Forecasting The Spread of Covid-19 Disease Patients to Allocate The PPE for Medical Hospital Staffs in Indonesia

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Abstract

The existence of this pandemic has disrupted many sectors. This pandemic continues to spread to several regions due to transmission which is quite short by sticking between hosts. This has led to an increase in the number of patients who need to be treated. However, Indonesia still has weaknesses in planning and procuring the amount of Personal protective equipment (PPE) available. This model explores the spread of disease in a number of different conditions and environments. In particular, it explores how making assumptions about the interactions of agents can drastically affect the results of the model. This will illustrate the number of patients who need special treatment. With this prediction of the number of patients, then the preparation of procurement of goods can be immediately handled. Allocation of PPE to be produced and distributed to various areas affected by COVID-19.

Keywords
COVID-19, Personal Protective Equipment, Agen-based

1. Introduction

A new coronavirus was identified as the causative agent and then called COVID-19 by the World Health Organization (WHO). Considered a severe acute respiratory syndrome (SARS) and Middle Eastern respiratory syndrome (MERS), COVID-19 is caused by a betacoronavirus named SARS-CoV-2 which affects the lower respiratory tract and manifests as pneumonia in humans. The recent COVID-19 outbreak has been considered a global health emergency. Internationally, the number of confirmed reports continues to increase, various countries have been attacked by the Pandemic 19 pandemic outbreak. This pandemic is transmitted quickly through droplets from sick people. Many people are still not aware of the pandemic that is currently endemic. The number of victims of this Pandemic will continue to increase in the future. The number of victims of this pandemic can be reduced with a variety of treatments, intensive care, physical distancing, and also maintain a healthy lifestyle. One of the things that needs to be predicted is the number of COVID-19 patients that will increase.

By looking at the current conditions, the government only knows that the pattern of increasing numbers of COVID-19 patients follows an exponential pattern. This shows the number of patients continues to grow, therefore the government has a way to reduce the number of COVID-19 patients with physical distancing. With the prediction of the number of patients, this can help the logistics of a country prepare PPE needs for medical personnel to be able to handle COVID-19 patients properly. In accordance with Minister of Health Regulation No. 8 of 2010, Personal Protective Equipment is a tool to isolate part or all of the body from potential hazards. The importance of adherence to the strict PPE protocol is paramount. Improper PPE doffing on health workers is common: one study found that

26% of health workers touched the front of their masks incorrectly when dressing up, and about half touched the surface of a potentially contaminated PPE with unwrapped hands.

According to the Recommended Standards for the Use of Personal protective equipment (PPE) for Handling Covid-19 in Indonesia, the standard for using PPE for medical personnel depends on the situation and conditions of patient care. The recommendations issued by the Covid-19 Task Force for the Acceleration of Handling mentioned that there are three levels of protection. In an already precarious situation, Indonesia has not yet prepared adequate health logistics and treatment in this disease condition. The lack of available PPE causes many medical personnel to become one of the COVID-19 patients. That way, the PPE that is needed should already be available in various referral hospitals so that things don't happen that don't happen.

Coronavirus 2019 (COVID-2019) has been recognized as a global threat, and several studies are underway using various mathematical models to predict the possible evolution of this epidemic. Existing spread has been unexpected, this occurs uncertainty caused by inadequate test kits for virus detection in the early stages of the outbreak. ARIMA method and epidemiological data are used to predict epidemiological trends in the prevalence and incidence of COVID-2019. Research examines the effects of these uncertainties using the Monte Carlo method. The spread of outbreaks has been analyzed. The first analysis of a simple day-lag map shows some universality in the spread of the epidemic, showing that a simple plane-level model can be meaningfully used to collect quantitative images of epidemic spread, and in particular the height and time of peak infected individuals confirmed. Analysis of the same data in a simple vulnerable-recoverable death model shows that the kinetic parameters describing the recovery rate appear to be the same, regardless of the country, while the infection and death rates appear to be more variable. Analysis of the same data in a simple model of susceptibility to infection-recovery-recovery (SIRD) revealed that recovery rates were the same for Italy and China, while infection and death rates appeared to be different. Researcher has calculated the SIRD model predictions modified by the highly awaited effect of infectivity that fades after locking. The research also presented the results of a fast but powerful simulation study that opened up some new research tensions on the impact of COVID-19.

With the lack of available PPE, a simulation is performed which illustrates the condition of the area which will be isolated or not. With estimates from the simulation results of forecasting the number of patients affected by COVID-19, the government can make requests for PPE or PPE production precisely and quickly. This will also make it easier to determine the allocation of PPE which will be distributed to various referral hospitals. The method to be used is agent-based modeling. In research demonstrating how simulation-based methodologies can be used to test and predict the impact of epidemic outbreaks on SC performance.

2. Literature Review

Corona virus is a virus RNA with a particle size of 60-140 nm (Meng et al., 2020; Zhu et al.,2020). Xu et al. (2020) do research to find out the agent Causes of the outbreak in Wuhan by making use of the network the 2019-nCoV genome, which worked isolated from infected patients in Wuhan. The 2019-nCoV . genome sequence then compared with SARS-CoV and MERS-CoV. The result, multiple sequences of the 2019-nCoV genom genome researched are almost identical to each other others and 2019-nCoV share a series genome that is more homologous to SARS-CoV compared to MERSCoV. Further research by Xu et al. (2020) done for find out the origin of the 2019-nCoV and genetic relationship with viruses Another Corona by using phylogenetic analysis. Research results shows that 2019-nCoV Journal of Medika Malahayati, Volume 4, Number 3, July 2020 196 belongs to the genus betacoronavirus (Xu et al., 2020). Similar research for identify the causative agent of the epidemic in Wuhan was also carried out by Zhu et al. (2020). Electron micrograph results of 2019-nCoV . negative strand particles showed that the morphology of the virus generally spherical with some pleomorphisms. Diameter virus varies between 60-140 nm. Virus particles have spike proteins which is quite typical, which is around 9-12 nm and make the appearance of the virus similar to the sun's corona. The morphology obtained by Zhu et al. (2020) similar to family Coronaviridae. The results of the phylogenetic analysis done by Zhu et al.(2020) shows the same result as research by Xu et al. (2020), that the virus this belongs to the genus betacoronavirus with subgenus the same as the Corona virus which caused a severe acute outbreak Respiratory Syndrome (SARS) in 2002-2004 ago, namely Sarbecovirus. International Virus Classification Commisson named the causative agent this as SARS-CoV-2(Lingeswaran et al., 2020; Susilo et al., 2020).

Virus virulence mechanism Corona is related to protein structural and non-structural proteins. Corona virus provides messenger RNA (mRNA) that can help process translation of process replication/transcription. The gene that take part

in the process this replication/transcription covers 2/3 of the 5'-end and two .-end RNA sequences Open Reading Frame (ORF) which overlap, namely ORF1a and ORF1b. In the host's body, the virus Corona performs polyprotein synthesis 1a/1ab (pp1a/pp1ab). Process transcription on pp1a/pp1ab . synthesis going through the complex replication-transcription in vesicles double membrane and also lasts through the synthesis of RNA sequences subgenomics. There are 16 non . proteins structural code coded by the ORF. The other 1/3 of the RNA . sequence viruses, which do not play a role in replication/transcription process in coding for 4 structural proteins, namely protein S (spike), protein E (envelope), M protein (membrane), and protein N (nucleocapsid) (Gennaro et al., 2020; Ye et al., 2020). The entrance of the virus into the cell is essential for transmission. The whole Corona virus coding for surface glycoproteins, namely spike protein (S protein), which binds to host receptors and become the entryway for the virus to in the cell. For genus betacoronavirus, there is a domain receptor binding on the S protein which mediate interactions between receptors in host cells and viruses. After bonding occurs, proteases in the host will break down the viral S protein which next will cause fusion of spike and peptides facilitate the entry of the virus into the in the host's body (Letkodkk., 2020). Virus virulence mechanism Corona is related to function non-structural proteins and proteins structural. Research has emphasizes that nonstructural proteins are able to block innate immune response of the host. Protein E in viruses has a crucial role in viral pathogenicity. Protein E will trigger collection and release viruses (Gennaro et al., 2020).

3. Research Methods

This condition is increasingly complex, on the other hand the existing tools and methods (tool / toolkit / simulation) cannot represent the increasingly complex system so new methods are needed to handle it. The existing database system has been able to organize data up to the level of micro-data so that it can support micro-simulation. In addition, the computing system has also been able to handle computing to the micro-data level.

Agent based modeling is a simulation model that depicts individuals (agents) in a complex and dynamic system. This pandemic condition describes the relationships between people who interact. Transmission that occurs is also influenced by several factors so that the disease can be transmitted or can make humans able to recover from the COVID-19 virus. This model represents a system whose components are individuals and their behavior. In addition, this model does not only model variables that represent the entire system. Every human being has a heterogeneous and autonomous nature and can interact between agents and their environment. The people in Indonesia also have an adaptive nature where they can adapt to their current conditions, with other agents, and with their environment. Society as an agent that is active in the current condition faces problems related to emergence (a dynamic system that arises due to the relationship between agents or between agents and their environment). Agent Based Model can explain the reciprocal relationship between systems and individuals (what happens to the system due to individual behavior and what happens to individuals due to system work).

4. Result and Discusssion

4.1 Data

Data obtained on the case of positive new patients COVID-19. This data illustrates the latest conditions that occur in the world. This data illustrates the increase in patients infected with COVID-19.
Positive patient data for Covid-19 continues to fluctuate. The development of this positive patient is quite significant because there is no significant action taken by the government. This data follows an exponential distribution which shows that the data always increases over time. The data increased dramatically because the government began to understand how to detect positive patients with Covid-19 which involved several individuals to launch a government program. This data will be used as a reference in modeling the simulation. The picture of the situation included in the model is still a lot of assumptions used. This will show how fast the development of Covid-19 patients will help predictions in PPE procurement.

This data shows the distribution of patients from the past several months. This data shows the number of COVID-19 patients spread in several countries, from this diagram researchers can find out the most rapid spread rate in which country. With this information, researchers will explore the reasons for the spread of the virus quickly. This information will help researchers model a real system for forecasting the spread of patients which will increase over time.

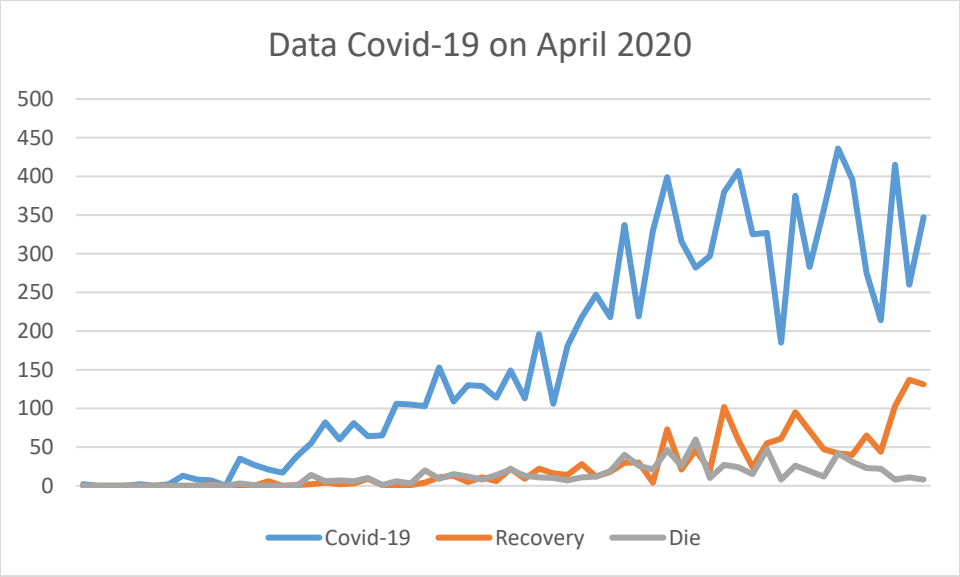

Figure 1. Covid case growth chart in Indonesia on April 2020
(covid19.go.id, 2020)

This data will describe the spread of patients in Indonesia. Figure 1 describe predictions about patients affected by COVID-19 will be easier to model by considering several characters from each of the existing agents. The character that has been built will describe the condition of the mode of transmission that occurs, the cause of transmission, and the character of the agent that is easily the object of transmission.

4.2 Problem Simulation

The situation of the model illustrates that the infection will continue to develop due to the fairly rapid transmission process. Infected people will infect ordinary people very quickly, each individual has a 5% chance of being initialized as infected. The possibility of transmission of the disease from one person to another will also be regulated in a simulation model. The likelihood of recovery after an infection lasts longer than one's recovery time. The average time it takes for someone to recover. The individual recovery time is actually drawn from the normal distribution which will be arranged in a simulation built according to real system conditions. There is an average individual's tendency to isolate themselves and not spread the disease. After an infected person is identified as positive for Covid-19, the individual will isolate himself in the current location and will stay there until full recovery. If an infected person is identified as a "hospital visitor," then he will go to the hospital, and will recover in half the time of the average recovery period specified in the model, due to better treatment and rest. Number of health workers or ambulances who move randomly, and force quarantine-sick people upon contact. Health workers are immune to illnesses, and they themselves do not physically accompany patients to the hospital. They move at speeds 5 times faster than other individuals in the world and are not limited by geographical area. It's possible for someone to get vaccinated, and therefore be immune from the virus. In this model, the person will move at the distance indicated by the slider in the simulation at each time step. Thus, the lower the level of intra-mobility, the less movement in individuals. Individuals move randomly with this given value; Ambulance always moves 5 times faster than this given value.

The limitation of modeling in this study is the disposable PPE that is used by medical personnel on duty. Every positive patient who goes to the hospital is handled by 4 medical personnel consisting of doctors, nurses, hospital staff who will contact directly to treat patients. The assumption used is 7 days of treatment with 2 times the doctor's visit. One medical person can treat 5-10 patients in one day, so the amount of PPE needed is the number of patients divided by the number of days added, the data is an estimate of the number of patients in one day. PPE used is divided into 5, this is because medical personnel will do the same visit on the same day with the same PPE. This data shows data on the addition of patients in one hospital. Because Indonesia's condition is quite alarming, this plan will help preventive logistics so that the needs of health workers are met.

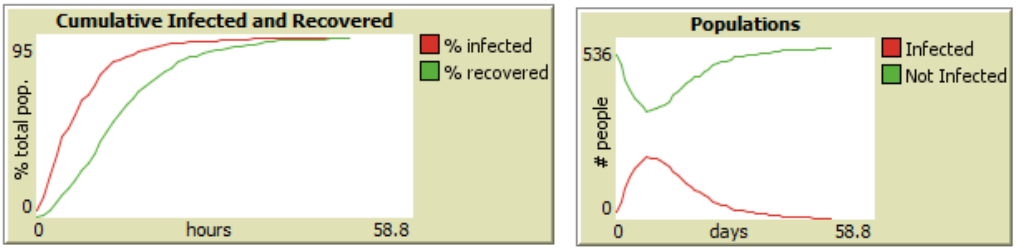

Figure 2. Number of people infected in Scenario 1

From figure 2, it is found that infected people will decrease over time, because the immune system of each person who has recovered will slowly form and gradually return to normal. The picture was obtained in a condition where awareness of isolation was not high enough, outdoor activities were also still high. With that, it is found that almost 95% of the population is infected with the amount of recovery that is not so high. In this condition the highest number of people infected is around 200 to 300 people in one day of the population in the model. In a free condition without restrictions on community activities, it can be estimated PPE needs in this condition is 240 to 320 in a day.

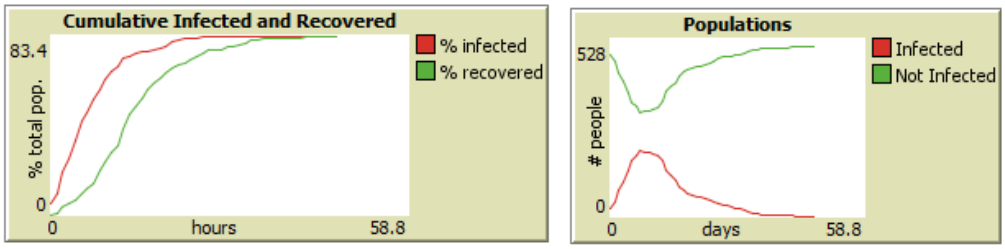

Figure 3. Number of people infected in Scenario 2

Figure 3 describe when the condition of activities outside the home is reduced and the awareness to do independent isolation is also very active. With this condition, the number of infected people is around 83% of the population. This second scenario is run with the same hospital capacity, ambulance, and services so that it can be seen that independent isolation has a significant impact on the rate of transmission of the Covid-19 virus.

The social distancing conditions that have been implemented by the Indonesian government illustrate the reduced rate of transmission in Indonesia. From the simulation that has been modeled, the predicted transmission rate will decrease for 58 days. This shows that the average Covid-19 patient would be 150-200 per day. With the use of PPE with frequent intensity from various hospitals spread throughout Indonesia, the disposable PPE planning can reach 120 to 240 units every day.

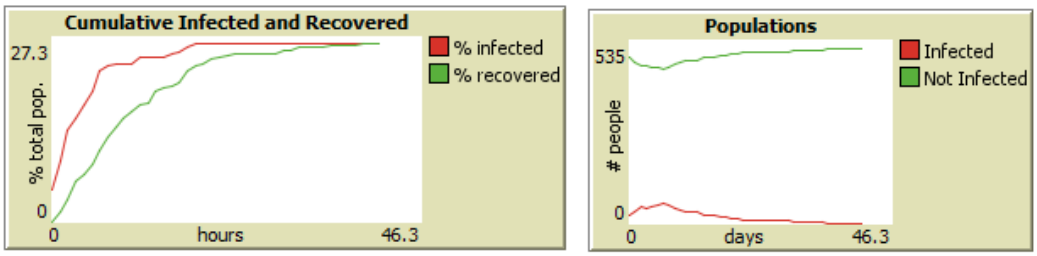

Figure 4. Number of people infected in Scenario 3

This scenario is based on restricted community activities, and health care is quite active in the conditions of this scenario. Figure 4 illustrates the conditions availability of health facilities is increased, the speed of COVID-19 detection tests is increased, and also the ambulance service until health services are improved. With the massive handling carried out, the infection rate to the community can drop dramatically. This scenario shows that only 27% of people are infected with COVID-19. Around 80-100 people are infected every day. PPE needs for medical personnel will also decrease if this scenario can be implemented well by the community and also the government. The amount of PPE needed is around 64 to 80 pieces every day.

From this scenario, it can be seen that community collaboration for independent isolation at home and government policies in dealing with this outbreak quite well can make a significant impact. With good cooperation, this outbreak will be handled well and can be completed in a short amount of time. In addition, medical workers will also be easier to control medical treatment for other patients.

5. Conclusion

Based on the results and discussion described earlier, an agent-based model has been built which is used to predict the number of patients affected by COVID-19. The results of this simulation will illustrate the number of patients that must be handled by medical personnel in accordance with the mindset that was built at the beginning, where the number of patients will affect the number of PPE needed by medical personnel. PPE distribution will be based on the number of needs of the distribution of COVID-19 patients in several regions, this will also be influenced by the ability of the factory to produce PPE in large numbers. This plan aims to meet the needs of PPE in the future to avoid over-demand which will make the manufacturers overwhelmed in the production process. In addition, with this forecasting, medical personnel will be assigned comfortably when handling COVID-19 patients. Therefore, the government can consider the application of prediction results from the model that has been built as an effort to improve decisions in handling COVID-19 outbreaks.

The model proposed to solve the problem of PPE needs for medical personnel needs additional studies on targeted distribution so that PPE can be distributed evenly in Indonesia. In addition, it is also necessary to consider the optimal costs in planning production and distribution, this research will help supply chain practitioners in determining decisions in handling to be carried out. Suggestions for further research are to involve several other stakeholders concerned with the making of PPE and its distribution. This research is expected to be one of the solutions so that the handling by the government will be faster and more precise.

References

Gennaro, F. Di, Pizzol, D., Marotta, C., Antunes, M., Racalbuto, V., Veronese, N., & Smith, L. (2020). Coronavirus Diseases (COVID-19) Current Status and Future Perspectives : A Narrative Review. International Journal of Environmental Research and Public HealthEnvironmental Research and Public Health, 17(2690), 1–11. https://doi.org/10.3390/ijerph17082690

Letko, M., Marzi, A., & Munster, V. (2020). Functional Assessment of Cell Entry and Receptor Usage for SARS-CoV-2 and Other Lineage B Betacoronaviruses. Nature Microbiology, 5, 562–569. https://doi.org/10.1038/s41564-020-0688-y

Lingeswaran, M., Goyal, T., Ghosh, R., & Suri, S. (2020). Inflammation , Immunity and Immunogenetics in COVID-19 : A Narrative Review. Indian Journal of Clinical Biochemistry, 35(3), 260–273. https://doi.org/10.1007/s12291-020-00897-3

Meng, H., Xiong, R., He, R., Lin, W., Hao, B., Zhang, L., & Lu, Z. (2020). CT Imaging and Clinical Course of Asymptomatic Cases with Covid-19 Pneumonia at Admission in Wuhan, China. Journal of Infection, 81(2020), e33–e39. Retrieved from https://doi.org/10.1016/j.jinf.2020.04.004

Susilo, A., Rumende, C. M., Pitoyo, C. W., Santoso, W. D., Yulianti, M., Sinto, R., … Yunihastuti, E. (2020). Coronavirus Disease 2019 : Tinjauan Literatur Terkini. Jurnal Penyakit Dalam Indonesia, 7(1), 45–67.

Xu, X., Chen, P., Wang, J., Feng, J., Zhou, H., Li, X., … Hao, P. (2020). Evolution of Novel Coronavirus from The Ongoing Wuhan Outbreak and Modeling of Its Spike Protein For Risk Of Human Transmission. Science China Life Sciences. Science China Life Sciences, 63(3), 457–460.

Ye, Q., Wang, B., & Mao, J. (2020). The Pathogenesis and Treatment of the ‘ Cytokine Storm ’ in COVID-19. Journal of Infection, 80(6), 607–613. https://doi.org/10.1016/j.jinf.2020.03.037

Zhu, N., Zhang, D., Wang, W., Li, X., Yang, B., Song, J., Tan, W. (2020). A Novel Coronavirus from Patients with Pneumonia in China, 2019. The New England Journal of Medicine, 382(8), 727–733. https://doi.org/10.1056/NEJMoa2001017

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