Simulation of the COVID-19 handling policy in Indonesia

Erman Aminullah,[1] Erwiza Erman,[2] Tri Edhi Budhi Soesilo[3]

[1]Research Center for Industrial, Service and Trade Economics, National Research and Innovation Agency, Jakarta; [2]Research Center for Area Studies, National Research and Innovation Agency, Jakarta; [3]School of Environmental Studies, University of Indonesia, Jakarta, Indonesia

Abstract

Background. This study's background was inspired by the current COVID-19 handling policy, which focuses on the balance of public health and social economy. However, there is a knowledge gap on the dynamic complexity of balancing public health and social economy during the new normal period of COVID-19 handling policy. A system dynamics simulation of the COVID-19 handling policy could be used to understand that gap.

Objective. This study aims to uncover the simulation of the COVID-19 handling policy in Indonesia.

Methods. This study combined quantitative and qualitative modeling methods with a system dynamics tool.

Results. This study revealed 3 elements in the dynamic balance of public health and social economy in the COVID handling policy system: i) COVID-19 and social-economic control; ii) COVID-19 escalation and de-escalation; iii) people's immunity enhancement. Such a mix of COVID-19-controlling policy instruments has maintained a dynamic equilibrium between easing economic suppression at the expense of worsening COVID-19 and tightening public health resolution at the expense of more economic suppression.

Conclusions. The study conclusions are as follows: i) the COVID-19 handling policy worked as a leverage factor in balancing public health resolution and economic interest during the new normal period in Indonesia; ii) experiential creativity to respond to the newly serious public health problems triggered by COVID-19 implies adding public health knowledge; iii) the study's outcomes imply re-examining the strengths and deficiencies of the entire health system for a better health system.

Correspondence: Erman Aminullah, Research Center for Industrial, Service and Trade Economics, National Research and Innovation Agency, Jalan Gatot Subroto 10, Jakarta Selatan 12710, Indonesia.
Tel.: 62.8161172487.
E-mail: aminullahe@yahoo.com

Key words: simulation, COVID-19 handling policy, mixed policy instruments.

Contributions: EA, study design, quantitative methodology, software, analysis and writing simulation results; EE, study design, qualitative methodology, analysis and writing qualitative discussion; TEBS, writing public health impact of simulation results.

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Introduction

The COVID-19 pandemic is a complex event with uncertainty on a global scale. Its complexity involves interactive elements of social-economic activity, public health conditions, and government COVID-19 handling policy. The uncertainty is caused by the nonlinear patterns of past COVID-19 data and its future possibilities. Under such dynamic complexity of social economy and public health, governments must balance public welfare, equality, individual rights, democratic processes, and COVID-19 handling norms.[1,2] Government policies need to find the right balance between human costs and economic costs during COVID-19.[3] In practice, this is a delicate balance of actions between the economy and health.[4] In reality, it is about how well health, freedom, and the economy are balanced without jeopardizing social and economic stability.[5] Technically, controlling the COVID-19 pandemic without shutting down the economy needs i) data-driven decision-making that accurately assesses local transmission risk;[6] ii) public communication issues that can balance the health-economic trade-off during the COVID-19 pandemic.[7]

COVID-19 total cases were around 28 thousand at the closing of the large-scale social restriction (LSSR) in the early COVID-19.[8] The new normal period characterized by the gradual opening of social economic activities started on June 1, 2020. During the new normal period, the COVID-19 total cases reached around 4.26 million by December 31, 2021.[9] The number of COVID-19 daily cases rose to the top of the first wave, around 15 thousand per day on January 15, 2021, then it climbed to the peak of the second wave, around 56 thousand per day on July 15, 2021.

These two waves indicated that: i) the second wave was far larger than the first wave; ii) the peak of the second wave was 4 times higher than the first wave; iii) the amplitude time between the first and second peaks was 6.5 months. Then, Indonesia became a low-risk COVID-19 country from October to December 2021.[10] In short, the COVID-19 cases were characterized by dynamic complexity in the period of the new normal.

In handling the dynamic complexity of COVID-19, Indonesia has applied a science-mix category in designing its COVID-19 handling policy,[8] which is essentially the balance of public health

and socio-economic activity. The implementation of health protocols, LSSR, and social activities restriction enforcement (SARE) is in balance with the continuity of socio-economic activities. The intensities of people's mobility and socio-economic activities are in balance with the levels of LSSR and SARE applications under the constant monitoring of health protocols application, including wearing masks, social distancing, and hand washing. There were some studies on the balance of public health and social economy;[1-7] however, there is no study on the dynamic complexity of balancing public health and social economy during the new normal period in Indonesia.

This study addressed two issues: i) the way Indonesia practiced the balance of public health and social economy under the dynamic complexity of COVID-19; ii) the conceptual and practical implications of practicing the balance of public health and social economy viewed from the lens of dynamic complexity.

Materials and Methods

Two types of data were used: i) quantitative data included the number of positive cases, number of patients in treatment, number of dead patients, number of recovered patients, and number of COVID-19 testing; the quantitative data sources were the daily statistics of COVID-19 that were published daily for public information by Beranda COVID19,[9] and Infeksi emerging;[11] ii) qualitative information related to the story of COVID-19 in the new normal period, changing patterns of government policy response to COVID-19 (from LSSR to SARE), leadership direction on making peace with COVID-19; implementation of health protocol on COVID-19, and gradual opening of social-economic activities. The qualitative information sources were the media mainstream news on COVID-19, namely CNN Indonesia, Kompas, Antaranews, and Investor Daily.

The study used a mix of quantitative,[12] and qualitative methods,[13] by applying system dynamics modeling which was used to understand the complexity of past policy implementation for future policy improvement. The stages of modeling and validation were designed according to the standard method of system dynamics modeling (Supplementary Material). The process of modeling and simulation was used as a tool for policy analysis. The simulation results met the standard process of model validation in system dynamics.[14] The results of the study in the graphics of dynamic patterns are described in the next section.

Results

Public health dynamics triggered by COVID-19

Dynamics of COVID-19 transmission

In the period of the new normal, COVID-19 transmission increased rapidly from June 2020 to January 2021. It reached the peak of the first wave on January 15, 2021, with around 15 thousand new patients per day. After the first peak, COVID-19 transmission slightly decreased between January 2021 and May 2021. The second wave occurred from June 2021 to August 2021, with its peak on July 30, 2021, with around 56 thousand new patients per day. Two elements were influencing COVID-19 transmission: the potency of transmission scale and the potency of transmission speed. An increase in the potency of transmission speed after the first peak was not followed by an increase in real COVID-19 transmission (Figure 1).

The potencies of transmission scale and speed influenced the patterns of COVID-19 transmission before the first wave, as denoted by the increase in the potencies of transmission scale and speed that led to the increase of COVID-19 transmission between June 2020 and January 2021. The COVID-19 transmission pattern was either caused by or fitted to the patterns of transmission scale after the peak of the first wave. Whereas the pattern of transmission speed had not matched or was less associated with the patterns of COVID-19 transmission after the first wave. Between February 2021 and November 2021, the trends showed that: i) the potency of transmission speed was decreasing, while COVID-19 transmission was increasing during the second wave; ii) after the second wave, the COVID-19 transmission was decreasing, while the potency of transmission speed was increasing. These trajectories are explained in the next sections.

Dynamics of public health impact and response

The dynamics of public health impact triggered by COVID-19 are presented in Figure 2.

Firstly, positive cases of COVID-19 show a sigmoid curve trend, which was characterized as follows: at the beginning of the pandemic, the number of positive cases was still small. This related to the fact that the number of infected people was still small, the mobility of infected people was still limited to the surroundings of the people's houses or work, and the tracing system was not properly implemented. In the mid of the pandemic period, a rapid increase in the number of positive cases of COVID-19 was in line with the uncontrolled mobility of some people who tested positive for COVID-19, so the transmission rate was getting bigger, the contact rate was getting higher, and there was contact between healthy people and asymptomatic people with COVID-19.

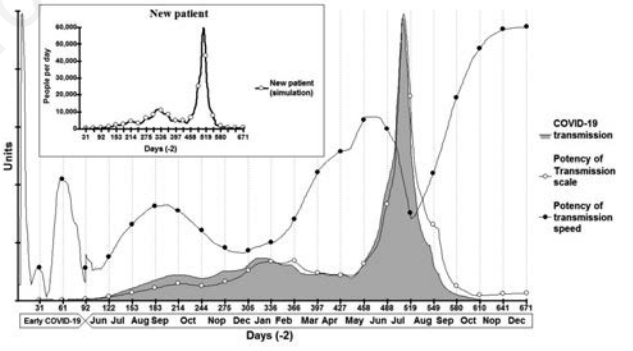

Figure 1. Dynamics of COVID-19 transmission.

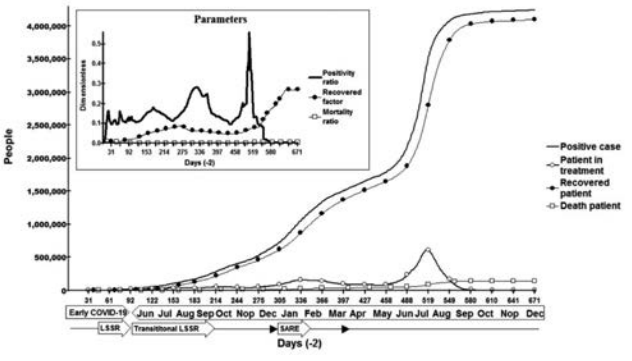

Figure 2. Dynamics of public health impact triggered by COVID-19.

Towards a steady state, the number of positive COVID-19 cases decreased because the number of daily positive COVID-19 cases decreased rapidly in line with the effectiveness of the mix of ways of controlling COVID-19.

Secondly, simulation results for the recovered patient from COVID-19 show the same pattern as positive cases of COVID-19. This happened due to the handling process of positive cases of COVID-19 which was getting wider in quantity and better in quality, in addition to an intensified vaccination program to achieve communal immunity. The simulation results demonstrate steady-state conditions were reached after the pandemic lasted approximately 19 months, as indicated by a rapid decline in the positivity ratio of positive cases against COVID-19 testing. This achievement can be explained by a mix of COVID-19 handling programs that were implemented by the government, including the success of partial lockdown under LSSR, the effectiveness of multi-level restrictions under SARE, increased vaccination coverage, and relatively high public awareness to implement health protocols such as washing hands, wearing masks, and keeping your distance.

Thirdly, the number of patients in treatment had two peaks. The first peak was in the middle of January 2021, and the second peak was in the middle of July 2021. The high number of patients in treatment overwhelmed the health system during the second wave.

Fourthly, the deaths of COVID-19 patients continued to decrease as shown by decreasing trends of mortality ratio, from 0.054 to 0.034 in the new normal period.

Furthermore, in terms of public health response, there are 2 public health responses to COVID-19: preventive and curative measures. We focused on preventive measures related to the application of health protocols (social distancing, wearing masks, and hand washing), the improvement and easing of social activity restriction enforcement, and the enhancement of people's immunity by intensifying the vaccination program (Figure 3).

Health protocol application increased during the early COVID-19. At the beginning of the new normal the health protocol application was stable through transitional LSSR (June-August 2020), and it was intensive during strict LSSR (September-October 2020). The health protocol application slightly lessened again during transitional LSSR (November-December 2020). Subsequently, the COVID-19 handling method had shifted from large scale to micro scale, by applying SARE since January 2021.

The health protocol application decreased during the shifting of the program method from LSSR to SARE. Afterward, the health protocol application continuously increased under a variety of SARE including micro SARE (February-June 2021), emergency SARE (July 3-20, 2021), and 4 levels of SARE, related to very high, high, moderate, and low risk of COVID-19 areas (since July 21, 2021).

The health protocol application had slightly decreased in parallel with the rapid lowering of SARE levels. In general, the health protocol application has been relatively stable in Indonesia. The application of emergency SARE as well as the very high levels of SARE had been parallel to an intensive vaccination program that contributed to the rapid lowering of COVID-19 transmission after the peak of the second wave.

The vaccination program started in mid-January 2021. After the first wave, the program had been intensified to accelerate achieving the people's herd immunity. Indonesia put the target vaccination to cover a population of 208.3 million. The number of vaccinated people reached around 77.40% (first dose) and 54.33% (second dose) of the target by the end of December 2021.[11] The vaccination program contributed to lower COVID-19 transmission during the second wave; natural immunity and super immunity (after the second wave) also contributed to the rapidly lowering COVID-19 transmission after the peak of the second wave.[15]

Social economy dynamics triggered by COVID-19 transmission

COVID-19 transmission can be explained by the potencies of transmission scale and speed, and its effects on socio-economic dynamics were the following.

Firstly, people's contact influenced the potency of transmission scale in the period of the early COVID-19.[8] In the period of the new normal, people's contact has tended to be stable and much lower. People's contact included close contacts from mobility and gathering. The close contact from gathering included social gathering and economic activity crowding. The patterns of people's close contact from mobility matched with the patterns of COVID-19 transmission. It is associated with i) mass trips at the beginning of the new normal euphoria; ii) the effect of mobility restriction; iii) the effect of mass traveling before the new year vacation; iv) the effect of social activity restriction enforcement (SARE) (Figure The potency of transmission scale during and after the second wave was not matched with the close contact from mobility. There were strict mobility restrictions through emergency SARE during the second wave triggered by the new Delta variant. After passing the peak of the second wave, there was a gradual easing of strict mobility restrictions from the 4th down to the 1st level. The close contact from mobility had increased, but the potency of the

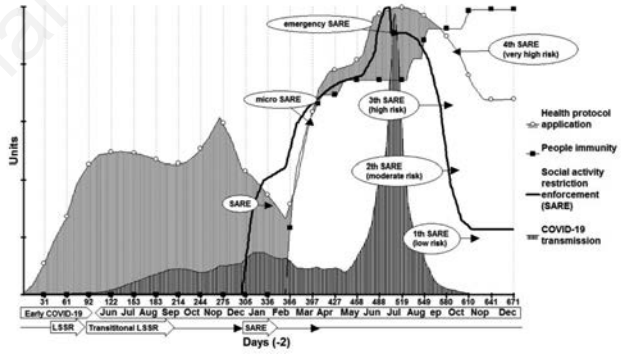

Figure 3. Dynamics of public health response triggered by COVID-19.

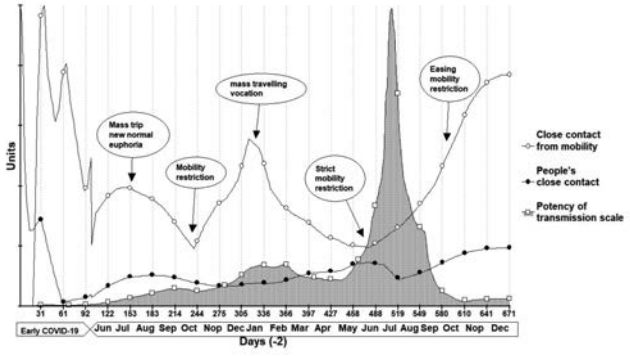

Figure 4. Social economy dynamics from the COVID-19 transmission scale.

COVID-19 transmission scale had continued to decrease. How such dynamic patterns happened is explained in the Discussion section.

Secondly, the transmission speed has matched the pattern of people's mobility, including at the end of the early COVID-19 period.[8] In the period of the new normal, the fluctuation of people's mobility corresponded with both economic and social activities. High and low intensities of both economic and social activities affected the rise and fall of people's mobility. The people's close contact occurred because of mobility and gatherings: i) opening of economic activities at the beginning of the new normal which induced the rise of people's mobility; ii) increase in social economic activities after the first wave, from February to June 2021; iii) maintaining essential economic activities during the second wave, from July to August 2021; iv) the impact of strict social economic restrictions after the second wave; v) easing of the social economic restrictions after the second wave. The fall in people's mobility occurred due to the effect of SARE and as a result of strict SARE during the second wave (Figure 5).

Discussion

The aforementioned findings of empirical simulation on the dynamic balance of public health and social economy in the COVID-19 handling system contained the 3 following elements.

Mutual control between COVID-19 and social-economy

By limiting and controlling socio-economic activities, the balance of public health and social economy was maintained. The dynamic balance between easing socio-economic activities and intensifying COVID-19 handling (through transitional LSSR and SARE) depended on the trends of COVID-19 cases. If COVID-19 cases increased, then COVID-19 handling intensified; if the COVID-19 cases were under control, restrictions on socio-economic activities were eased. Such a process of mutual control was in line with the continuously stable, even intensive, application of health protocols during the two waves of COVID-19. The intensive application of health protocol during micro SARE controlled the first wave; whereas, emergency SARE controlled the second wave. The decreasing trends of COVID-19 cases determined an easing of economic activities after passing the peak of the two waves. The analogy of mutual control is like pressing alternately on both the brake and the gas pedal of a car to balance manageable health risks and continuous economic activities.[8]

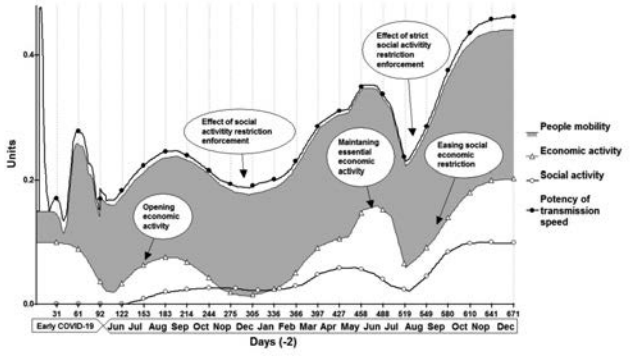

Figure 5. Social economy dynamics from the COVID-19 transmission speed.

Escalation and de-escalation of COVID-19

The partial opening of social-economic activities probably caused COVID-19 spreading to rise or escalate; enforcing almost full restrictions on socio-economic activities allowed to stop the spreading of COVID-19 and favor de-escalation.

De-escalation means pushing escalation back to balance. The balance of public health and social economy is achieved when the partial opening of socio-economic activities is permitted to operate by the safety check of rising COVID-19 spreading and based on the safety check of rising COVID-19 spreading. The imbalance of public health and social economy occurs at the full opening of socio-economic activities that allows COVID-19 spreading to jump rapidly. The imbalance of public health and social economy also occurs at the almost shutdown of socio-economic activities (lockdown), which makes COVID-19 spreading stop rapidly. The strategy of de-escalating COVID-19 was implemented by emergency SARE measures during the peak of the second wave. Such a rapid response was important to prevent the extreme imbalance by a large scale of COVID-19 spreading.[16] The extreme imbalances create either a sharp fluctuation of COVID-19 under fully opening economic activities or a flat trend of COVID-19 by enforcing lockdown of economic activities.

People's immunity enhancement

Mutual control between COVID-19 and social economy leads to an escalation under control by limiting the increase of both COVID-19 cases and socio-economic activities. The controlled escalation unintendedly allows some people to be exposed to COVID-19. Most exposed people were living in dense areas or remote areas far from healthcare facilities, and doing activities in crowded traditional markets. Some of them were undetected and asymptomatic carriers that recovered from COVID-19 and got natural immunity, even super immunity when recovered from the second wave.[15] People who have previously recovered from COVID-19 have a stronger immune response after being vaccinated than those who have never been infected. The number of people with natural immunity was around 44% in the Jakarta region in March 2021. People's immunity rose rapidly because of the intensive vaccination program and reached around 77.40% (first dose) and 54.33% (second dose) by the end of December 2021.[11] Natural immunity enhancement by intensive vaccination contributed to the rapid lowering of COVID-19 cases that brought Indonesia to the status of a COVID-19 low-risk country at the end of October 2021.[10]

Limitations

The model worked through computer simulation that mimics real systems. The strength of system dynamics is that the model could explain how and why the patterns of nonlinearity in system behavior occurred, caused primarily by the design of feedback structure inside the system. While the limitation of the feedback structure, based on the dynamic complexity perspective, is that the different perspectives result in different designs of the feedback structure and produce different patterns of system behaviors as well.[17]

Conclusions

Firstly, the COVID-19 handling policy worked as a leverage factor for balancing public health resolution and economic interest during the new normal period in Indonesia. The policy system to balance public health and social economy contained 3 elements: i) mutual control between COVID-19 and social economy; ii) esca-

lation and de-escalation of COVID-19; iii) people's immunity enhancement.

Such a mix of policy instruments to control COVID-19 has maintained a dynamic equilibrium between easing economic suppression at the cost of worsening COVID-19 and tightening public health resolution at the cost of more economic suppression.

Secondly, there is the emergence of mixed policy instruments for controlling COVID-19. The creativity emerged from learning by experiencing the COVID-19 handling policy. Such experiential creativity is needed to respond to the newly serious public health problems triggered by COVID-19. This implies adding the knowledge of public health for sustained improvement in global emergency care.[18]

Lastly, learning from the application of creative experiential response implies re-examining the strengths and deficiencies of the entire health system for a better health system and preparedness to handle future epidemics/pandemics.

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Online supplementary material:
Supplementary Material: stages of modeling and validation according to the standard method of system dynamics modeling.