

Dynamic Transmission of Dengue Hemorrhagic Fever and Climate Variability Patterns in Depok and Bogor

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Abstract

Dengue hemorrhagic fever (DHF) has become an endemic in major cities in Indonesia. Climate change, and poor level of awareness and knowledge of the community in Indonesia causes the case of DHF to continue to exist and it tends to increase. In the extraordinary events in 2015 the morbidity rate reached 50.75. The Intergovernmental Panel on Climate Change (IPCC) prediction in 1996 stated that the incidence of dengue hemorrhagic fever in Indonesia will increase threefold from 2070, if the environment and community conditions do not change. This study aims to produce a system dynamics model with ecological analysis to determine the dynamics of the DHF incidence with climate variability patterns in Depok and Bogor. The design of this study is ecologic study with hypothesis test, modeling, simulation, and intervention. Interviews with respondents include the level of knowledge, attitudes, and behavior (PSP) of the community. Measurement of climate factor includes rainfall, temperature, humidity, and CO₂ level in the ambient environment. The results of DHF system dynamics model simulation show the program intervention scenario that has the most significant effect on the decline of Breeding Places and the decrease of DHF cases by increasing the participation of the community to actively control water places that are potential for mosquito breeding places.

Key words: *system dynamics model, intervention, simulation, dengue hemorrhagic fever, climate change*

Introduction

The increasing population has caused cases of communal disease to increase. DHF cases in Indonesia have relationship between environmental changes and an increase in cases of disease. The number of environmental factors that are identified as having an effect on the incidence of DHF which tend to recurred encourage researchers to figure out what environmental factors can be used as indicators in predicting the occurrence of DHF cases and DHF transmission system in Depok

and Bogor, as well as predicting the incidence of DHF through intervention models on system dynamics.

This study produces a dynamics model of DHF transmission in relation to climate variability patterns that will contribute to improvements in development on a local and even national scale. The dynamics model of DHF transmission is expected to be an innovation to reduce the incidence of DHF, especially in Depok and Bogor.

Method

This study includes ecological studies by using hypothesis test. Modeling and simulation is carried out to identify factors that are relevant to future DHF cases. The eminence of this study links environmental factors in ecology such as rainfall, temperature and humidity as well as basic indicators of air quality, namely CO₂, with

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larva free index.

Study related to the determination of dynamics model to recognize early warning of the emergence of DHF cases has been started since 2006. It is expected that the patterns that have been found are continued in the concept of this study for a broader area, namely in Jakarta, Bogor, Depok, Tangerang and Bekasi (Jabodetabek).

The samples in this study are air quality sample, larva free index, case sample, house sample, and respondent sample. Air quality sample is taken from the research location. Larva free index obtained from the Depok and Bogor Health Services. Case samples are DHF experienced by respondents in the last two years. House sample is determined based on WHO standards for larvae and mosquito surveys according to the area and population: "Cluster Design Sampling".¹

The minimum number of samples calculated based on the prevalence of DHF in the preliminary study was 14%, while the expected prevalence of control variables that had been found was 4%. In the hypothesis test using a 5% confidence level and 90% test strength. The distribution of household sample was carried out by dividing the sample proportionally according to the number of cities in the Special Capital Region of Depok (Depok Village and Pancoran Mas Village, Pancoran Mas District and Beji Village and Tanah Baru Village, Beji District) and Bogor (Kedung Badak Village, Kayu Manis Village, Kencana Village, and Mekar Wangi Village, Tanah sereal District). In each region, a total of 220 houses were taken with individual analysis units.

The study is conducted within three years starting in 2018. Data is collected from the Special Capital Region of Jakarta, include: Environmental data (rainfall, temperature, humidity, and CO₂ level in the ambient air through direct measurements at the sampling point) and Community data to find out the knowledge, attitudes and behavior of the community about DHF.

Rainfall measurements are carried out every rainy day using rain gauge. Temperature and humidity are measured using thermo hygrometer, and CO₂ level is measured using RAC sampling. Community data collection is carried out through interviews using a questionnaire to determine social, economic and education status of the community, as well as knowledge, attitudes and behavior of the community about DHF, prevention and eradication of *Aedes* vectors.

To obtain the concept of DHF control in the future, a system dynamics model is used. The stages of the study to obtain the research outcome are: (1) validation of environmental components (2) demonstration of the model in the relevant environment, (3) report on comprehensive activities. In this study, the case of DHF is considered as one of the components of the causal system in a scenario simulated through intervention.

Simulation is carried out through modeling, model production, simulation and validation of the simulation results stages to determine the compatibility between the simulation results and the imitated mechanism. Simulation results are used to understand process behavior and predict future trends.²

Results and Discussion

Dengue Hemorrhagic Fever Case Prediction based on Model Simulation Based on Figure 1, it is known that climate variability patterns affect the incidence of DHF because the life of the disease vectors and dengue virus as an agent is very dependent on environmental conditions. Temperature, humidity, air chemical composition, water chemical composition as the breeding place for mosquitoes, rainfall, wind speed and other environmental factors are the limiting factors of its life. Therefore, the environmental system associated with the incidence of DHF has 4 subsystems, namely: climate subsystem, *Aedes* mosquito, human and DHF. These four subsystems are interconnected and they influence each other.

Climate subsystem is a series of climate factors related to global climate change that triggers an increase in global earth temperature. As a result, this global warming phenomenon can affect living things. The most dominant insect causing DHF is *Aedes aegypti*. CH₄, N₂O, CO₂ and CFC-11 are gases that cause the global climate change or the so-called greenhouse effect if it is at a concentration exceeding normal concentration. The increase in global temperatures will increase sea surface temperatures so that the next impact is to encourage the El Nino phenomenon. According to the World Meteorological Organization (WMO), there is a relationship between the occurrence of El Nino and the incidence of DHF in Indonesia.³ This cycle forms the climate subsystem in the model.

The second subsystem is the *Aedes* mosquitoes, from eggs to adult mosquitoes, which is indicated by a positive arrow. The connecting factor of the climate

subsystem and mosquito subsystem is the breeding places for mosquitoes. Breeding places are highly affected by rainfall. When rainfall is high, containers are easily filled with water and this relationship is indicated by a positive arrow. Another connecting factor of the climate subsystem is the ambient temperature which then affects the Extrinsic Incubation Period (EIP). Extrinsic Incubation Period is influenced by environmental temperature, humidity, level of viremia in humans, and viral strains.⁴ Temperature increase will shorten EIP and increase transmission. Temperatures that increase to 34°C will affect the temperature of the water in breeding places which also accelerates the hatching of eggs into larvae.

After the *Aedes* mosquito bites a human, the virus replicates in the human body. The more viruses incubated into humans the more humans become infectious so that the number of DHF cases in the community increases. This link is indicated by a positive arrow.

Human activity is indicated by the intensity of petroleum fuels usage. The impact of fuel utilization is the increase of CO₂ emissions; the relationship is indicated by a positive arrow. The Landing Rate factor is also related to the human subsystem through the individual activeness factor. The more inactive a person is, the easier for mosquitoes to approach, especially during peak hours.

In this case, intervention in increasing the knowledge, attitudes and behavior (PSP) of the community is required. From the analysis, it is known that the factors that are significantly related to the occurrence of DHF in the community are knowledge, attitudes and behavior factors. This program provides community awareness education. This relationship is indicated by a positive arrow for PSP. Figure 3 shows the diagram stock flow scheme which is the model production stage, where all variables are included as factors that influence the incidence of DHF.

Conclusions

System dynamics model simulation of DHF shows the program intervention scenario that has the most significant effect on the decline of Breeding Places and the decrease in DHF cases is by increasing the participation of the community to actively control water places that are potential to be mosquito breeding places. Environmental factors influence DHF cases and the vectors *Aedes aegypti* and dengue viruses related to climate change. The Indonesia geography, knowledge, attitude and practice have caused DHF cases were increase.

Simulation in this study has produced a model that can be used for other infectious diseases. Through system dynamics modeling, the transmission model of the disease can be known in details, so that the most effective interventions can be determined in handling infectious disease cases.

Conflict of Interest Statement: The authors of this research declare that there is no conflict of interest related to this study

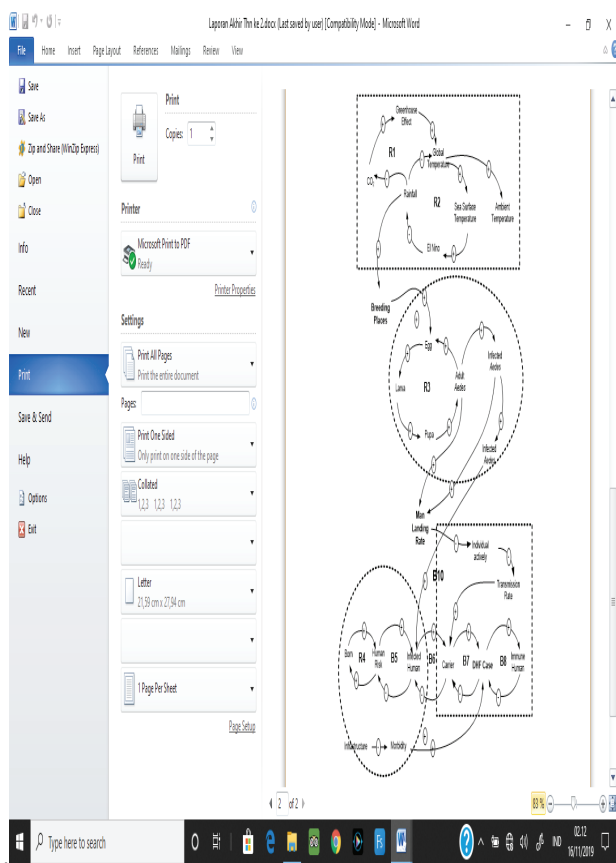


Figure 1. Dynamics System Model of DHF Cases with Community Role Improvement (PSP) intervention

Vector subsystem and disease subsystem are connected by Landing Rate and the role of dengue virus factors. The presence of DHF is determined by the contact between mosquitoes and humans. It is assumed that the larger the mosquito population the higher the Landing Rate, so the connecting arrow becomes positive. The larger the *Aedes* mosquito population the larger the infective *Aedes* population that carries the Dengue virus. This relationship is indicated by a positive arrow

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