore, it is necessary to present a less complicated approach to the mathematical model solution. In addition, the public also needs to know the meaning of the influence of parameters on the COVID-19 transmission. As a result, this article will go into how to use Microsoft Excel to determine the numerical solution of the COVID-19 distribution compartment model. When selecting Microsoft Excel, we took into consideration the features that are well-known to the general public.

#### **RESEARCH METHODOLOGY**

The SEIRD model is a compartment model that divides the population into five subpopulations, namely *Susceptible (S), Exposed (E), Infectious (I), Recovered (R)*, and *Death (D)*. The population is dynamic, which is influenced by the rate of natural births and deaths. Natural birth rate ( $\alpha$ ), the mortality rate ( $\mu$ ), transmission rate ( $\beta$ ), virus incubation rate ( $\sigma$ ), recovery rate ( $\gamma$ ), and death rate induced by COVID-19 are model parameters (d). The following is a flow chart of the SEIRD model.

![](_page_9_Figure_5.jpeg)

FIGURE 1. Flowchart of SEIRD model

Based on Figure 1 above, a system of differential equations has obtained as follows.

$$\begin{cases} \frac{ds}{dt} = \alpha N - \beta SI - \mu S \\ \frac{dE}{dt} = \beta SI - \sigma E - \mu E \\ \frac{dI}{dt} = \sigma E - \gamma I - dI - \mu I \\ \frac{dR}{dt} = \gamma I - \mu R \\ \frac{dD}{dt} = dI \end{cases}$$
(1)

Under  $S(0) \ge 0, E(0) \ge 0, I(0) \ge 0, R(0) \ge 0$  and  $D(0) \ge 0$ . System of differential equations can be solved numerically by first converting the equations system above into a system of altering equations [21]. Furthermore, for the parameters in the model, intervals will be calculated. The parameter values in the model use data sourced from [6, 22–24]. The crude birth rate (CBR) and crude mortality (CDR) in Indonesia during 2018-2020 were  $8 \le CBR \le 20$ and  $6 \le CDR \le 8$  [5]. The intervals for the cure rate and mortality rate parameters, namely  $0.03 \le \gamma \le 0.66$  and  $0.03 \le \gamma \le 0.66$ , are obtained in Berger and Oliger's study [23]. The basic reproduction number ( $\Re_0$ ) and mass contact incidence (*a*) [24] are used in this article to establish the virus's degree of transmission. The following are the equations used to determine the  $\beta$  parameter.

$$\beta(N) = aN^{-0.95} \tag{2}$$

And,

$$\Re_0 = \frac{N_0 \beta(N_0)}{\gamma + d} \tag{3}$$

In Brauer et al. [23], the interval  $\Re_0$  is  $1.4 \leq \Re_0 \leq 6.49$ . The mass action incidence interval,  $0.0443 \leq a \leq 3.1012$ , is calculated using equations (3) and (4). In the study of Zoupeng Xiao et al. [25] obtained the value of the virus incubation rate is  $7 \leq \sigma \leq 14$ . The numerical solution of the model calculated using Microsoft Excel. Each parameter in the model is created in the Scroll Bar, is available on the Developer menu. This Scroll Bar application makes the simulation more interactive. Furthermore, iteration is carried out based on the differential equation system above with time units in weeks. The SEIRD model's solution graph is displayed using the Chart function.

#### **RESULT AND DISCUSSION**

The system of differential equations for the above system of differential equations is as follows.

$$\begin{cases} \Delta S = (\alpha N - \beta SI - \mu S)\Delta t\\ \Delta E = (\beta SI - \sigma E - \mu E)\Delta t\\ \Delta I = (\sigma E - \gamma I - dI - \mu I)\Delta t\\ \Delta R = (\gamma I - \mu R)\Delta t\\ \Delta D = dI\Delta t \end{cases}$$
(4)

Each parameter is given a value during the iteration process. Each parameter's values are listed in Table 1.

TABLE 1. Value of parameter of the model								
Parameter	Value	Reference						
α	$3.7 \times 10^{-4}$	CBR Indonesia						
$\mu$	$1.39 \times 10^{-4}$	CDR Indonesia						
а	1.13	Assume						
d	0.45	Assume						
γ	0.28	Assume						
σ	10.016	Assume						

Transmission rate ( $\beta$ ), virus incubation rate ( $\sigma$ ), recovery rate ( $\gamma$ ), and death rate induced by COVID-19 are model parameters (d) obtained from analysis of daily COVID-19 case data in Indonesia from March to August 2021 published by KawalCOVID-19 [26]. Figure 2 depicts the outcomes of the iteration using Microsoft Excel. The graph in Figure 3 depicts the SEIRD model's solution. The graphs below are made by drawing each point with the coordinates (t, N), (t, S), (t, E), (t, I), (t, R), and (t, D). According to the graph of the SEIRD model solution above, the pandemic peaked at week 8 with a total infected population of 2362 people (23%) and 585 (5%) deaths until 52 weeks. During the 52 weeks, the populaces also experienced growth due to the birth rate and crude mortality rate. As a result, as of the end of week 52, there were 9539 individuals in the population.

The SEIRD model solution presentment using Microsoft Excel simplifies for the general public to understand pandemic behavior. Also, the scroll bar feature allows users to increase or decrease the parameter values depending on their preferences. After changing the parameter values, the user will immediately read the solution graph from the model. That feature will give users an overview of the effect of parameter values on the COVID-19 transmission. In addition, the existence of interventions carried out by the government through the application of health protocols can also influence the solution of the model. The health protocol implementation through 3M activities (wearing masks, washing hands, and maintaining a distance) will reduce the risk of COVID-19 infection. In addition, lockdown areas for the strict regulation of COVID-19 transmission are present in several countries. The SEIRD model will apply any of these interventions. The application of the health protocol to the population is called the new normal condition.

	•	× ✓	fx										
A	В	с	D	E	F	G	н	1	J	к	L	М	
				1	Iteration	Table o	of SEIRI	Model					
t	N	$\Delta N$	$\beta(N)$	S	ΔS	E	ΔΕ	I	$\Delta I$	R	$\Delta R$	D	
0	10008	0.29216	0.00018	10000	-0.93199	3	-2.95098	5	3.71312	0	0.462	0	0.
0.14	10008.3	0.26878	0.00018	9999.07	-1.86428	0.04902	2.11938	8.71312	-0.79141	0.462	0.80508	0.0315	0.0
0.28	10008.6	0.27377	0.00018	9997.2	-1.66506	2.16841	-1.05171	7.92171	2.2586	1.26708	0.73194	0.08639	0.0
0.42	10008.8	0.25955	0.00018	9995.54	-2.2316	1.1167	0.98965	10.1803	0.56088	1.99903	0.94062	0.1363	0.0
0.56	10009.1	0.25602	0.00018	9993.31	-2.37168	2.10635	-0.25797	10.7412	1.89324	2.93965	0.99243	0.20044	0.0
0.7	10009.4	0.24411	0.00018	9990.94	-2.84593	1.84838	0.57808	12.6344	1.34461	3.93208	1.16735	0.2681	0.
0.84	10009.6	0.23564	0.00018	9988.09	-3.18214	2.42646	0.10374	13.979	2.02248	5.09942	1.29156	0.3477	0,0
0.98	10009.8	0.22291	0.00018	9984.91	-3.68798	2.5302	0.46418	16.0015	1.96829	6.39099	1.47842	0.43577	0.
1.12	10010.1	0.21052	0.00018	9981.22	-4.17967	2.99439	0.30504	17.9698	2.42488	7.8694	1.66026	0.53658	0.
1.26	10010.3	0.19525	0.00018	9977.04	-4.7851	3.29943	0.48282	20.3947	2.61324	9.52966	1.88428	0.64979	0.1
1.4	10010.5	0.17879	0.00018	9972.25	-5.43682	3.78225	0.4576	23.0079	3.0323	11.4139	2.12571	0.77828	0.
1.54	10010.6	0.15969	0.00018	9966.82	-6.19235	4.23986	0.57156	26.0402	3.37462	13.5397	2.40585	0.92323	0.
1.68	10010.8	0.13844	0.00018	9960.63	-7.03208	4.81142	0.60995	29.4148	3.84295	15.9455	2.71762	1.08728	0.
1.82	10010.9	0.11423	0.00018	9953.59	-7.9871	5.42137	0.7098	33.2578	4.31887	18.6631	3.07266	1.27259	0.
1.96	10011	0.08702	0.00018	9945.61	-9.05869	6.13117	0.78623	37.5767	4.88782	21.7358	3,47166	1.48212	0.
2.1	10011.1	0.05623	0.00018	9936.55	-10.2694	6.9174	0.89458	42.4645	5.50778	25.2074	3.92323	1.71885	0.
2.24	10011.2	0.02154	0.00018	9926.28	-11.6309	7.81198	1.00186	47.9723	6.21848	29.1307	4.43207	1.98638	0.3
2.38	10011.2	-0.01764	0.00018	9914.65	-13.1646	8.81385	1.13099	54.1907	7.00945	33.5627	5.00657	2.2886	0
2.52	10011.2	-0.0618	0.00018	9901.48	-14.8891	9.94484	1.26978	61.2002	7.9034	38.5693	5.65415	2.63	0.
2.66	10011.1	-0.11159	0.00018	9886.59	-16.828	11.2146	1.42835	69.1036	8.90372	44.2235	6.38431	3.01556	0.
2.8	10011	-0.16769	0.00018	9869.77	-19.0051	12.643	1.60292	78.0073	10.0276	50.6078	7.20689	3.45092	0.
2.94	10010.9	-0.23087	0.00018	9850.76	-21.4482	14.2459	1.79858	88.0349	11.2854	57.8147	8.1333	3.94236	0.5
3.08	10010.6	-0.30197	0.00018	9829.31	-24.1862	16.0445	2.01494	99.3203	12.6934	65.948	9.17592	4.49698	0.
3.22	10010.3	-0.38195	0.00018	9805.13	-27.2514	18.0594	2.25511	112.014	14.2657	75.1239	10.3486	5.1227	0.
3.36	10009.9	-0.47184	0.00018	9777.87	-30.6779	20.3145	2.51996	126.279	16.0196	85.4725	11.6666	5.82839	0.3
3.5	10009.5	-0.57278	0.00018	9747.2	-34.5027	22.8345	2.81165	142.299	17.9717	97.139	13.1465	6.62395	0.8
3.64	10008.9	-0.68602	0.00018	9712 69	-38 7644	25 6461	3 13131	160 271	20 1402	110 286	14 8069	7 52043	11

FIGURE 2. Iteration using Microsoft Excel

![](_page_11_Figure_2.jpeg)

FIGURE 3. Solution of SEIRD model

![](_page_12_Figure_0.jpeg)

FIGURE 4. Comparison of Normal, New Normal, and Lockdown Conditions for Infectious Compartment.

New normal assuming a reduction in virus transmission rates of up to 50% with apply this condition. Meanwhile, the COVID-19 infection rate can decrease to 0% by executing lockdown conditions. All of these interventions are assumed to begin at week 4. Based on the graph in Figure 4, the comparison of the peak of the COVID-19 pandemic for three conditions, namely week 8 for old normal conditions, week 10 for new normal conditions, and week 6 for lockdown conditions. Furthermore, the infection rates for these outbreaks were 24%, 4%, and 3%, respectively.

#### CONCLUSION

The SEIRD model solution is determined numerically using a system of difference equations. The simulation results show that individual and government interventions have a positive impact in preventing the transmission of COVID-19. New Normal and Lockdown strategies can reduce infected individuals by 20% for 52 weeks. The iteration has been performed with Microsoft Excel assistance by users (the general public). The features in Microsoft Excel can be applied to understand the graphic interpretations of the COVID-19 transmission in Indonesia. The discrete method in solving the system of differential equations is a limitation in this study. The future research requires to compare the margin of the solution produced with the system's analytical solution in this study.

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