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Optimization of Personal Protective Equipment Distribution Costs to Health Centers with Stepping Stone Method

Arief Budi Nugroho[1], Meinarini Catur Utami [2], Suryo Santoso Putro[3]

***Abstract*—This study aims to apply the Stepping Stone transportation method to optimize transportation costs for sending personal protective equipment (PPE) to thirteen health centers in Pamekasan. The method used is the Stepping Stone transportation method because it can manage the distribution of several warehouses that provide products to be sent to places in need optimally, which was previously a problem due to the length of time for sending medicines and PPE to each health centre and shipping operational costs are increasing because the distance of each warehouse to each health centre in each sub-district is very influential for cost as well as time. Based on the results of transportation simulations with this method, the results of the distribution cost of PPE delivery to each health centre in Pamekasan were obtained with distribution to Pamekasan warehouses of 30,000 units, Pakong warehouses of 15,000 units, Tlanakan warehouses of 10,000 units, and Pasean warehouses of 19,500 units, with optimal costs of IDR 37,000,000. The contribution of this research can be used by the Pamekasan District Health Office as an alternative policy for distributing PPE to each health centre in Pamekasan at an optimal cost.**

***Index Terms*—Stepping stone, transportation, optimal cost.**

I. Introduction

Corona virus (COVID-19) is a large family of viruses that cause respiratory infections, from the common cold to serious diseases like Middle East respiratory syndrome (MERS) and severe acute respiratory syndrome (SARS). The disease mainly spreads among people through respiratory droplets from coughing and sneezing. The COVID-19 pandemic is a disease caused by exposure to a virus commonly called COVID-19. Medically, this corona virus is also called severe acute respiratory syndrome 2 (SARS-CoV-2). This virus can survive up to three days in plastic and stainless steel [1]. SARS CoV-2 can survive for up to three days or in aerosols for three hours. By this, the coronavirus can only move through intermediaries like hands, clothes, or other media exposed to droplets of coughing and sneezing. Indonesia is one of the positive countries for COVID-19. This disease began in China along with the spread of the Corona virus.

The first case in Indonesia occurred in Indonesia and was experienced by two residents of Depok, West Java. This was announced directly by President Joko Widodo at the Presidential Palace, Jakarta on Monday, March 2, 2020. According to Mr. Joko Widodo, the two residents are a 64-year-old mother and her 31-year-old daughter. Both are suspected of contracting the coronavirus due to contact with Japanese citizens who came to Indonesia. The Japanese citizen was detected by Corona after leaving Indonesia and arriving in Malaysia. The Ministry of Health team traced other residents who had previously interacted with Japanese citizens while in Indonesia. According to the Ministry of Health, the child is thought to have contracted coronavirus 2 while dancing with Japanese nationals at a club in Jakarta on February 14, 2020 [2]. Secretary of the Directorate General of Disease Prevention and Control of the Ministry of Health Achmad Yurianto said that the number of people who attended the event was 50 people. On February 16, 2020, the child complained of coughing and being a bit hot, then went to the doctor. After the event, the Ministry of Health tried to track everyone who participated in dancing at the event. After announcing the first case of the coronavirus in Depok, President Joko Widodo ensured that the government had prepared health facilities and medical equipment to treat coronavirus patients that met international standards. The government has allocated a budget for handling the coronavirus outbreak in the country [3].

The outbreak of COVID-19 pandemic has made health workers work more optimally to serve people who are experiencing illness, including health workers who work in health center, both in big cities to remote areas spread across Indonesia. As is known that the numbers of health center during COVID-19 are around 10,203 units as seen in Figure 1. However, the increase in health center has experienced an upward trend from 2016 to 2020, consisting of 4,119 inpatient health centers and 6,086 non-inpatient health centers [4].

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[1]A. B. Nugroho, UIN Syarif Hidayatullah Jakarta, Indonesia (email: arief.bn18@mhs.uinjkt.ac.id)
[2]M. C. Utami, UIN Syarif Hidayatullah Jakarta, Indonesia (email: meinarini@uinjkt.ac.id)
[3]S. S. Putro, Tohoku National University, Japan (email: suryo.santoso.putro.q1@dc.tohoku.ac.jp)

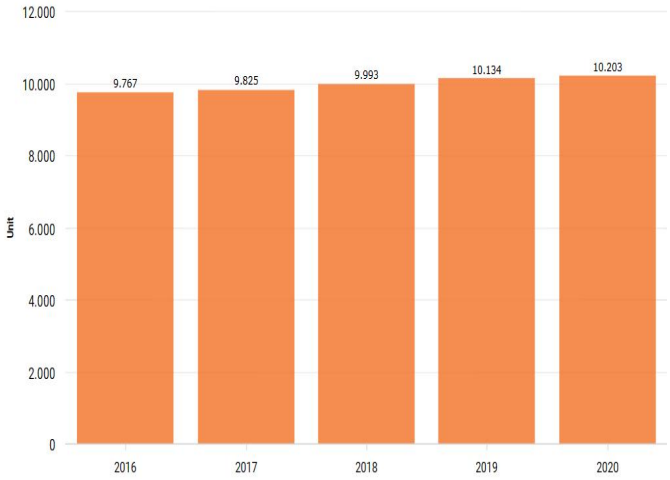

Fig. 1. 1 Health Center Unit From 2016-2020

The existence of COVID-19 requires all health centers to be ready and alert, so that a health centre, as a community health centre, must be able to provide maximum services for 24 hours. In 2020, the number of health workers in health centers reached 1,081,579 [5]. This is a challenge for the government, and it turns out that not only the distribution of medicines needs to be considered to overcome the spread of the COVID-19 virus but also the distribution of PPE for health workers also needs to be considered. The need for medicines and personal protective equipment (PPE) in each health center has increased, therefore the regional government has increased the supply of medicines and personal protective equipment to prevent the transmission of COVID-19 in the community

As stated in the previous paragraph, health centers have been located throughout Indonesia, including Madura. Madura is an island located east of Java. Madura consists of several major cities, namely Bangkalan, Pamekasan, Sumenep, and Sampang. When COVID-19 occurs, the number of COVID-19 cases can increase to 417 people in a month, so in June 2020, COVID-19 cases reached 501 people, with the most death cases in Pamekasan [6]. The distribution of health centres in Pamekasan, which regency has 13 sub-districts with a population spread across 178 villages and 11 sub-districts of 850,057 people, can be seen in Figure 2: 433,096 female residents and 416,961 male residents in 2020 [7].

There were the most cases of death in Pamekasan at that time, raising fears of severe transmission. Death cases are suspected not only among patients but also among health workers who are directly involved when handling COVID-19 patients; as reported by BBC Indonesia on August 30, 2021, the number of deaths of health workers in Indonesia due to COVID-19 is the highest in Asia [8].

Data on the distribution map of COVID-19 in Pamekasan are shown in Figure 2. It shows that in 2022 there were 2603 positive COVID-19 cases, with each sub-district having high and medium risks. Looking at this data, it is certain that the need for drugs for patients and PPE for health workers must be considered. The need for medicines and PPE in each health center will certainly also increase, so the regional government, through the Pamekasan Regency Health Office, must have a large stock of medicines and PPE to be able to serve the needs of the community [9].

Fig. 2. Situation of Covid-19 in Pamekasan Regency

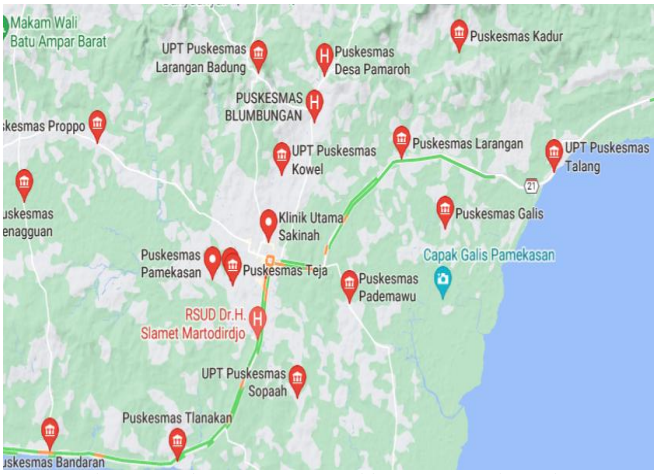

Fig. 3. Pamekasan Regency Health Center Location Point

The distribution of community health centers in Pamekasan can be seen in Figure 3. The problem that occurs in the field is the length of time it takes to send medicine and PPE to each health center, and the operational cost of delivery is increasing. This is the focus of researchers conducting research aimed at optimizing the distribution of drug and PPE shipments to each health center in the 13 districts of Pamekasan. Therefore, researchers in this study used transportation methods to determine the distribution of medicines and PPE to the 13 health centres in Pamekasan.

The transportation method is a method in operations research that usually manages the distribution or delivery of a product from several sources that provide the same product to several places that need it optimally [10]. The transportation method is a method used to organize the distribution from those sources that provide the same product to places of optimal need [11]. The allocation of this product must be arranged in such a way because there are differences in the costs of allocation from one source to another [12]. One of the optimization models is the transport model. The transportation model is a mathematical model and a special type of linear programming model [13]. In addition to the transportation model, also

included in the special type of transportation model is the transshipment model.

Some of the previous studies on the application of the transportation model are as follows: optimization of LPG delivery distribution using transportation and transshipment methods [14], allocation of goods distribution with minimum total costs [15], optimization of water distribution [16], optimization of the distribution of fish transport vessels [17], and optimization of animal feed delivery [18]. These are examples of studies that specifically optimize the cost, like the writer of this research. There are several methods of transportation completion, namely northwest corner, stepping stone, and Vogel approximation [10].

Many researchers have used all three methods of solving the problem. Hasanah et al. [19] used the northwest corner and stepping stone methods for pharmaceutical product distribution. The results showed that transportation costs using the Stepping Stone method were lower at IDR 13,341,654,000 than using the North West Corner at IDR 21,394,461,000. The results of research by Nteseo et al. [20] showed the same results as [19], where Nteseo used two methods, namely the northwest corner and stepping stone, to determine the distribution cost of 3 kg LPG cylinders, with smaller stepping stone results compared to the northwest corner. Furthermore, their research results from Imbang [21] use the North West Corner method to obtain material distribution costs for the construction of the laboratory building of the Faculty of Engineering, Sam Ratulangi University [20], [21]. In addition, there is research from Lestari and Christy [22] that uses the Vogel Approximation Method and Modified Distribution Methods for the delivery of PT. Coca-Cola. The results showed that the calculation of distribution costs using the Vogel Approximation Method was higher than using Modified Distribution. The Stepping Stone method was also used by Fahmi [23] and succeeded in determining the optimal solution for shipping goods.

In this study, the author uses the Stepping Stone transportation method to solve transportation problems for drug and PPE shipment distribution and determine product delivery costs. The author chose this method because, based on the literature study mentioned in the previous paragraph, the stepping stone method proves to be able to provide cheap distribution costs compared to the other two methods. Besides, the stages of working on the stepping stone method are easy to understand, so it is easy for the author to practise optimizing the distribution of PPE from the storage warehouse to each health center using the stepping stone transportation method.

II. Research Methodology

The tool used in this study is the stepping stone transportation method. This method is a procedure for finding the potential of any non-basic variables (empty cells) in terms of the objective function. And with this method in this case of research, optimal cost can be found, and the Steeping Stone is the easiest method to do.

Data collection is obtained by a method that is not addressed directly to the research subject, using secondary documents written based on other people's reports or stories [24, 25]. The data used came from other research conducted by four authors from the Madura Islamic University of Informatics Engineering study programme [26]. With this complete data now published, writers have chosen to use it as a secondary document and put it on a different method than the previous one, which did not use the Stepping Stone transportation method.

Based on the data that has been obtained, there are 4 warehouses as the main distributors of the health center in the Pamekasan district, as seen in Table 1.

Table 1. Warehouse Name and Its Capacity

Warehouse Name	PPE and Medicine Capacity
Pamekasan	30.000
Pakong	15.000
Tlanakan	10.000
Pasean	20.000

III. Results and Discussion

A. Data Identification

A total of 13 districts with various requests have been classified in Table 2. This request has already been equated with previous research.

Table 2. Request for Each District

Region	Demand
Kec 1	4.000
Kec 2	7.000
Kec 3	3.000
Kec 4	4.000
Kec 5	2.000
Kec 6	7.000
Kec 7	8.000
Kec 8	8.500
Kec 9	3.000
Kec 10	5.000
Kec 11	7.000
Kec 12	9.000
Kec 13	7.000

As can be seen in Table 3, the distance between PPE storage warehouses and health centers is calculated in kilometres; however, this table has been reorganized by the writer from previous research. Transportation costs every 1 km at IDR 50, and the total cost of shipping medicines and PPE from the warehouse to the health center is obtained by multiplying the mileage by costs and requests (this statement has already been settled by previous research). The capacities of Pamekasan Warehouse are 30,000, Pakong

Warehouse is 15,000, Tlanakan Warehouse is 10,000, and Pasean Warehouse is 20,000.

Table 3. The Distance of Each Warehouse to Each District

Destination\ Source	Dis 1	Dis 2	Dis 3	Dis 4	Dis 5	Dis 6	Dis 7	Dis 8	Dis 9	Dis 10	Dis 11	Dis 12	Dis 13
Warehouse Pamekasan	5	10	8	9	11	8	15	20	15	22	25	30	35
Warehouse Pakong	15	17	16	14	12	13	12	8	8	5	8	10	12
Warehouse Tlanakan	3	11	9	12	7	10	17	22	17	24	27	32	38
Warehouse Pasean	38	32	27	24	17	22	17	15	20	9	6	5	3

B. Stepping Stone Test

After obtaining the data needed for the use of the Stepping Stone transport method, input all the data into the table and execute the steps according to the way. As we know, this method is to find an optimal cost, so we start to make Table 4 and add the demand for each region, and at the next column, add capacity for each warehouse, then at the northwest corner, put demand from each region, then continue to the right until the capacity of the first warehouse has been reached.

Table 4. Calculation By Stepping Stone Method

Destination\ Source	Dis 1	Dis 2	Dis 3	Dis 4	Dis 5	Dis 6	Dis 7	Dis 8	Dis 9	Dis 10	Dis 11	Dis 12	Dis 13	Capacity
P1	5 4000	10 7000	8 3000	9 4000	11 2000	8 7000	15 3000	20	15	22	25	30	35	3000
P2	15	17	16	14	12	13	12	8	8	5	8	10	12	15000
P3	3	11	9	12	7	10	17	22	17	24	27	32	38	10000
P4	38	32	27	24	17	22	17	15	20	9	6	5	3	20000
Demand	4000	7000	3000	4000	2000	7000	8000	8500	3000	5000	7000	9000	7000	

Then, when the capacity in the first warehouse has already been filled but there's still demand in that region, put that demand on the next warehouse with the amount of demand that has already been reduced from the first warehouse. After continuing to the right like in the beginning, this step is shown in Table 5.

Table 5. Calculation Progress by Stepping Stone Method

Destination\ Source	Dis 1	Dis 2	Dis 3	Dis 4	Dis 5	Dis 6	Dis 7	Dis 8	Dis 9	Dis 10	Dis 11	Dis 12	Dis 13	Capacity
P1	5 4000	10 7000	8 3000	9 4000	11 2000	8 7000	15 3000	20	15	22	25	30	35	3000
P2	15	17	16	14	12	13	12 5000	8 8500	8	5	8	10	12	15000
P3	3	11	9	12	7	10	17	22	17	24	27	32	38	10000
P4	38	32	27	24	17	22	17	15	20	9	6	5	3	20000
Demand	4000	7000	3000	4000	2000	7000	8000	8500	3000	5000	7000	9000	7000	

The final result of the stepping stone method is shown in Table 6.

Table 6. Final Table Result With Stepping Stone

Destination\ Source	Dis 1	Dis 2	Dis 3	Dis 4	Dis 5	Dis 6	Dis 7	Dis 8	Dis 9	Dis 10	Dis 11	Dis 12	Dis 13	Capacity
P1	5 4000	10 7000	8 3000	9 4000	11 2000	8 7000	15 3000	20	15	22	25	30	35	3000
P2	15	17	16	14	12	13	12 5000	8 8500	8 1500	5	8	10	12	15000
P3	3	11	9	12	7	10	17	22	17 1500	24 5000	27 3500	32	38	10000
P4	38	32	27	24	17	22	17	15	20	9	6 3500	5 9000	3 7000	20000
Demand	4000	7000	3000	4000	2000	7000	8000	8500	3000	5000	7000	9000	7000	

Table 6 is described as follows:
P1 = (IDR 50 × 4000 × 5) + (IDR 50 × 7000 × 10) + (IDR 50 × 3000 × 8) + (IDR 50 × 4000 × 9) + (IDR 50 × 2000 × 11) + (IDR 50 × 7000 × 8) + (IDR 50 × 3000 × 15) = IDR 13,650,000
P2 = (IDR 50 × 5000 × 12) + (IDR 50 × 8500 × 8) + (IDR 50 × 1500 × 8) = IDR 7,000,000
P3= (IDR 50 × 1500 × 17) + (IDR 50 × 5000 × 24) + (IDR 50 × 3500 × 27) = IDR 12,000,000
P4= (IDR 50 × 3500 × 6) + (IDR 50 × 9000 × 5) + (IDR 50 × 7000 × 3) = IDR 4,350,000
P1 + P2 + P3 + P4 = IDR 37,000,000

Figure 5 shows the results of the Stepping Stone's calculations, which show that the cost of transporting PPE shipments from warehouses to several health centres is IDR 37,000,000. The results of the distribution of PPE shipments to each health center are as follows:

- Kec 1 is sent from Pamekasan warehouse 4000 equal to the number of requests for 4000 units.
- Kec 2 is shipped from the Pamekasan warehouse 7000 equal to the number of requests for 7000 units.
- Kec 3 shipped from Pamekasan warehouse 3000 is equal to the number of requests for 3000 units.
- Kec 4 is shipped from Pamekasan warehouse 4000 equal to the number of requests for 4000 units.
- Kec 5 shipped from Pamekasan warehouse 2000 is equal to the number of requests for 2000 units.
- Kec 6 shipped from Pamekasan warehouse 7000 is equal to the number of requests for 7000 units.
- Kec 7 is shipped from the Pamekasan warehouse 3000 and Pakong 5000 equal to the total demand of 8000 units.
- Kec 8 shipped from Pakong warehouse 8500 is equal to the requested amount of 8500 units.
- Kec 9 shipped from Pakong warehouse 1500 and Tlanakan warehouse 1500 equal to the total demand of 3000 units.
- Kec 10 shipped from Tlanakan warehouse 5000 equals the number of requests 5000 units.
- Kec 11 was shipped from Tlanakan warehouse 3500 and Pasean warehouse 3500 with a total demand of 7000 units.
- Kec 12 shipped from Pasean warehouse 9000 equals the number of requests of 9000 units.
- Kec 13 shipped from Pasean warehouse 7000 equals the number of requests of 7000 units.

For the total shipments from each warehouse, optimal results are obtained on demand at each health center, namely:

- Pamekasan's warehouse has distributed 30,000.
- Pakong's warehouse has distributed 15,000.
- Tlanakan's warehouse has distributed 10,000.
- Pasean's warehouse has 19,500 still 500 units left in the warehouse.

The results shown in this study have a more valid calculation basis than those in the previous literature. The calculation results refer to the steps as recommended by the stepping stone method. While the literature only relies on Excel solvers with steps that can only be accessed with Microsoft Excel software.

IV. CONCLUSION

This research has shown that Stepping Stone's method of getting PPE to each health centre and getting goods from the

warehouse to each health centre is the best way to figure out how much each should cost. The cost required to be able to send PPE is IDR 37,000,000. The results of the distribution of medicines and PPE from the warehouse to the health center are as follows: The Pamekasan Warehouse has 30,000 units distributed all; the Pakong Warehouse has 15,000 units distributed all; the Tlanakan Warehouse has 10,000 units distributed all; and the Pasean Warehouse has 19,500 units distributed all. There are still 500 units left in the warehouse. This research can be used as a reference by the Pamekasan Regency Government in optimizing the distribution of PPE to each health center. Although the results of the previous study had fewer cost results than this study.

There are several gaps between this research and previous research using the same data. First, in addition to the amount of IDR produced by this research being greater than before, the research uses a method that is easier than before. Prior research must first establish some kind of decision variables, constraints, and objectives. Therefore, previous research used 16 decision variables, 20 constraints, and 1 goal that aimed for the same thing as this research: minimizing shipping costs.

Although the results of this study are much more expensive than previous studies, the author finds another point of view on an existing problem and creates new and original innovations. For the next work, this study can develop another point of view such as the North-West Corner or the Vogel Approximation Method. The calculation results will probably be different from the calculation results in this study. The results of this calculation will be further analyzed if the cause of the calculation results of the 3 methods applied.

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