# A Multi-Criteria Decision-Making Model for a Drive-Through Test Station Site Selection in Epidemic Situations

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## Abstract

The COVID-19 virus, which was first detected in 2019, was declared a pandemic by the World Health Organization in March 2020 and turned into a historical event that affected the whole world. In addition to being a global health crisis, controlling the epidemic, which has become an economic, political and social problem, has become the number one priority of the world's countries. Studies and statistics on the subject have shown the importance of case detection in order to prevent COVID-19. The finding that the number of cases decreases as the number of tests increases is the main reason for this paper. The drive-through test station, which was first built in South Korea, has demonstrated that the COVID test practice is much safer, efficient, and practical. Although the application started to be used in many countries later on, there is no example in Turkey yet. This paper uses two different multi-criteria decision-making approaches for the drive-through test station location selection in cases of epidemics in the Şehitkamil and Şahinbey districts of Gaziantep. In the study, while the considered criteria are prioritized using the analytic hierarchy process (AHP), the alternative sites illustrated using Bing Maps are ranked using the combinative distance-based assessment (CODAS) approach. As a result of the research, candidate places for drive-through test stations that could be established in the event of a possible epidemic in the future, and it is determined that these candidate places could also be used as distribution points in future emergencies other than the epidemic situation.

## Keywords
AHP, CODAS, Drive-through, COVID-19, Site selection

## 1. Introduction
COVID-19, which started in Wuhan province of China and affected the whole world and was declared by the World Health Organization as an international public emergency on January 30, 2020, and as a pandemic on March 11, 2020. Since then, the virus has spread all over the world, and as of 18 July 2022, it has infected 5.82 million people, and caused 6.37 million deaths. (Yang, L., Liu, S., Liu, J., Zhang, Z., Wan, X., Huang, B., ... & Zhang, Y. (2020). COVID-19: immunopathogenesis and Immunotherapeutics. Signal transduction and targeted therapy, 5(1), 1-8.) Covid 19 not only put human life at risk, but also caused the world economy to shrink. Pandemic comes etymologically from a Greek word "pandemos", it means a global epidemic, it is distinguished from an epidemic, which may connote limitation to a smaller area and a concept pertaining to all people and the public in the world. Therefore, a pandemic is defined as the highest level of global health emergency and affecting multiple regions of the world. In general, declaring a pandemic is assumed a historical event since it is not just a health issue, it has also economic, political and social dimensions at the global level. (Açikgöz, Ö., & Günay, A. (2020). The early impact of the Covid-19 pandemic on the global and Turkish economy. Turkish journal of medical sciences, 50(SI-1), 520-526.) There were curfews around the world. Travel restrictions have been imposed worldwide. As a result of all these developments, it has become the priority of countries to prevent the virus. Along with the measures taken to control the spread of the epidemic, it is observed that international supply chains, supply-demand balances, producer/consumer behavior,

business methods, working models, and daily life are changing dramatically, and many problems triggered by the epidemic are being addressed and solutions are proposed becomes important. (McKibbin ve Fernando, 2020)

A lot of measures have been taken to prevent the spread of the virus such as social distance, sanitation of the hands regularly for at least 20 seconds, wearing masks. As the virus got worse day by day, tests have been developed to detect the disease. Due to the epidemics and pandemics that have been seen in our world for centuries, there are many researchers who have worked on these issues and are still doing it. Various studies such as developing vaccines, drugs or new types of tests for the epidemic continue at full speed. (Granade, 2005; Vasoo vd. 2009; Xie vd. 2020; Deeks vd. 2020; Lurie vd. 2020)

Studies and statistics show that as the number of tests increases, the number of cases decreases drastically. Researches (Binnicker 2020; Balilla, 2020) show that it is important to increase the number of tests, accelerate the process and at the same time perform the tests in a geographically balanced way in order to control and prevent the epidemic. Although the tests for COVID-19 vary, there are 3 test methods with proven success. These are (Xie et al. 2020): (i) Polymerase chain reaction test, (ii) Serological antibody test, and (iii) Computed tomography of the chest test. The most used method is the polymerase chain reaction (PZT) test. In PZT tests, samples are taken from the nose and throat by swab method. This test is the most used test in Turkey as well as in the world. Although the PZT Test is the easiest covid test to apply, it also offers the opportunity to be applied outside the hospital. This opportunity also paved the way for the establishment of drive-through test stations. Drive-through Covid-19 testing is safe and efficient for the patients and health care workers.

### 1.1 Objectives

This study aims are established during the pandemic. Gaziantep was one of the worst cities in Turkey in terms of pandemic. The crowded population and lack of precautions makes the situation the way it was. According to the analysis, higher test numbers supported the decrease of COVID cases. However, in Turkey and also in Gaziantep, people had to go to the hospitals to take the PCR test and this cause interaction which is helped the virus to spread. This study aims to locate the most suitable locations to establish drive through test station for COVID-19 testing. Drive through testing will helped the people to take the PCR test with the minimum interactions and it will protect both the patients and the health workers.

Furthermore, with this study and the methods that will be used, researchers aimed to locate the critical points for epidemic situations with using multiple criteria and aspects of the epidemic and the pandemic. The second and important purpose is to use these locations not only for drive-through test station and for other emergency situations. For example, if it will be needed, these locations can be used for food distribution, vaccination, or any other emergency aid.

## 2. Literature Review

Studies on COVID19 and Drive Through test station were examined. Finally, the following findings were reached.
**Varma et al. (2020):** The value of this MOPH project and how it has assisted in addressing the problem is investigated in this paper. The "Drive-Thru" swabbing hubs have been a practical approach because they lower the risk of exposure for travelers to COVID-19 patients who may be suspected at COVID centers. By making testing simple and lessening traveler concern, this has helped to stop the spread of COVID-19 and lessen the burden of an exponentially growing number of travelers visiting COVID centers.

**Flynn et al. (2020):** A high-volume COVID-19 drive-through testing approach for kids and pediatric healthcare professionals is investigated in this research, along with its design and implementation. Through this study, the authors were able to test patients quickly, avoid long lines, save PPE, maintain a top-notch patient and family experience, scale and replicate the model to boost volume, and test more patients. Age data indicate that a sizeable number of the healthcare professionals working with children made up our testing sample, underlining our vital role in assisting healthy workers return to the workforce.

**Ton et al. (2020):** This study shows the use of the drive-through COVID-19 test as an effective strategy to minimize patient contact and save PPE. A drive-through unit for COVID-19 testing has been installed for established patients on the Mayo Clinic, Florida campus. Transit operates 6 hours a day, 7 days a week and consists of 3 stations. In Ward 1, the patient displays his or her patient ID and mobile number on the vehicle's dashboard. You will receive a handout on the expectations of result notifications and recommendations from the Centers for Disease Control and Prevention regarding COVID-19 prevention and symptom monitoring.

**Summerlin-Long et al. (2021):** As part of the care of COVID-19 patients in high-risk areas, we have introduced a personal protective equipment (PPE) monitor. Despite caring for more than 1400 COVID-19 patients, PPE monitors assisted health care workers (HCPs) when dressing and undressing, and nearly COVID-19 to HCPs. Contributes to zero infection.

**Zmora et al. (2021):** One of the strategies to contain a pandemic is a mass test. Magen David Adom (MDA), Israel's National Emergency Medical Services (EMS) organization, has undertaken this mission by running a series of drive-through test complexes nationwide. The purpose of this study is to draw lessons from the analysis of these centers.

As a result of the literature review, there are several studies related to COVID19 Drive Through test stations. However, there is no other study focus on facility location for Drive Through test station with using Analatical Hyriearchy Process, P-Median Model and Center of Gravity Method. With the element of these techniques, this study is becoming a uniq research. There are Drive Through test stations all over the World however there is no example in Turkey yet and also there is no current research to be able to establish such facilty.

## 3. Methods

Mathematical modeling provides a framework that, given data, facilitates understanding of how changes within the framework can affect outcomes. Modeling combined with data can explain past behavior, predict, and forecast future behavior, and evaluate how changes may alter these predictions. Mathematical modelling is the process of describing a real world problem in mathematical terms, usually in the form of equations, and then using these equations both to help understand the original problem, and also to discover new features about the problem.

**The Analytical Hierarchy Process (AHP Method):** The Analytical Hierarchy Process (AHP) was first introduced by Myers and Alpet in 1968. It was introduced in 1977 by Saaty in solving decision making problems developed as a usable method. AHP is a multi-criteria decision-making method that can evaluate quantitative and qualitative criteria in decision-making, can include the preferences, experiences, intuitions, knowledge, judgments, and thoughts of the group or individual in the decision process, and that enables complex problems to be solved by considering them in a hierarchical structure. The decision maker can include both objective and subjective thoughts in the decision process. Therefore, this situation provides the decision maker with the opportunity to recognize their own decision-making mechanisms. In AHP, hierarchy is established at least at three levels. At the top of the hierarchy is purpose. A sub-level includes the main criteria, if any, sub-criteria under the main criteria. At the bottom level, there are decision options. In order for pairwise comparisons to be consistent, the number of criteria must be determined correctly, and each criterion must be defined correctly. The criteria should be classified according to their common characteristics. AHP can be applied with a large number of criteria. It is a very good method for making group decisions. Thanks to the sensitivity analysis, it is possible to analyze the flexibility of the result. Since the creation of hierarchy and pairwise comparison matrices are subjective, experienced, and expert people are needed.

**Table 1.** AHP Method Steps

| Step | Definition |
|---|---|
| 1 | Creating a hierarchical structure |
| 2 | Creating a pairwise comparison matrix |
| 3 | Determination of Eigen Vector |
| 4 | Calculation of consistency |

The weighting results using the AHP method by following the four steps shown in Table 1 are as follows. In the literature, the Saaty (1990) scale chart is generally used when making pairwise comparisons (Table 2). All comparison values are positive. The application of the AHP method is as follows (Saaty, 1990);

**Table 2.** Pairwise Comparison Scale (Saaty, 1990)

| AHP Scale | Value Provision |
|---|---|
| 1 | Equally importance |
| 3 | Moderate importance |
| 5 | Strong importance |
| 7 | Very strong importance |
| 9 | Extreme importance |
| 2,4,6,8 | Intermediate values between the two adjacent judgment |

**Codas Method:** In this method, the desirability of alternatives is determined by using two measures. The main and primary measure is related to the Euclidean distance of alternatives from the negative-ideal. Using this type of distance requires an I2 -norm indifference space for criteria. The secondary measure is the Taxicab distance which is related to the I1 -norm indifference space. It's clear that the alternative which has greater distances from the negative-ideal solution is more desirable. In this method, if we have two alternatives which are incomparable according to the Euclidean distance, the Taxicab distance is used as secondary measure. Although the I2 -norm indifference space is preferred in the CODAS, two types of indifference space could be considered in its process. (Keshavarz Ghorabaee, M., Zavadskas, E. K., Turskis, Z., & Antucheviciene, J. (2016).

**P-Median Method:** P-median problem; It is the problem of placing p facilities on the network consisting of n nodes with minimum cost and determining the demand points that will receive service from these placed facilities. The minimum cost mentioned here is; it can be time, money, total distance or any other similar criterion (Bastı, M. 2012). Population density was an important criterion for applying the P-Median model for test station site selection with car service.

**Center of Gravity Method:** Centre of gravity is based primarily on cost considerations. This method can be used to assist managers in balancing cost and service objectives. The center of gravity method takes into account the locations of plants and markets, the volume of goods moved, and transportation costs in arriving at the best location for a single intermediate warehouse.

The centre of gravity is defined to be the location that minimizes the weighted distance between the warehouse and its supply and distribution points, where the distance is weighted by the number of tones supplied or consumed. He first step in this procedure is to place the locations on a coordinate system. The origin of the coordinate system and scale used arbitrary, just as long as the relative distances are correctly represented. This can be easily done by placing a grid over an ordinary map. The centre of gravity is determined by the formula.

$C_X = \sum D_{ix}.W_i/\sum W_i$ and $C_Y = \sum D_{iy}.W_i/\sum W_i/\sum W_i$

Where $C_X$ = x-coordinate of the centre of gravity
$C_Y$ = y-coordinate of the centre of gravity
$D_{ix}$ = x-coordinate of location i
$D_{iy}$ = y-coordinate of location i

## 4. Data Collection

In the first stage, criteria affecting the test station location were determined by making use of the project team, Gaziantep University Hospital Chief Physician and the literature (Araz et al. 2020; Kim 2020a; Kwon et al. 2020). The criteria to be considered after the preliminary study is given in Table 3 with its main lines.

**Table 3.** Criteria

| # | **Criteria** |
|---|---|
| 1 | Proximity to hospitals |
| 2 | Traffic Density |
| 3 | COVID density maps |
| 4 | Infrastructure |
| 5 | Population density |

In the second stage of the methodology to be applied, it was ensured that the importance levels of the criteria were determined. At this stage, the AHP method was applied. Expert opinion was taken from the doctors of Gaziantep University Hospital, Hatay State Hospital and Cinderes Emergency Aid Hospital and criteria were weighted. A decision-making group was formed, consisting of four people (one consultant, Associate Professor Dr. Eren Özceylan, and the other 3 doctors from Gaziantep University Hospital, Hatay State Hospital and Cinderes Emergency Aid Hospital). Opinions of decision makers were taken with Delphi Technique. As a result of confidentiality and controlled feedback in participation, the decision makers were not informed about each other's views, and the final control was carried out with the decision makers by taking the geometric average of four different views.

Proximity to the hospitals was determined with using updated maps of Gaziantep city center for Şehitkamil and Şahinbey neighborhoods. Also, researcher timed the distance between the hospitals and considered the results within the study. For traffic density, updated traffic maps are not consistent and for that reason, researcher contacted with the General Directorate of Rail Systems and the Traffic Police Department for data of the vehicle numbers that uses main boulevards and with this information traffic density become consistent and it used in the study.

Health Ministry of Turkey published COVID density maps for each city in Turkey and also for each neighborhood. Those maps collected and used in this study. Infrastructure considered as electricity, water and internet. Gaziantep Metropolitan Municipality and also Şahinbey and Şehitkamil Municipality supported the study in terms of infrastructure resources on the selected locations. In addition, Şehitkamil and Şahinbey Population Directorate provide the population density information to the researcher.

## 5. Results and Discussion

The criteria were weighted by the AHP method and the weight order was determined as follows;
5(Population Density)>4(Infrastructure)>3(COVID Density Maps)>2(Traffic Density)>1(Proximity to the Hospitals)

Consistency Ratio = 0,11375

The sample taken from the patient for the PCR test can last for 2 days under suitable temperature conditions (to be frozen at -20C or ideally -70C and sent on dry ice) and does not affect the accuracy of the test. Proximity to hospitals was determined as the least important criterion since the test stations with car service will be in the city centre. Traffic density has been seen as a criterion that can have both positive and negative effects for test stations. The reason for this is the available capacity of the candidate place for vehicle waiting. While this criterion has a positive effect in some locations while weighting the candidate places, it has been seen as a disadvantage for other candidate places.

With the decrease of the effect of the pandemic over time, the case density decreased significantly, but in this study, the changes in the COVID density maps over a 1-year period were examined and it was observed that the number of cases was always higher in places where the population density was high. It has been seen that the increase in the number of tests leads to a decrease in the number of cases, and for this reason, it has been considered important to establish a test station in the regions where the case density is high in the COVID density maps.
At the test station with car service, healthcare workers will need water to maintain hygiene and sanitation, and electricity and internet infrastructure to record and protect the data they collect. For this reason, infrastructure facilities are an important criterion for the station.

Although COVID-19 is in the highest contagious virus group, it could not be brought under control in places where human interaction is high over time. During the pandemic process, many measures such as curfews, travel restrictions and the obligation to wear masks were taken to control the virus, and human interaction was tried to be reduced. For this reason, it is vital to increase the number of tests in places where the population density is high. A decision matrix consisting of n test station alternatives and m evaluation criteria was created. The decision matrix consists of the fitness value of each selected test station alternative in each criterion. The n and m values are as follows;

n: Test Station Alternative
m: Criteria
n= 7
m= 5

Data related to the determined criteria were collected. In the light of these data and in accordance with the structure of the station, candidate places with vehicle entrance and, where necessary, vehicle waiting area were determined. While determining these candidate places, the area of Şahinbey and Şehitkamil districts, their total population density and their proximity to each other were also taken into consideration.

**Table 4.** Gaziantep Şahinbey and Şehitkamil Districts Total Population and Surface Area

| Year | District | Total Population | Surface Area |
|---|---|---|---|
| 2021 | Şahinbey | 936.351 | 6.819 km² |
| 2021 | Şehitkamil | 839.552 | 1.250 km² |

Şahinbey and Şehitkamil districts are very close to each other and are the two largest districts of Gaziantep in terms of population density. Şehitkamil consists of 147 neighborhoods and Şahinbey consists of 181 neighborhoods. There are 17 hospitals in total in Şehitkamil and Şahinbey districts of Gaziantep. Table 5 shows the distribution of hospitals by districts.

**Table 5.** Hospital List

| Hospital Name | Distrcit |
|---|---|
| Özel Hatem Hospital | Şahinbey |
| Özel Kemal Bayındır Hospital | Şahinbey |
| Özel Akademi Hospital | Şahinbey |
| Özel Hayat Hospital | Şahinbey |
| Özel Düztepe Yaşam Hospital | Şahinbey |
| Özel Sev Amerikan Hospital | Şahinbey |
| Tam-med Özel Hospital | Şahinbey |
| MMT Amerikan Hospital | Şahinbey |
| Abdulkadir Yüksel Devlet Hospital | Şahinbey |
| Özel Mediantep Tıp Merkezi | Şahinbey |
| Özel Emek Hospital | Şehitkamil |
| 25 Aralık Devlet Hospital | Şehitkamil |
| Özel Sani Konukoğlu Hospital | Şehitkamil |
| Anka Hospital | Şehitkamil |
| Özel Sultana Hospital | Şehitkamil |
| NCR International Hospital | Şehitkamil |
| Gaziantep Liv Hospital | Şehitkamil |

Considering geographical conditions, proximity to hospitals, population density, case density, traffic density and infrastructure facilities (internet, water and electricity), 7 candidate station locations were determined. Table 6 shows the list of possible station location.

**Table 6.** Possible Station Location List

| Possible Station Location Name | District | Neighborhood |
|---|---|---|
| 1ŞA (1.Şahinbey Station) | Şahinbey | Karataş |
| 2ŞA (2.Şahinbey Station) | Şahinbey | Güneykent |
| 3ŞA (3.Şahinbey Station) | Şahinbey | Şahintepe |
| 4ŞA (4.Şahinbey Station) | Şahinbey | Şahintepe |
| 1ŞE (1.Şehitkamil Station) | Şehitkamil | Güvenevler |
| 2ŞE (2.Şehitkamil Station) | Şehitkamil | Güvenevler |
| 3ŞE (3.Şehitkamil Station) | Şehitkamil | Batıkent |

Candidate places are weighted according to each other using 5 criteria.
n: Test Station Alternative
m: Criteria
n= 7
m= 5

## 4.1 Numerical Results

Criteria weighted with using Analytical Hierarchy Process and the results are as following;

**Table 7.** Criteria

| # | Criteria |
|---|---|
| 1 | Proximity to hospitals |
| 2 | Traffic Density |
| 3 | COVID density maps |
| 4 | Infrastructure |
| 5 | Population density |

**Table 8.** Decision Matrix (Criteria Weighting)

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 3 | 5 | 7 | 9 |
| 2 | 0,333333333 | 1 | 3 | 5 | 6 |
| 3 | 0,2 | 0,333333333 | 1 | 3 | 5 |
| 4 | 0,142857143 | 0,2 | 0,333333333 | 1 | 3 |
| 5 | 0,111111111 | 0,166666667 | 0,2 | 0,333333333 | 1 |
| Total | 1,787301587 | 4,7 | 9,533333333 | 16,33333333 | 24 |

Consistency Ratio = %5.5
5(Population Density)>4(Infrastructure)>3(COVID Density Maps)>2(Traffic Density)>1(Proximity to the Hospitals)

**Consistency Ratio = 0,11375**
The sample taken from the patient for the PCR test can last for 2 days under suitable temperature conditions (to be frozen at -20C$^0$ or ideally -70C$^0$ and sent on dry ice) and does not affect the accuracy of the test. Proximity to hospitals was determined as the least important criterion since the test stations with car service will be in the city centre.

Traffic density has been seen as a criterion that can have both positive and negative effects for test stations. The reason for this is the available capacity of the candidate place for vehicle waiting. While this criterion has a positive effect in some locations while weighting the candidate places, it has been seen as a disadvantage for other candidate places.

With the decrease of the effect of the pandemic over time, the case density decreased significantly, but in this study, the changes in the HES maps within 1 year were examined and it was always seen that the number of cases was higher in places where the population density was high. It was seen that the increase in the number of tests resulted in a decrease in the number of cases, and for this reason, it was considered important to establish a test station in the regions where the case density is high on the HES maps.

At the test station with car service, healthcare workers will need water to maintain hygiene and sanitation, and electricity and internet infrastructure to record and protect the data they collect. For this reason, infrastructure facilities are an important criterion for the station.

Although COVID-19 is in the highest contagious virus group, it could not be brought under control in places where human interaction is high over time. During the pandemic process, many measures such as curfews, travel restrictions and the obligation to wear masks were taken to control the virus, and human interaction was tried to be reduced. For this reason, it is vital to increase the number of tests in places where the population density is high. A decision matrix consisting of n test station alternatives and m evaluation criteria was created. The decision matrix consists of the suitable value of each selected test station alternative in each criterion. The n and m values are as follows;

Data related to the determined criteria were collected. In the light of these data and in accordance with the structure of the station, candidate places with vehicle entrance and, where necessary, vehicle waiting area were determined. While determining these candidate places, the area of Şahinbey and Şehitkamil districts, their total population density and their proximity to each other were also taken into consideration.

**Table 9.** Gaziantep Şahinbey and Şehitkamil Districts Total Population and Area

| Year | District | Total Population | Area |
|---|---|---|---|
| 2021 | Şahinbey | 936.351 | 6.819 km² |
| 2021 | Şehitkamil | 839.552 | 1.250 km² |

Şahinbey and Şehitkamil districts are very close to each other and are the two largest districts of Gaziantep in terms of population density. Şehitkamil consists of 147 neighborhoods and Şahinbey consists of 181 neighborhoods. There are 17 hospitals in total in Şehitkamil and Şahinbey districts of Gaziantep. Table 10 shows the distribution of hospitals by districts.

**Table 10.** Hospital List

| Hospital Name | District |
|---|---|
| Özel Hatem Hospital | Şahinbey |
| Özel Kemal Bayındır Hospital | Şahinbey |
| Özel Akademi Hospital | Şahinbey |
| Özel Hayat Hospital | Şahinbey |
| Özel Düztepe Yaşam Hospital | Şahinbey |
| Özel Sev Amerikan Hospital | Şahinbey |
| Tam-med Özel Hospital | Şahinbey |
| MMT Amerikan Hospital | Şahinbey |
| Abdulkadir Yüksel Devlet Hospital | Şahinbey |
| Özel Mediantep Tıp Merkezi | Şahinbey |
| Özel Emek Hospital | Şehitkamil |
| 25 Aralık Devlet Hospital | Şehitkamil |
| Özel Sani Konukoğlu Hospital | Şehitkamil |
| Anka Hospital | Şehitkamil |
| Özel Sultana Hospital | Şehitkamil |
| NCR International Hospital | Şehitkamil |
| Gaziantep Liv Hospital | Şehitkamil |

Considering geographical conditions, proximity to hospitals, population density, case density, traffic density and infrastructure facilities (internet, water and electricity), 7 candidate station locations were determined. Table 11 shows the list of candidate places.

**Table 11.** Possible Station Locations

| Possible Station Name | District | Neighbourhood |
|---|---|---|
| 1ŞA (1st Şahinbey Station) | Şahinbey | Karataş |
| 2ŞA (2nd Şahinbey Station) | Şahinbey | Güneykent |
| 3ŞA (3rd Şahinbey Station) | Şahinbey | Şahintepe |
| 4ŞA (4th Şahinbey Station) | Şahinbey | Şahintepe |
| 1ŞE (1st Şehitkamil İstasyonu) | Şehitkamil | Güvenevler |
| 2ŞE (2nd Şehitkamil İstasyonu) | Şehitkamil | Güvenevler |
| 3ŞE (3rd Şehitkamil İstasyonu) | Şehitkamil | Batıkent |

Candidate places are weighted with each other using 5 criteria.
n: Test Station Alternative
m: Evaluation Criteria
**n= 7**
**m= 5**
The weighting of candidate sites according to the population density criterion is shown in Table 12.

**Table 12.** Weighting of Candidate Sites by Population Density

| | 1ŞA | 2ŞA | 3ŞA | 4ŞA | 1ŞE | 2ŞE | 3ŞE |
|---|---|---|---|---|---|---|---|
| 1ŞA | 1 | 3 | 4 | 5 | 6 | 7 | 9 |
| 2ŞA | 0,333333333 | 1 | 2 | 4 | 5 | 7 | 9 |
| 3ŞA | 0,25 | 0,5 | 1 | 2 | 4 | 5 | 7 |
| 4ŞA | 0,2 | 0,25 | 0,5 | 1 | 3 | 5 | 6 |
| 1ŞE | 0,166666667 | 0,2 | 0,25 | 0,333333 | 1 | 3 | 4 |
| 2ŞE | 0,142857143 | 0,1428571 | 0,2 | 0,2 | 0,3333333 | 1 | 2 |
| 3ŞE | 0,111111111 | 0,1111111 | 0,14285714 | 0,166667 | 0,25 | 0,5 | 1 |
| Total | 2,203968254 | 5,2039683 | 8,09285714 | 12,7 | 19,583333 | 28,5 | 38 |

Consistency Ratio = %5.8
The weighting of the candidate sites according to their infrastructure facilities is shown in Table 13.

**Table 13.** Weighting of Candidate Locations According to Infrastructure Opportunities

| | 1ŞA | 2ŞA | 3ŞA | 4ŞA | 1ŞE | 2ŞE | 3ŞE |
|---|---|---|---|---|---|---|---|
| 1ŞA | 1 | 3 | 4 | 5 | 6 | 7 | 9 |
| 2ŞA | 0,333333333 | 1 | 2 | 5 | 7 | 8 | 9 |
| 3ŞA | 0,25 | 0,5 | 1 | 6 | 7 | 8 | 9 |
| 4ŞA | 0,2 | 0,2 | 0,16666667 | 1 | 2 | 3 | 4 |
| 1ŞE | 0,166666667 | 0,142857 | 0,14285714 | 0,5 | 1 | 2 | 4 |
| 2ŞE | 0,142857143 | 0,125 | 0,125 | 0,3333333 | 0,5 | 1 | 3 |
| 3ŞE | 0,111111111 | 0,111111 | 0,11111111 | 0,25 | 0,25 | 0,333333 | 1 |
| Total | 2,203968254 | 5,078968 | 7,54563492 | 18,083333 | 23,75 | 29,33333 | 39 |

Consistency Ratio = %7.9
Weighting of candidate sites according to HES Maps is shown in Table 14.

**Table 14.** Weighting of Candidate Sites According to HES Maps

| | 1ŞA | 2ŞA | 3ŞA | 4ŞA | 1ŞE | 2ŞE | 3ŞE |
|---|---|---|---|---|---|---|---|
| 1ŞA | 1 | 3 | 4 | 5 | 6 | 7 | 9 |
| 2ŞA | 0,333333333 | 1 | 2 | 4 | 5 | 7 | 9 |
| 3ŞA | 0,25 | 0,5 | 1 | 2 | 4 | 5 | 7 |
| 4ŞA | 0,2 | 0,25 | 0,5 | 1 | 3 | 5 | 6 |
| 1ŞE | 0,166666667 | 0,2 | 0,25 | 0,3333333 | 1 | 3 | 4 |
| 2ŞE | 0,142857143 | 0,1428571 | 0,2 | 0,2 | 0,3333333 | 1 | 2 |
| 3ŞE | 0,111111111 | 0,1111111 | 0,1428571 | 0,1666667 | 0,25 | 0,5 | 1 |
| Total | 2,203968254 | 5,2039683 | 8,0928571 | 12,7 | 19,583333 | 28,5 | 38 |

Consistency Ratio = %5.8
The weighting of the candidate places according to the traffic density is shown in Table 15.

**Table 15.** Weighting of Candidate Places by Traffic Density

| | 1ŞA | 2ŞA | 3ŞA | 4ŞA | 1ŞE | 2ŞE | 3ŞE |
|---|---|---|---|---|---|---|---|
| 1ŞA | 1 | 2 | 6 | 7 | 8 | 8 | 9 |
| 2ŞA | 0,5 | 1 | 3 | 5 | 6 | 6 | 7 |
| 3ŞA | 0,166666667 | 0,3333333 | 1 | 2 | 3 | 4 | 5 |
| 4ŞA | 0,142857143 | 0,2 | 0,5 | 1 | 3 | 4 | 5 |
| 1ŞE | 0,125 | 0,1666667 | 0,333333 | 0,333333 | 1 | 2 | 4 |
| 2ŞE | 0,125 | 0,1666667 | 0,25 | 0,25 | 0,5 | 1 | 3 |
| 3ŞE | 0,111111111 | 0,1428571 | 0,2 | 0,2 | 0,25 | 0,3333333 | 1 |
| Total | 2,170634921 | 4,0095238 | 11,28333 | 15,78333 | 21,75 | 25,333333 | 34 |

Consistency Ratio = %6.5
The weighting of the candidate places according to the criteria of proximity to the hospitals is given in Table 16.

**Table 16.** Weighting of Candidate Places by Proximity to the Hospitals

| | 1ŞA | 2ŞA | 3ŞA | 4ŞA | 1ŞE | 2ŞE | 3ŞE |
|---|---|---|---|---|---|---|---|
| 1ŞA | 1 | 2 | 5 | 5 | 3 | 6 | 9 |
| 2ŞA | 0,5 | 1 | 4 | 5 | 3 | 7 | 8 |
| 3ŞA | 0,2 | 0,25 | 1 | 3 | 2 | 2 | 4 |
| 4ŞA | 0,2 | 0,2 | 0,3333333 | 1 | 2 | 3 | 4 |
| 1ŞE | 0,33333333 | 0,3333333 | 0,5 | 0,5 | 1 | 4 | 5 |
| 2ŞE | 0,16666667 | 0,1428571 | 0,5 | 0,3333333 | 0,25 | 1 | 2 |
| 3ŞE | 0,11111111 | 0,125 | 0,25 | 0,25 | 0,2 | 0,5 | 1 |
| Total | 2,51111111 | 4,0511905 | 11,583333 | 15,083333 | 11,45 | 23,5 | 33 |

Consistency Ratio = %6.7
The 5 main criteria, which were determined by taking expert opinions, were weighted within themselves for 7 candidate station locations determined in the light of the data collected regarding these criteria. The used formula is as following;
***R= a.w1+b.w2+c.w3+d.w4+e.w5***

**Table 17.** Weighting of Candidate Places

| DECISION MATRIX | | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | RESULT |
| 1ŞA | 2,396457787 | 2,430774511 | 2,396457787 | 2,430744841 | 2,164547063 | 12,91615199 |
| 2ŞA | 1,226647733 | 1,326633311 | 1,226647733 | 1,402078682 | 1,575633341 | 6,866789121 |
| 3ŞA | 0,717076427 | 1,037287285 | 0,717076427 | 0,530604615 | 0,656899702 | 4,229607676 |
| 4ŞA | 0,436357643 | 0,299205463 | 0,436357643 | 0,360373839 | 0,40337979 | 2,125703434 |
| 1ŞE | 0,228609591 | 0,199362169 | 0,228609591 | 0,199631941 | 0,395859761 | 1,210743825 |
| 2ŞE | 0,089191655 | 0,092784257 | 0,089191655 | 0,094431883 | 0,137895907 | 0,495894336 |
| 3ŞE | 0,042158658 | 0,045177867 | 0,042158658 | 0,042399742 | 0,056929779 | 0,465055175 |

According to the above formula, the importance of the possible station locations determined as following;
***1ŞA>2ŞA>3ŞA>4ŞA>1ŞE>2ŞE>3ŞE***

## 4.1 P-Median Model Results

P-median problem; It is the problem of placing p facilities on the network consisting of n nodes with minimum cost and determining the demand points that will receive service from these placed facilities. The minimum cost mentioned here is; time, money, total distance or any other similar criterion (Bastı, M. 2012). Population density was an important criterion for applying the P-Median model for test station site selection with car service. The population numbers of the neighborhoods where the stations are located are given in Table 18.

**Table 18.** Possible Station Locations Population Density

| Station Name | Neighbourhood | Population |
|---|---|---|
| 1ŞA | Karataş | 43878 |
| 2ŞA | Güneykent | 41367 |
| 3ŞA | Şahintepe | 36657 |
| 4ŞA | Şahintepe | 36657 |
| 1ŞE | Güvenevler | 31197 |
| 2ŞE | Güvenevler | 31197 |
| 3ŞE | Batıkent | 29413 |
| **Total** | | **250366** |

The distance between neighborhood combinations is given in Table 19.

**Table 19.** Distance Between the Neighbourhoods

| Mahalleler | Mesafe |
|---|---|
| Karataş-Güneykent | 9 km |
| Karataş-Şahintepe | 36 km |
| Karataş-Güvenevler | 40 km |
| Karataş-Batıkent | 10 km |
| Güneykent-Şahintepe | 18 km |
| Güneykent-Güvenevler | 18 km |
| Güneykent-Batıkent | 12 km |
| Şahintepe-Güvenevler | 23 km |
| Şahintepe-Batıkent | 9,25 km |
| Güvenevler-Batıkent | 2,58 km |
| **Toplam** | **177,83 km** |

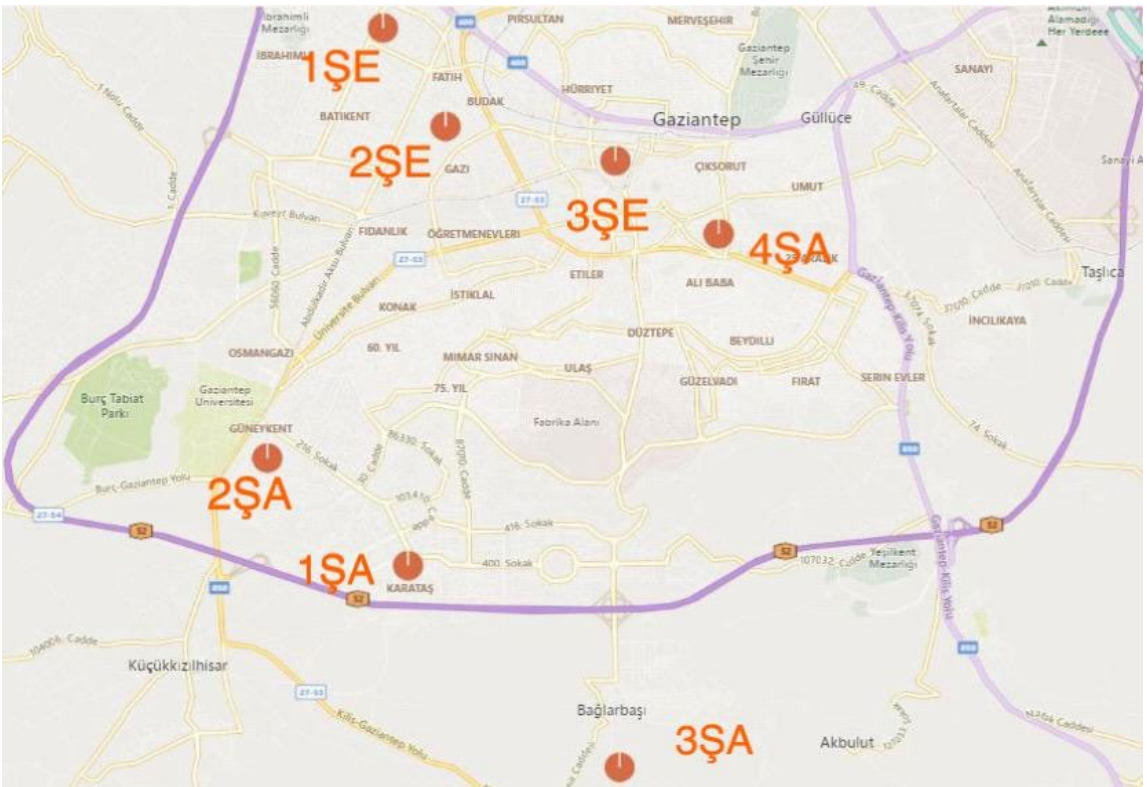


**Figure 1.** Possible Locations Distribution on Gaziantep Map

Considering the distances between the neighborhoods and the map in Figure 1, the distances between the neighborhoods were accepted as the hypotenuse and the approximate values of the X,Y coordinates were determined. 2 of the 7 candidate places determined were located in the same neighborhood. These are determined as 3ŞA-4ŞA and 2ŞE-3ŞE stations. While creating the P-Median model, the stations in the same neighborhood and the sum of their demands were taken together. As can be seen in Figure 2, T represents demand and population is accepted as demand. As mentioned before, the demand (ie population) of the most populated neighborhood was determined as 7 and calculated as 7,6,5,4,3,2,1.

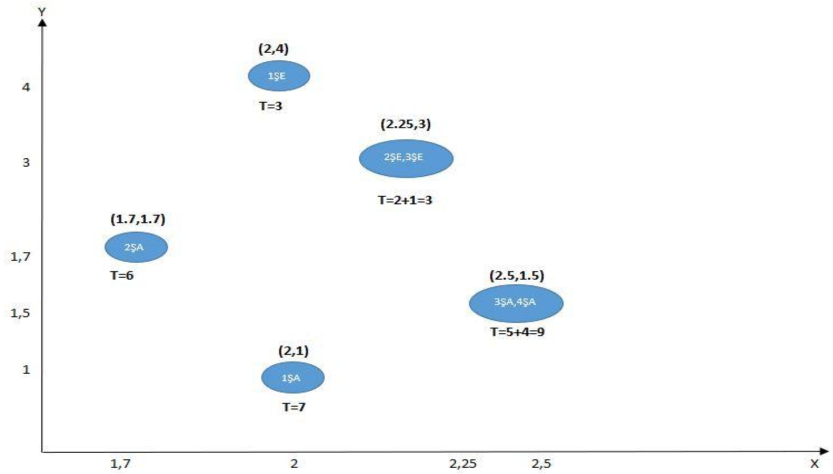


**Figure 2.** Positions of Candidate Stations Relative to Each Other and Demand Quantities Graph

The center of gravity method was applied as follows. Finding a single candidate place with the center of gravity method showed which point should be used if only one place is opened in the future.

$$C_x = \frac{\sum x_i W_i}{\sum W_i} \tag{1}$$

***$C_x$*** *: Optimal X position*
***$X_i$*** *: X coordinate*
***$W_i$*** *: Weight(Demand)*
**$C_x$** = [(1,76*6)+(2*7)+(2*3)+(2,25*3)+(2,5*9)]/(6+7+9+3+3) = 2,12

The value of 2.12 was determined as the most suitable x coordinate value.

$$C_y = \frac{\sum y_i W_i}{\sum W_i} \tag{2}$$

**$C_y$** : Optimal Y position
**$Y_i$** : Y coordinate
**$W_i$** : Weight(Demand)

**$C_y$** = [(1,7*6)+(1*7)+(4*3)+(3*3)+(1,5*2,25)]/(6+7+9+3+3) = 1,48
The value of 1.48 was determined as the most suitable y coordinate value.

X = 2.12 and Y = 1.48 coordinates gave us the optimum station location. The graphical visual of the coordinators is given in Figure 3.

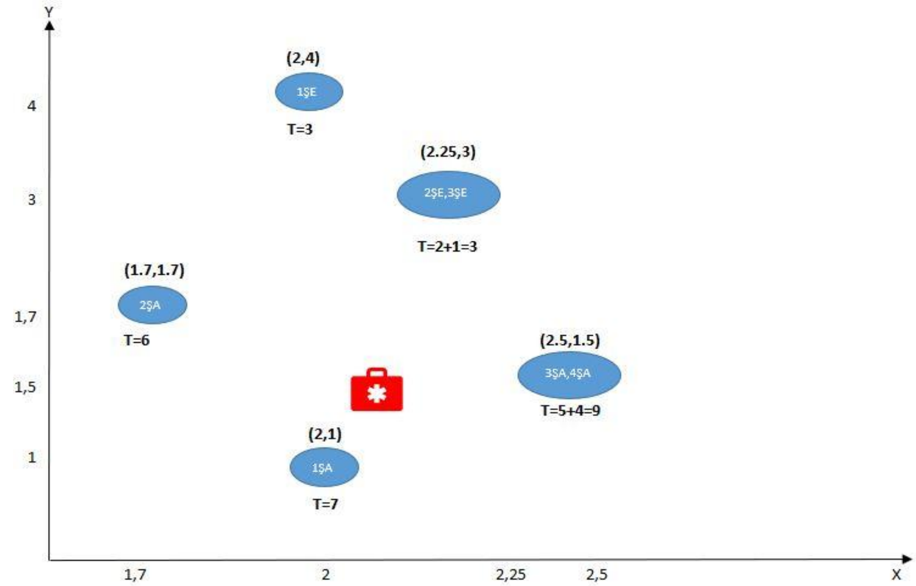


**Figure 3.** Graphical Display of Center of Gravity Result Coordinates

Since the cost for the test station establishment will be almost the same for all of them, minimizing the distance instead of the cost was taken as a basis in the decision phase. The cost (distance) matrix of the problem is given in Table 20.

**Table 20.** Cost (Distance) Matrix of the Problem

| Station | Total Distance(km) | | | | |
|---|---|---|---|---|---|
| | Neighbourhoods(Clients) | | | | |
| | ***A*** | ***B*** | ***C*** | ***D*** | ***E*** |
| ***1ŞA*** | 0 | 9 | 36 | 40 | 10 |
| ***2ŞA*** | 9 | 0 | 18 | 18 | 12 |
| ***3ŞA-4ŞA*** | 36 | 18 | 0 | 18 | 9,25 |
| ***1ŞE*** | 40 | 18 | 23 | 0 | 12 |
| ***2ŞE-3ŞE*** | 10 | 12 | 9,25 | 2,58 | 0 |

*A : Karataş Neighbourhood*
*B : Güneykent Neighbourhood*
*C : Şahintepe Neighbourhood*
*D : Güvenevler Neighbourhood*
*E : Batıkent Neighbourhood*

The myopic heuristic algorithm given in Figure 4 was used to solve this problem.

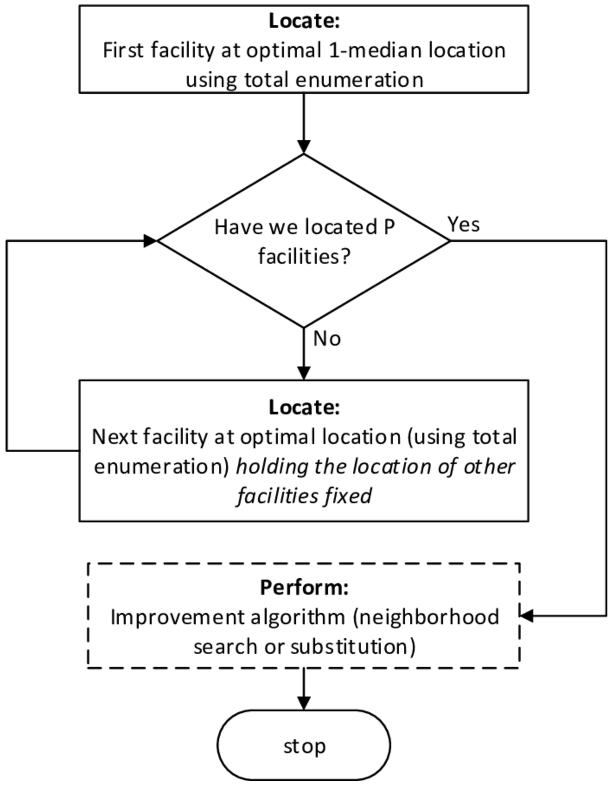


**Figure 4.** Myopic Heuristic Algorithm (Daskin, 1995)

As can be understood from the Table 21 matrix below, when p = 1, that is, when a single facility is opened, the E node that gives the lowest distance is determined as the median matrix. In other words, if all demands are met from facility E, the total distance to be created is determined as 44.25 km.

**Table 21.** Distance Matrix and Selecting the Facility with the Lowest Distance

| Station | Total Distance(km) | | | | |
|---|---|---|---|---|---|
| | Neighbourhoods(Clients) | | | | |
| | *A* | *B* | *C* | *D* | *E* |
| *1ŞA* | 0 | 9 | 36 | 40 | 10 |
| *2ŞA* | 9 | 0 | 18 | 18 | 12 |
| *3ŞA-4ŞA* | 36 | 18 | 0 | 18 | 9,25 |
| *1ŞE* | 40 | 18 | 23 | 0 | 12 |
| *2ŞE-3ŞE* | 10 | 12 | 9,25 | 2,58 | 0 |
| ***Total*** | **95** | **57** | **86,25** | **78,58** | **43,25** |

The steps of the heuristic algorithm in Figure 4 are applied and the second least distance facility is found by making all values of the E matrix 0 (zero) in the distance matrix to locate the second median facility.

**Table 22.** Distance Matrix and 2nd Facility Location Selection with the Lowest Distance

| Station | Total Distance(km) | | | | |
|---|---|---|---|---|---|
| | Neighbourhoods(Clients) | | | | |
| | ***A*** | ***B*** | ***C*** | ***D*** | ***E*** |
| ***1ŞA*** | 0 | 9 | 36 | 40 | 10 |
| ***2ŞA*** | 9 | 0 | 18 | 18 | 12 |
| ***3ŞA-4ŞA*** | 36 | 18 | 0 | 18 | 9,25 |
| ***1ŞE*** | 40 | 18 | 23 | 0 | 12 |
| ***2ŞE-3ŞE*** | 0 | 0 | 0 | 0 | 0 |
| ***Total*** | **85** | **45** | **77** | **76** | **43,25** |

According to the distance matrix, the facility giving the second lowest distance was determined as B. In this case, the second median facility was B.

**Table 23.** Determined Median Facilities and Distances

| Station No | Station | Total Distance |
|---|---|---|
| 1 | E | 43,25 km |
| 2 | B | 45 km |

The process of determining the median facilities, which is the first step of solving the problem, is completed here. After this stage, each demand point is assigned to the closest median facility. During the assignment process, the distance of each demand point to the determined median facilities was checked. In the example, the demand points A, B, C, D, E nodes are assigned to the facility which is closest to the median facilities E and B. At the same time, the median facilities E and B are assigned to them. An issue that should be mentioned here is that a demand point is equidistant from both median facilities. In such a case, the demand point can be arbitrarily assigned to any of the median facilities (Daskin, 1995: 213). When the cost matrix given in Table 20 is taken into consideration and assignments are made according to the rule stated above, the results given in Table 24 are obtained.

**Table 24.** Median Facilities and Demand Points Assigned to These Facilities

| Station No | Station | Demand Points Assigned to the Facility |
|---|---|---|
| 1 | E | C,D,E |
| 2 | B | A,B |

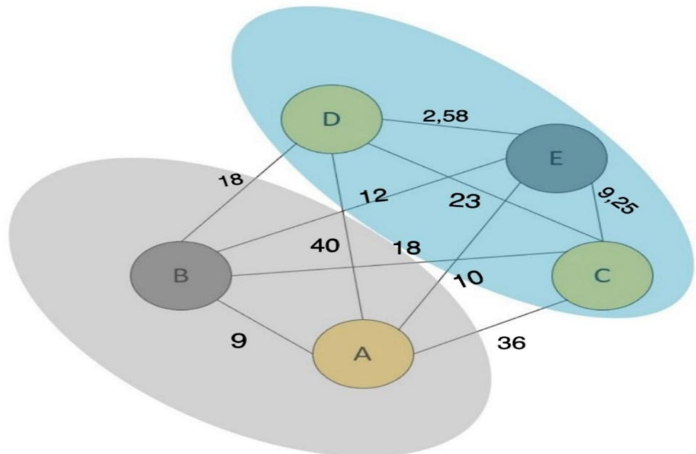


**Figure 5.** Selected E and B Median Facilities and Demand Points Assigned to Facilities

The total distance table that emerged according to the results of this assignment was as in Table 25.

**Table 25.** Distances of Selected E and B Facilities

| Deman Points | Stations | |
|---|---|---|
| | E | B |
| A | 0 | 9 |
| B | 0 | 0 |
| C | 9,25 | 0 |
| D | 2,58 | 0 |
| E | 0 | 0 |
| Column Total | 11,83 | 9 |
| Total Distance | 20,83 | |

The total distance was 20.83 km, which is the sum of the costs of facilities E and B. As can be seen, while the cost (ie the distance) of opening the E facility alone is 43.25 km, this distance is determined as 20.83 with a decrease of 22.42 units in case of opening the E and B facilities together. In this framework, the cost (ie distance) of opening 3 facilities can be investigated separately.

## 4.2 Proposed Improvements

This paper discusses using multi criteria decision making tools to determine feasible locations for Drive-Through test station and with using center gravity method, the optimal location is determined. However, there can be improvements for this study, such as, if the cost of establishing a Drive-Through test station is calculated, a mathematical model can be created and it will give more accurate outcome related to the establishment of the test stations.

Furthermore, this study's main aim is finding most suitable locations for Drive-Through COVID test stations with using multi criteria decision making tools and mathematical modelling. However, in the future the same tools and techniques with different criteria and data can be used for vaccination statations, food distribution or any other emergency needs. Also, CODAS technique can be add to the AHP calculation stage. Another improvement can be expand this study to other cities.

In conclusion, with this study and used techniques, the proposed improvements will make the study as a precaution emergency plan for Gaziantep city for possible crisis and also usuable for other cities.

## 5. Conclusion

The criteria determined by taking expert opinions during the research process of test station location selection with car service (Drive Through) in case of epidemics were weighted by collecting the necessary data for Gaziantep Şehitkamil and Şahinbey districts. Then, as a result of these data, considering the criteria weights, 7 candidate places were determined and these candidate places were weighted within themselves. The implementation of this project on the basis of the two largest districts of Gaziantep city contributed to the researchers to create a more accurate decision-making model, to the dynamic structure of the city, to being one of the high-risk cities during the pandemic.

The inverse ratio of the number of tests and the number of cases, which is one of the most important data revealed as a result of the researches carried out during the pandemic process, formed the basis of this project. In the later stages of the pandemic, the test stations with car service, which were first implemented in South Korea, have proven their effectiveness in terms of safety of health care workers and the patients. The lack of practice examples in Turkey has been one of the reasons for the emergence of this research. As a result of the research, candidate places that can be used effectively in a possible emergency for the city of Gaziantep were determined. By using the P-Median method, the optimum result was found in the case of opening a single station, then the problem solution was expanded for the case of opening 2 station. By using the same method, the problem solution can be expanded to open 7 or more stations when necessary. Researchers physically visited the candidate sites and made observations. Due to the limited time and the difficult conditions of the pandemic, CODAS and mathematical models could not be applied, but in the future, the study can be carried to an advanced stage if the necessary data is collected. The reason why the mathematical model could not be applied is that cost analysis could not be done. However, based on distance and population density, which is the most weighty criterion, P-Median was applied and a model was created for possible solutions.

Although the disaster created by COVID-19 seems to have come to an end, this event, which is a lesson for human history, has shown that the results can be vital if the necessary precautions are not taken for the future. It is envisaged that the places determined in this research and the methods used in this decision process can be used for locating test stations, vaccine stations or distribution points in future crises. The effectiveness and efficiency of the methods used showed that this project could be implemented in other cities if the necessary data were collected, and this once again revealed the importance of the research.

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## Biographies

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