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Preliminary Step for Designing an Agent-Based COVID-19 Spread Model in Indonesia

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Abstract

The spread of COVID-19 disease is increasingly widespread in various regions around the world. The speed of the spread of COVID-19 varies in different areas. This difference can be caused by multiple things, such as community habits, government policies, and climate. Research on predicting the spread of COVID-19 has been carried out using various methods. One method that can be used to model the spread of COVID-19 is Agent-Based Modeling. Through this model, the spread of the virus can be seen from each individual or agent so that the model will look more real. In making models using Agent-Based Modeling, standardization is necessary so that the model description is 8more complete and easier to understand. Standardization can be done by determining the ODD (Overview, Design Concept, and Details) Protocol. This study will discuss the determination of the ODD Protocol in making agent-based models of the spread of COVID-19 disease. The ODD protocol that has been created can be used to build models and coding in the next step in agent-based modeling.

Keywords: Agent-Based, COVID-19, Model, ODD Protocol

I. INTRODUCTION

In early 2020, the world was shocked by the emergence of a new infectious disease. This disease was named Coronavirus Disease-2019 (COVID-19) by WHO on February 11, 2020 (Wu, Chen, and Chan, 2020). Coronavirus disease 19 (COVID-19) first appeared in Wuhan, China. This disease is a highly contagious viral infection caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Shereen *et al.*, 2020). This virus is highly infectious; the transmission of this virus can occur through direct contact or droplets (Wu, Chen and Chan, 2020). According to global data, COVID-19 has affected 213 countries and territories worldwide, with the recovered rate from the data that has been obtained globally is 96%, and the mortality rate is 4%. Until September 24, 2020, the countries with the largest total cases were the USA, India, Brazil, and Russia. Indonesia ranks 23 in total cases (Worldometer, 2020).

The difference in the spread of COVID-19 is influenced by various things, such as individual behavior, government policies, and climate. Individual behavior such as obedience in carrying out health protocols (wearing masks, washing hands, and social distancing) and clean living habits can

affect the spread of COVID-19. Eikenberry, in his research, stated that face masks could significantly contribute to the control of COVID-19 (Eikenberry *et al.*, 2020). Government policies also may affect the speed at which the virus spreads, such as policies on closing access (total lockdown, partial lockdown), restrictions on public transportation, travel, and restrictions on community activities (Killeen and Kiware, 2020). A conceptual model by considering individual behavior and government action has also been carried out in Wuhan (Lin *et al.*, 2020).

The spread of COVID-19 can be modeled in various ways. In Indonesia, various models have been used to predict and describe the spread of COVID-19, including the Richard Model to predict the spread of COVID-19 in South Sulawesi (Zuhairoh and Rosadi, 2020), the SEIR model with MATLAB (Rustan and Handayani, 2020), etc. Another model that can be used to describe and predict the spread of COVID-19 is the agent-based model. This model can explain the spread of COVID-19 through interactions between agents so that the model can look more realistic. With agent-based modeling, it can be seen the effect of each individual's different behaviors on the spread of COVID-19. To get a good model and meet the standards, it is necessary to follow the steps in the ODD (Overview, Design concept, and Details) Protocol (Grimm *et al.*, 2010). With this ODD Protocol, the model will be well documented, developed by other researchers, and easier to understand. This study will discuss the ODD Protocol's determination as a preliminary step in designing a model for the spread of COVID-19 in Indonesia with Agent-based modeling.

II. LITERATURE REVIEW

Modeling human behavior is not clear because humans are not random. Humans have diverse knowledge, abilities, and humans are controlled by rational decision making and social-emotional behavior (Kennedy, 2011). Agent-based modeling is a computational modeling method that allows describing the behavior of an agent/ individual.

Various studies using agent-based modeling have been carried out in various fields. Ramadhan and Nugraha (2014) conducted agent-based modeling related to the food industry, which has complexity, in the form of the many components involved, the interdependence between complex components including the effect of component feedback, the presence of an element of uncertainty, and dynamic processes. This complexity indicates the need for a comprehensive model to be used in analyzing policy. One method that can be used in analyzing complex system problems is agent-based modeling and simulation. This method can show the characteristics and behavior of each system actor that has an impact on the system as a whole (Ramadhan and Nugraha, 2014).

Agent-based modeling in the economic sector has also been developed by Worldailmi and Ismianti (2020). This study discusses the trend of using non-cash transactions (e-payment). From the simulation results, the number of e-payment users follows the S-curve pattern. From the sensitivity analysis, perceived security, performance expectations, and business expectations have an important role to play in this trend (Worldailmi and Ismianti, 2020).

The use of ABM in modeling the spread of the disease has also been widely used. A study was conducted to simulate a measles outbreak that occurred in Schull, Ireland, in 2012 (Hunter, Namee, and Kelleher, 2018). The outbreaks were simulated in 33 different cities and looked at the correlation between model results and city characteristics (population, area, vaccination rate, and age structure) to determine whether the model results were influenced by city characteristics and decision agents in the model.

Laskowski et al. (2011) developed an agent-based modeling framework to simulate influenza virus infection spread on a layout based on an emergency department hospital in Winnipeg, Canada. The results show that in the context of the examples given, patient-oriented infection control policies are likely to have a greater effect than policies targeting healthcare workers (Laskowski *et al.*, 2011).

Saputra, Irawan, and Kusuma (2018) have conducted a simulation modeling of the spread of tuberculosis disease based on agent systems. Various factors influence the spread of this disease, including contact with infected people, the distance between healthy people and infected people, environmental factors, room temperature, and the human immune system (Saputra, Irawan, and Kusuma, 2018).

Nuraini et al. (2020) has simulated the spread of COVID-19 in Indonesia with a model based on the Richard Curve. This simulation uses initial endemic data. The results show that the endemic of COVID-19 will end in April 2020 with more than 8000 cases. However, in reality, until October 2020, the COVID-19 pandemic has not ended, and Indonesia's positive cases have reached more than 315,000 cases (Nuraini, Khairudin, and Apri, 2020).

Publications regarding the model of the spread of COVID-19 using agent-based modeling do not yet exist in Indonesia. With this model, it is hoped that it can increase knowledge about the spread of COVID-19 in Indonesia based on agents, and efforts can be made to minimize the spread of COVID-19.

III. RESEARCH METHODOLOGY

The stages in this research started from the study literature, identifying the main variables in the study, determining the ODD protocol, collecting secondary data, building models, and verifying and validating the models. The stages of this research can be seen in Figure 1.

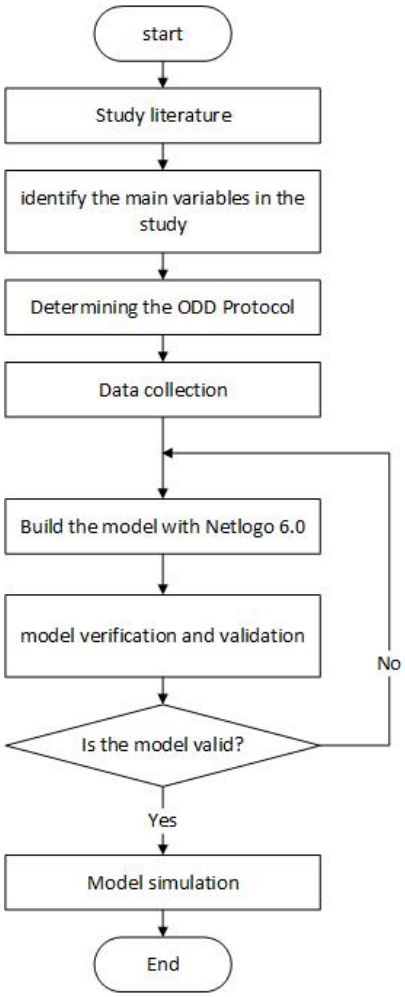

Figure 1. Research methodology

Literature studies were conducted to complement the various information needed in this study. The literature study carried out contains literature regarding the COVID-19 disease and its spread as well as literature on infectious disease modeling using Agent-based modeling.

The next step after conducting a literature study is to identify the key variables in the spread of COVID-19. These key variables will be used in modeling considerations. In this model, some of the key variables are implementing health protocols and government policy.

After conducting the study literature and identifying the main variables, the next step is the preparation of the ODD Protocol. The ODD protocol was created to make the model more standardized, easier to understand, and other researchers can continue the model. This paper will only discuss until the stage of determining the ODD protocol in modeling the spread of COVID-19. It is crucial to determine the ODD protocol as an initial step in agent-based modeling.

IV. FINDING AND DISCUSSION

Agent-Based Modeling (ABM) is a computer-based modeling paradigm that can describe the behavior of the agents contained in it (Wilensky and Rand's, 2015). This method uses simple rules for coding each agent's behavior and then observes the results of the interaction of these agents in the output form of the system. This method can describe various kinds of the system, but the advantages will be seen when applied to a complex system (Arfani *et al.*, 2019).

ODD (Overview, Design Concept, Detail) Protocol is a procedure made in the development of the ABM model, which aims to make the model more understandable and complete with its elements that aim to standardize and answer the ABM's criticism model (Grimm *et al.*, 2010). Although initially designed specifically for ABM, in its development, the ODD Protocol can also be used for modeling outside of ABM (Arfani *et al.*, 2019). Table 1 shows the elements of the updated ODD protocol (Grimm *et al.*, 2010).

Table 1. Elements of the updated ODD Protocol

	Elements
Overview	1. Purpose 2. Entities, state variables, and scales 3. Process overview and scheduling
Design Concepts	4. Design concepts • Basic principles • Emergence • Adaptation • Objectives • Learning • Prediction • Sensing • Interaction • Stochasticity • Collectives • Observation
Details	5. Initialization 6. Input Data 7. Submodels

IV.1. Purpose

The first element that needs to be determined in creating a model is the goal. In the ODD protocol, the purpose must be predetermined and must be clear. This research aims to model and simulate the spread of COVID-19 to know the steps that need to be taken to reduce this disease's spread.

IV.2. Entities, State Variables, and Scales

Entities : The entities in this study consist of mobile agents and stationary agents. Table 2 shows the entities of the research.

Table 2. Entities of the model

	Entities
Mobile agent	People, with the attribute : - Ages - Colour: to determine the health status (healthy, positive for COVID-19, and immune) - Congenital disease - Shape: person
Stationary agent	Hospital, with the attribute : - Capacity - Colour: to determine the capacity of the hospital - Shape: house

In a population, everyone has a different age. This age can influence a person's recovery against COVID-19, so that age is used as an inherent attribute of every human agent. Congenital diseases suffered by a person can also affect a person's recovery so that congenital conditions are also included in the attribute of the agent.

The availability of hospitals is included in this model. The number of hospitals can be adjusted according to the number of hospitals in the area. Hospitals are depicted in two colors indicating full hospital capacity or not.

State Variables : The state variable is the identification number of the agent. The agent would still keep a particular identity. The state variables in this study are age and congenital disease.

Scales : The scale is the amount of space and time represented in the model. The scale is crucial to determine to know what the model unit means in reality (Grimm *et al.*, 2010). In this study, the scale used is one tick representing one week.

IV.3. Process overview and scheduling

Process overview and scheduling describe what entities do, in what order, and when state variables change. In this study, the process overview and scheduling include move, infect, dead, immune, and service.

Each person's agent can move randomly. When moving, everyone has the opportunity to meet other people. When a person who is positive for COVID-19 meets a healthy person, then a positive person can infect the person they meet. A person who is positive for COVID-19 can die or be cured (immune) according to age or congenital disease.

IV.4. Design concepts

Basic principles: Compliance in implementing health protocols represents the use of masks, social distancing, and washing hands. Government policies represent the government's policies in implementing Large-Scale Social Restrictions (PSBB), regulations on vehicle restrictions, restrictions on transportation between regions, and rules for the closure of public places such as tourist attractions, schools, campuses, places of worship, and offices.

Emergence : Emergence in this model is people who are positive for COVID-19, people who are cured (immune), and people who died.

Objectives : The objectives of this model are for people healthy and have immunity.

Interaction : The interactions in this model include a healthy person with a positive person and a positive person with the hospital.

Stochasticity : Stochasticity in this model is a random value constructed for age, movement of people, and congenital illnesses.

Observation: In this model, the observations were the number of positive people, the number of immune people, the number of people who died, and the hospital's capacity.

IV.5. Initialization

Initialization in this model is the number of population, number of hospitals, health protocol slider, government policy slider, and tick starting from zero.

IV.6. Submodels

The sub-model in this study is to determine the effect of implementing health protocols on the spread of COVID-19 and to determine the impact of government policies on the spread of COVID-19.

The ODD protocol in this study includes various elements that have been described, but some elements were not included in this study, such as prediction, adaptation, sensing, and learning. After the ODD protocol is defined, the next steps needed in making this model are data collection, building the model in Netlogo, verifying the model, and the last step is validating the model. After the model is validated, the results will be more reliable. However, this paper only discusses the determination of the ODD protocol, which is used as a first step in building an agent-based COVID-19 spread model. An initial description of the model built on Netlogo 6.0.4 is described in Figure 2.

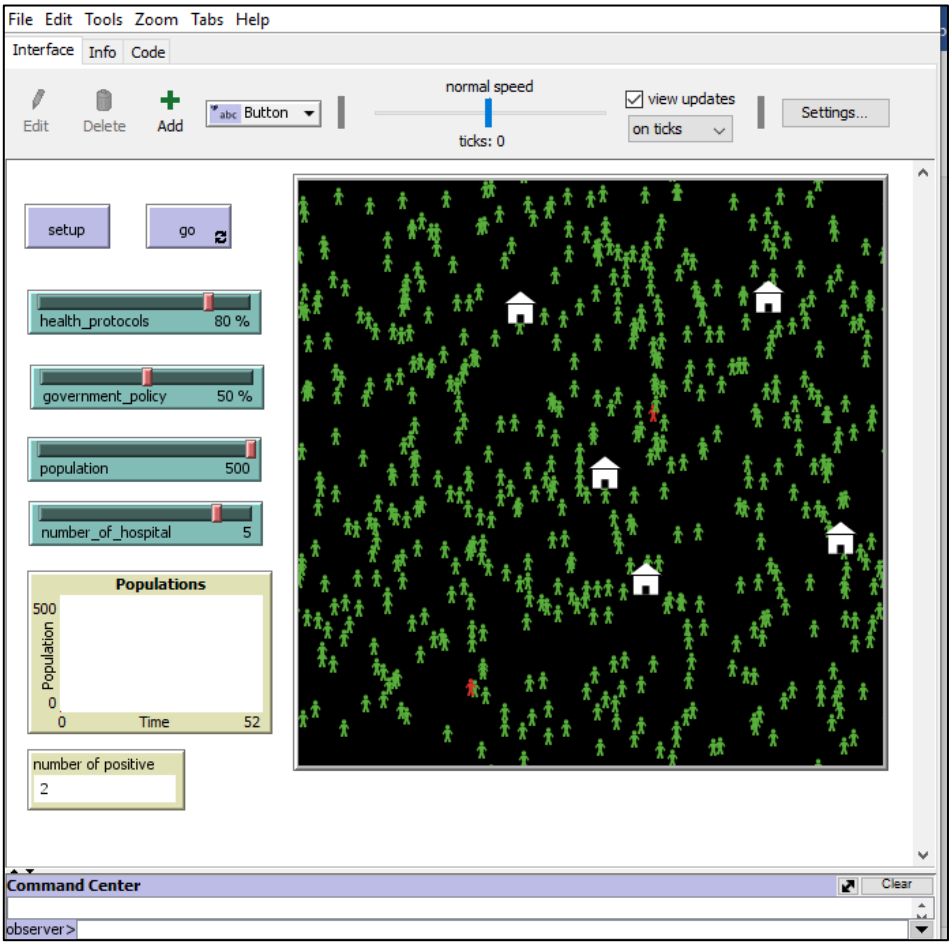

Figure 2. Overview of the model on Netlogo 6.0.4.

V. CONCLUSION AND FURTHER RESEARCH

This study results in a description of the elements in the ODD protocol that are used as a preliminary step in creating an agent-based COVID-19 spread model. The description in the ODD protocol is important so that the model that will be made is more standardized, easier to understand, and easier to develop by other researchers. Further research is needed to realize the model so that the model can be simulated, and the results can be validated.

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