Optimizing A Route Path For A Mobile Blood Collection System

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ABSTRACT- Today the population of the world is growing rapidly. Human life is under threat. There are many health problems all around the world. The most needed item for the healthcare is blood. Many of people search for suitable blood in case of a health problem. This is really necessary to get the suitable blood in right time. In this study, the optimal route for mobile blood collection system is determined. The blood is collected by the bus. An application is made in Ankara, Turkey. The bus must be placed in critical places in Ankara. Multi-objective programming is used for routing the buses. The objectives are minimizing the total distance and minimizing the fuel consumption. In this study, taking the blood in different parts of Ankara is helped to give the blood in right time to right person.

KEYWORDS Vehicle Routing Problem, Healthcare Logistic, Multi-Objective Programming, Mobile Blood Collection.

1. INTRODUCTION

In this study, one of the leading health problem is addressed. Population of human is growing rapidly. And there are many diseases in all over the world. The most needed item is blood for human life. Today, it is really difficult to get the blood when needed. There are many reasons. One of the reason is deficiencies of collecting blood. Many blood centres are available in Ankara. But the blood that collected from these centres isn't enough. Other methods must be used to get more. In this study, mobile blood collection system is used. The bus must go to the places that determined before. The population of these places can be decisive for collecting how much blood can be taken. Next section, the literature review is given about healthcare logistics. And in the other sections, a mathematical model is given for blood collection systems. An application is made in Ankara for this system.

2. LITERATURE REVIEW

The healthcare system is one of the most important system for human life. In the literature these problems can be classified under the medical supply transportation problems as a healthcare logistics problem[1]. There are so many studies that include these kinds of problems. In Sahin et al.'s study, the problem of location and allocation of blood center is determined. This problem is pq-median problem. The authors suggest a mathematical model in this study[2]. In Doerner et al.'s study, a route path is determined for mobile healthcare facilities. Multi-criteria decision tools are used to decide an optimal route[3]. In Yücel et al.'s study, the authors optimize specimen collection for processing in clinical testing laboratories. A linear mixed integer programming is used to transport the specimen[4]. In Alfonso et al.'s study, there is a simulation of blood collection system[5]. In Anaya-Arenas et al.'s study, biomedical sample transportation in Quebec is showed. Multi-trip vehicle routing problem with time windows is made for biomedical sample transportation[6]. In Banos et al.'s study, a hybrid meta-heuristic for multi-objective routing problems is developed with time windows[7]. In Liu et al.'s study, home healthcare work has been done. In this study, the limit of the storage arrival time is not considered. The arrival times of the vehicles are not considered[8]. In Kritikos et al.'s study, the authors have studied a time window vehicle routing problem that balances the medical supplies received by each vehicle[9]. In Lopez-Sanchez et al.'s study, a problem has been worked out which aims to minimize the time spent on vehicles. If the arrival times of the vehicles are not the same, what kind of arrangements are being made. The transport of medical supplies is covered[10]. In Naji-Azimi et al.'s study, a study has been carried out on the daily transport processes of biomedical samples taken from hospitals and clinics. Multiple routes are used. Samples are carried in cold boxes. Each sample has to reach the laboratories within a certain period of time.[11]. In Jozefowiez et al.'s study, they have studied a two-objective problem aimed at minimizing distances and distances in the road. They have determined the longest and shortest routes[12]. In Doerner et al.'s study, they have studied the problem of blood collection. The process of the problem of blood collection started from the moment of donation. Independent time windows are used. They also did not take into account the arrival times of reservoirs[13]. In Doerner et al.'s study, the problem of blood collection is studied[14]. In this study, a blood collection is also studied. But the mobile blood bus is used to collect the blood from different part of the city. The difference from the literature is using multi-objective approach to collect the blood for mobile blood service system. Next section, mobile blood system is described. And other sections, an application in Ankara is made and mathematical model for this problem is given. In the end, an optimal route for blood collecting bus is determined.

3. MOBILE BLOOD SYSTEM

Today, it is one of the most important thing to provide a good a health care system for people. Blood is the main thing to survive in the world. It could be really necessary to get the blood in right time. There are so many blood centers to collect more kinds of blood from people to keep it till someone needs them. But sometimes it can be difficult to collect enough blood. Healthcare centers find alternative ways to collect the blood fast. One of these alternative way is using mobile blood bus. The blood buses must have all the health supplies inside them.

Mobile blood buses collect the blood from different part of the city. And then blood samples are classified and go to the storage. The blood samples have to keep in cold boxes till arriving the blood centers.

4. APPLICATION

In this study, an application is made in Ankara. Ankara is the capital of the Turkey and the population is too high in this city. So it is necessary to use mobile blood buses in Ankara. In this study, a route path must be determined for a mobile blood bus. There are 5 bus stops to collect the blood samples. These stops are in Gölbaşı(G), Kızılay(K), Cebeci(C), Yenimahalle(Y) and Mamak(M). The bus starts working at 8 am and stops at 10 pm in a day. Deciding a route between these places is very important. The distance between these places are given in Table1.

Table 1. Results for the epsilon-constraint method

	G	*K*	*C*	*Y*	***M***
G	-	18	22	56	30
K	18	-	3	23	5
C	22	3	-	22	3
Y	56	23	22	-	44
M	30	5	3	44	-

A multi-objective mathematical model is used to determine an optimal route for the bus. The mathematical model is given below in next section.

5. MATHEMATICAL MODEL

In this study, the mathematical model has two objectives. These are minimizing total distance and minimizing fuel consumption of the blood bus. The notations and formulation of the mathematical model is given below.

5.1. Notations

Notation of the model is given below.

i, j: Transportation node index, i=1,…,5 and j=1,…,5 cell nodes and i,j=1 is blood center.

t_{ij}: The distance between the stop i to stop j.

R: A set of intermediate stops.

u_i: It has any real value of stop i.

s_{ij}: fuel consumption amount from stop i to stop j.

5.2. Objective Functions

$$\min F1 = \sum_{i=1}^{5} \sum_{j=1}^{5} t_{ij} x_{ij} \quad (1)$$

$$\min F2 = \sum_{i=1}^{5} \sum_{j=1}^{5} s_{ij} x_{ij} \quad (2)$$

5.3. Constraints

$$\sum_{i=0}^{N_k} x_{ij} = 1 \qquad \forall j=1,2,\ldots,5 \quad (3)$$

$$\sum_{j=0}^{N_k} x_{ij} = 1 \qquad \forall i=1,2,\ldots,5 \quad (4)$$

$$u_i - u_j + n.x_{ij} \leq n-1 \qquad \forall i \neq j \in R \quad (5)$$

In this mathematical model, the equations (1) and (2) are the objective functions. (3) and (4) constraints are providing to visit each stops at least once. And also equation (5) denotes the sub-tour elimination constraints, using Gomory cutting planes approach developed by Miller, Tucker and Zemlin[15]. These constraints took the tour of the state model to inhibit the formation of approximately (n^2-3n+2) lead to the addition of one constraint[16]. In particular, the use of this Miller, Tucker and Zemlin constraints in oversized model is much easier and the routing problem is one of the constraints to improved well-received tour blocking.

6. COMPUTATIONAL RESULTS

In this study, the mathematical model has two objective functions. To solve the multi-objective models, some methods can be used. In the literature, there are 3 leading methods in the vehicle routing problem. These methods are; the weighted-sum method, the €-constraint method and the augmented weighted tchebycheff function method. The results for the weighted-sum method are given in Table2.

Table 2. Results for the weighted sum method

Solutions	*Objective (F_1,F_2)*	*Route*
1-3	104,19	G-K-M-C-Y-G
4-21	96,20	G-M-C-Y-K-G

The other method to combine the objectives is the epsilon-constraint method. For this method, one of the objective function is written as the constraint and the problem is solved as it has one objective function. Epsilon values are changing between 19-99. Table3 shows the results of the epsilon-constraint method.

Table 3. Results for the epsilon-constraint method

Solutions	*Objective (F_1,F_2)*	*Route*
1	96,20	G-K-Y-C-M-G
2-21	102,23	G-C-Y-K-M-G

The third method is the augmented weighted tchebycheff function method. This method based on the minimization of distance from ideal point. Table4 shows the results of this method.

Table 4. Results for the augmented weighted tchebycheff function method

Solutions	***Objective (F_1,F_2)***	***Route***
1-21	96,20	G-M-C-Y-K-G

6. CONCLUSION

This study is an application to collect the blood samples by a mobile blood bus from different part of the cities. In this study, the mathematical model has two objective functions. Three of leading methods from the literature is used to combined the objectives. According to the results that calculated by GAMS 24.7.1 program, the best method for mobile blood systems routing problem is ‘Augmented Wighted Tchebycheff Function Method’. It has the pareto efficient point more in many place number of these places are higher than the other methods have. For both objective functions, the optimal is (F_1=96, F_2=20). Finally, the optimal route for the mobile blood is determined. The route must be G-M-C-Y-K-G. So sequence must be Gölbaşı, Mamak, Cebeci, Yenimahalle, Kızılay. Finally the bust have to come back the blood center in Gölbaşı.

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