



**College of Engineering**  
**Department of Industrial Engineering**  
**(IE 313 (Simulation**

**A clinic emergency department System**

|                  |                              |
|------------------|------------------------------|
| <b>:Due Date</b> | <b>Thursday, 26 Nov 2020</b> |
|------------------|------------------------------|

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|                                |               |
|--------------------------------|---------------|
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## INTRODUCTION

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If we thought about the most important thing to humans and we cannot accept any kind of concession dereliction, you will directly think about HEALTH. And as the emergency department is the first defense line in case of any unexpected tough medical condition, we decided to look forward about how it works and study the quality of the provided services to the patients. We noticed that waiting times of the patients are little long which has a negative effect on service quality which directly affects their lives negatively. Referring to that importance of emergency department we are going to improve the system to reduce .waiting time

### Understanding the system:

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The emergency department in one of the clinics consists of reception center, primary care room and an advanced care room with 6 beds inside. A patient enters and goes to the reception center, or if it is critical situation the patient goes directly to the advance care room, 90% of patients go through the reception center and 10% go directly to the advanced care room. The time in reception center takes TRIA (0.66, 1, 1.33) minute, after the reception center, the patients go to the primary care room, the time in the primary care room takes TRIA(3, 5, 8) minutes. After the primary care, 70% of patients leave the system, and 30% need to go to the advanced care room, (whenever a patient needs an advance care but there is no bed available, the patient should leave the clinic), the time in the advanced care room takes TRIA(1, 2, 4) hours, when the patients leave the advanced care room, 90% of them leave the system and 10% need more special care and will be transferred to the general .hospital

There is one employee in the reception center and one in the primary care room, and in the advanced care room there are three employees distributed on 6 beds (each employee is assigned to two beds), and there

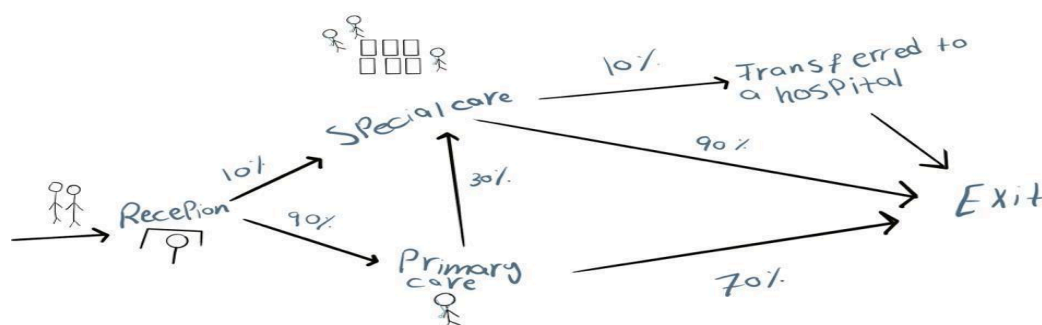
is one employee for the transportation of patients to the general hospital  
.with one car

There are three shifts during the day, each employee works for one shift, which means a total of three reception staff, a total of three primary care staff, a total of six advanced care staff and a total of three staff for the transportation process. There is a break time for each employee and for only one hour, except the reception employees, their break time last only 15 minutes (if the patient was in process and the time of the break begun, the employee needs to finish the current service first, and then  
.(takes the full time of the break

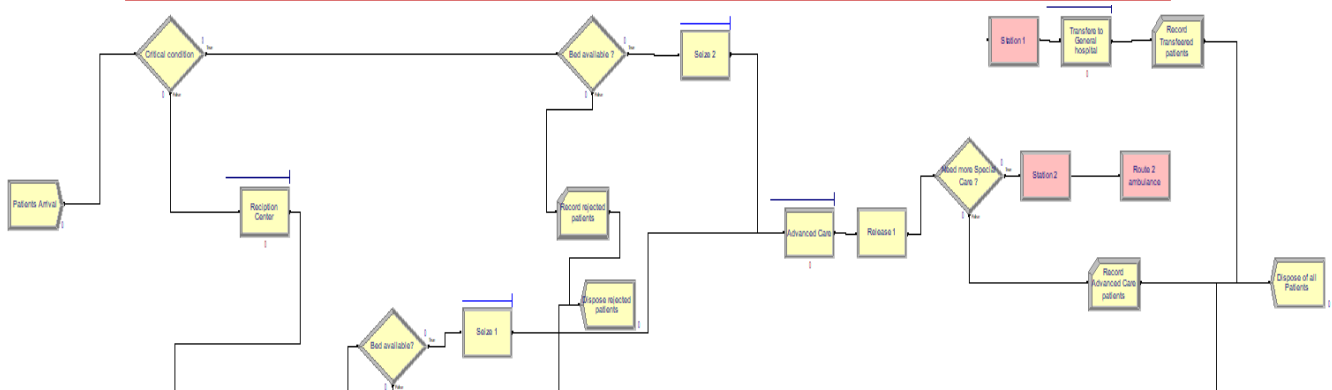
### Goals of the study:

Our goal is to reduce the average total time, average waiting time in queue, the time to transfer patients to the general hospital, increasing the utilization of employees and reject no patient that comes to the clinic by suggesting alternative solutions that improve the system.

### Sketch:



### Arena model:



## Design of experiment:

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### The system consists of

Create (1x)  
Process (4x)  
Assign (3x)  
Record (5x)  
Seize(2x)  
Release(1x)  
Decide (5x)  
Station(2x)  
Rout(1x)  
Dispose (2x)

The screenshot shows the 'Run Setup' dialog box with the following settings:

- Number of Replications:** 5
- Initialize Between Replications:** ☒ Statistics, ☒ System
- Start Date and Time:** ☒ 00:00:06 1442/ ربيع الأول /21
- Warm-up Period:** 0.0
- Replication Length:** 60
- Hours Per Day:** 24
- Base Time Units:** Minutes
- Time Units:** Hours (for Warm-up Period), Days (for Replication Length)
- Terminating Condition:** (empty field)

Buttons at the bottom: تطبيق (Apply), تطبيق (Apply), إلغاء الأمر (Cancel), موافق (OK).

### important point:

- ❖ The system will run 60 days with 24 hours each day.

### Repetition:

#### The benefit for Repetition:

- ✓ Make sure we get an accurate result
- ✓ To avoid unexpected errors or missing something
- ✓ Replicate it for five times

## Verified

Free from logical errors and run complete



No errors or warnings in model

## Validation

Due to the increase in the number of patients entering the emergency department, a number of them are rejected, and we also found that the ambulance takes a long time in the event that a patient is transferred to the General Hospital, also the utilization of the advanced care doctors seem to be poor, and through these problems, we found complaints from patients and the administration on these points. We will do a simulation based on real data collected to give us the simulation results through which we can verify the validity of the data, and compare it with the results and data in real life

## Results and Analysis:

|                                |  |                     |  |      |  |
|--------------------------------|--|---------------------|--|------|--|
| 01:33:45                       |  | Category Overview   |  | 2020 |  |
| Values Across All Replications |  |                     |  |      |  |
| Emergency Department           |  |                     |  |      |  |
| Replications: 5                |  | Time Units: Minutes |  |      |  |
| Key Performance Indicators     |  |                     |  |      |  |
| System                         |  | Average             |  |      |  |
| Number Out                     |  | 7,506               |  |      |  |

The number out the system is 7506

| Wait Time Per Entity          | Average | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|-------------------------------|---------|------------|-----------------|-----------------|---------------|---------------|
| Advanced Care                 | 5.6123  | 0.48       | 5.1957          | 6.2401          | 0.00          | 127.22        |
| Primary Care process          | 12.9818 | 1.47       | 11.5764         | 14.3678         | 0.00          | 129.31        |
| Reception Center              | 0.4181  | 0.04       | 0.3700          | 0.4403          | 0.00          | 16.4639       |
| Transfere to General hospital | 5.2278  | 1.35       | 3.5856          | 6.2353          | 0.00          | 76.8481       |

We notice the average waiting time for primary care is the longest with 13

mins  
and

And maximum 129.31 mins, after that the advanced care with 5.61 mins,

Maximum 127.22 mins.

| Total Time Per Entity         | Average | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|-------------------------------|---------|------------|-----------------|-----------------|---------------|---------------|
| Advanced Care                 | 144.97  | 0.63       | 144.50          | 145.57          | 61.0145       | 333.56        |
| Primary Care process          | 18.3160 | 1.47       | 16.9171         | 19.7028         | 3.0264        | 136.47        |
| Reception Center              | 1.4145  | 0.03       | 1.3667          | 1.4357          | 0.6606        | 17.3903       |
| Transfere to General hospital | 34.6914 | 1.19       | 33.1840         | 35.6827         | 18.5277       | 115.90        |

We notice the average total time for advanced care is very long, also

transfer to

General hospital takes a lot of time.

| Queue                               |         |            |                 |                 |               |               |
|-------------------------------------|---------|------------|-----------------|-----------------|---------------|---------------|
| Time                                |         |            |                 |                 |               |               |
| Waiting Time                        | Average | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
| Advanced Care.Queue                 | 5.6001  | 0.48       | 5.1855          | 6.2278          | 0.00          | 127.22        |
| Primary Care process.Queue          | 12.9811 | 1.47       | 11.5748         | 14.3678         | 0.00          | 129.31        |
| Reception Center.Queue              | 0.4181  | 0.04       | 0.3700          | 0.4403          | 0.00          | 16.4639       |
| Seize 1.Queue                       | 0.00    | 0.00       | 0.00            | 0.00            | 0.00          | 0.00          |
| Seize 2.Queue                       | 0.00    | 0.00       | 0.00            | 0.00            | 0.00          | 0.00          |
| Transfere to General hospital.Queue | 5.2278  | 1.35       | 3.5856          | 6.2353          | 0.00          | 76.8481       |

The average waiting time in queue is between 5.22 to 13 minutes and the maximum value is 129.31 minutes.

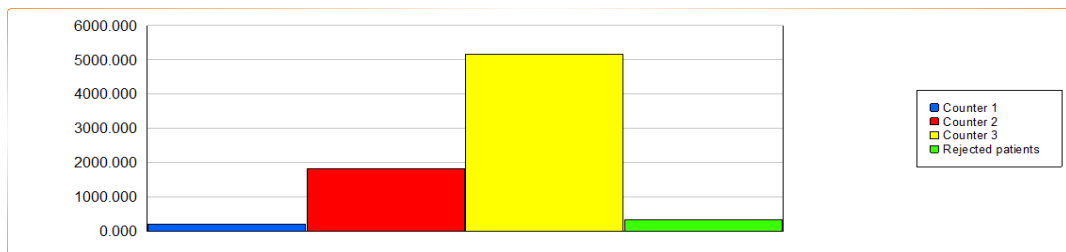
| Emergency Department                     |         |         |         |         |
|------------------------------------------|---------|---------|---------|---------|
| Replications: 5      Time Units: Minutes |         |         |         |         |
| Resource                                 |         |         |         |         |
| Usage                                    |         |         |         |         |
| Instantaneous Utilization                | Minimum | Maximum | Minimum | Maximum |

The average instantaneous utilization is between 6% to 63% and the maximum value is 100%

User Specified

## Counter

| Count             | Average | Half Width | Minimum Average | Maximum Average |
|-------------------|---------|------------|-----------------|-----------------|
| Counter 1         | 194.40  | 23.33      | 169.00          | 220.00          |
| Counter 2         | 1818.80 | 28.79      | 1795.00         | 1848.00         |
| Counter 3         | 5162.80 | 101.71     | 5100.00         | 5254.00         |
| Rejected patients | 329.80  | 28.63      | 308.00          | 361.00          |



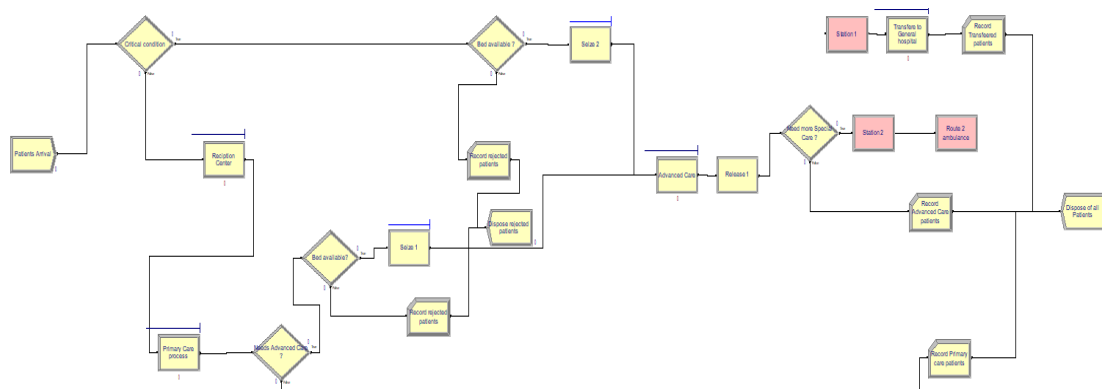
We notice the number of rejected patients is very big with average 329  
And maximum 361

### Alternative solution

To improve the system, we decided to implement some solutions, which are explained in detail in the following:

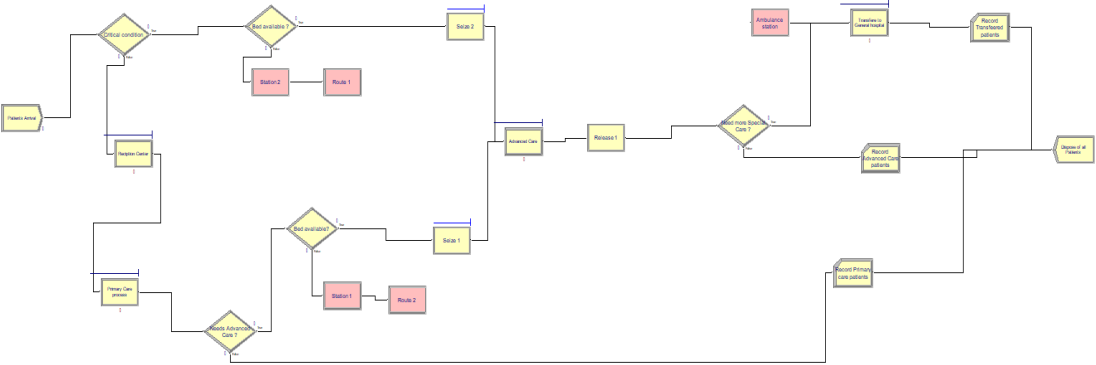
### Arena model:

**Before improvement:**





:After improvement



Results and Analysis:

Before improvement:

|                                       |  |                     |  |      |  |
|---------------------------------------|--|---------------------|--|------|--|
| 01:33:45                              |  | Category Overview   |  | 2020 |  |
| Values Across All Replications        |  |                     |  |      |  |
| Emergency Department                  |  |                     |  |      |  |
| Replications: 5                       |  | Time Units: Minutes |  |      |  |
| Key Performance Indicators            |  |                     |  |      |  |
| System                                |  | Average             |  |      |  |
| The number out of the system is 7,506 |  | 7,506               |  |      |  |
| Number Out                            |  |                     |  |      |  |

After improvement:

|                                                                 |  |
|-----------------------------------------------------------------|--|
| Values Across All Replications                                  |  |
| Emergency Department                                            |  |
| Replications: 5      Time Units: Minutes                        |  |
| Key Performance Indicators                                      |  |
| System                                                          |  |
| The number out of the system is 7586 (increased by 80 patients) |  |
| Average 7,586                                                   |  |
| Number Out                                                      |  |

### Before improvement:

| Wait Time Per Entity          | Average | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|-------------------------------|---------|------------|-----------------|-----------------|---------------|---------------|
| Advanced Care                 | 5.6123  | 0.48       | 5.1957          | 6.2401          | 0.00          | 127.22        |
| Primary Care process          | 12.9818 | 1.47       | 11.5764         | 14.3678         | 0.00          | 129.31        |
| Reception Center              | 0.4181  | 0.04       | 0.3700          | 0.4403          | 0.00          | 16.4639       |
| Transfere to General hospital | 5.2278  | 1.35       | 3.5856          | 6.2353          | 0.00          | 76.8481       |

### After improvement:

| Wait Time Per Entity          | Average | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|-------------------------------|---------|------------|-----------------|-----------------|---------------|---------------|
| Advanced Care                 | 8.2545  | 1.06       | 7.1323          | 9.2792          | 0.00          | 153.07        |
| Primary Care process          | 4.7151  | 0.25       | 4.4290          | 4.9348          | 0.00          | 84.9756       |
| Reception Center              | 0.4165  | 0.02       | 0.3954          | 0.4272          | 0.00          | 16.2150       |
| Transfere to General hospital | 3.4301  | 0.75       | 2.5557          | 4.2199          | 0.00          | 76.2435       |

We notice there is a very good improvement in the waiting time for the primary care process, and fair improvement in the transfer to general hospital.

- Reduced by almost 8 minutes for the primary care.
- Reduced by almost 2 minutes for the transferring (little change, but that 2 minutes may save a life).
- There is a little increasing for the advanced care and that happened because of the involving of its stuff in the primary care process, but it is not that matter as long as the patient exists near the doctors.

### Before improvement:

| Total Time Per Entity         | Average | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|-------------------------------|---------|------------|-----------------|-----------------|---------------|---------------|
| Advanced Care                 | 144.97  | 0.63       | 144.50          | 145.57          | 61.0145       | 333.56        |
| Primary Care process          | 18.3160 | 1.47       | 16.9171         | 19.7028         | 3.0264        | 136.47        |
| Reception Center              | 1.4145  | 0.03       | 1.3667          | 1.4357          | 0.6606        | 17.3903       |
| Transfere to General hospital | 34.6914 | 1.19       | 33.1840         | 35.6827         | 18.5277       | 115.90        |

### After improvement:

| Total Time Per Entity         | Average | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|-------------------------------|---------|------------|-----------------|-----------------|---------------|---------------|
| Advanced Care                 | 148.24  | 1.61       | 147.28          | 150.45          | 60.6688       | 334.66        |
| Primary Care process          | 10.0504 | 0.24       | 9.7831          | 10.2690         | 3.0124        | 89.5073       |
| Reception Center              | 1.4135  | 0.02       | 1.3936          | 1.4233          | 0.6606        | 17.1502       |
| Transfere to General hospital | 27.5382 | 0.77       | 26.5308         | 28.2000         | 12.1954       | 100.77        |

**\*We notice there is a very good improvement for the average total time spent in the primary care and transfer to general hospital processes:-**

- Reduced by 8 minutes for the primary process.
- Reduced by 7 minutes for the transferring process.
- For the Advanced care we notice a little increasing by almost 3 minutes, but it is not a big deal for a process that takes a quite long time.

## Before improvement

Values Across All Replications

### Emergency Department

Replications: 5 Time Units: Minutes

### Resource

#### Usage

| Instantaneous Utilization | Average    | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|---------------------------|------------|------------|-----------------|-----------------|---------------|---------------|
| Advance                   | 0.6320     | 0.01       | 0.6270          | 0.6387          | 0.00          | 1.0000        |
| Ambulance                 | 0.06625333 | 0.01       | 0.05781435      | 0.07336167      | 0.00          | 1.0000        |
| Beds                      | 0.5638     | 0.01       | 0.5582          | 0.5703          | 0.00          | 1.0000        |
| Primary                   | 0.4544     | 0.01       | 0.4484          | 0.4637          | 0.00          | 1.0000        |
| Reception                 | 0.08488304 | 0.00       | 0.08381417      | 0.08660184      | 0.00          | 1.0000        |

## After improvement

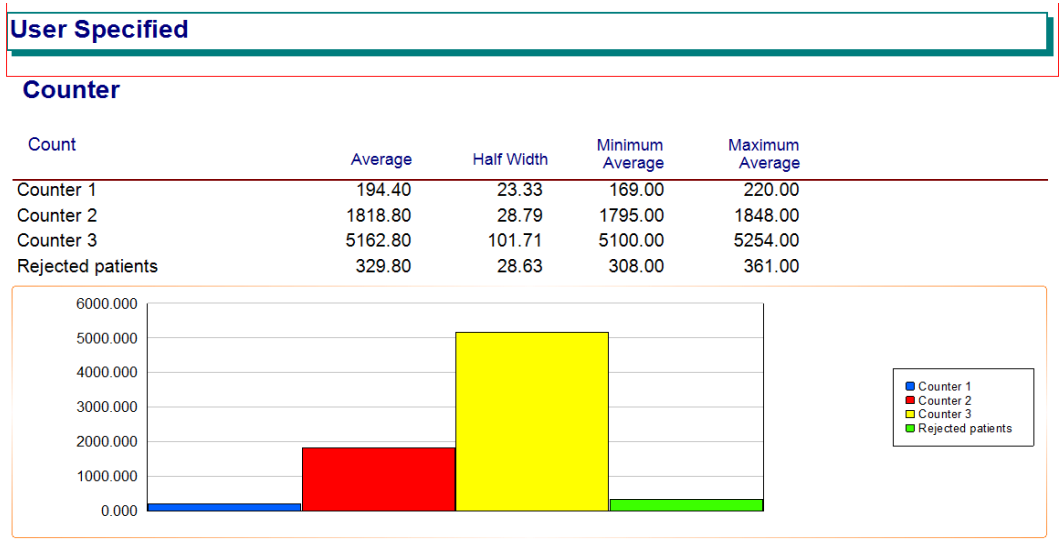
### Resource

#### Usage

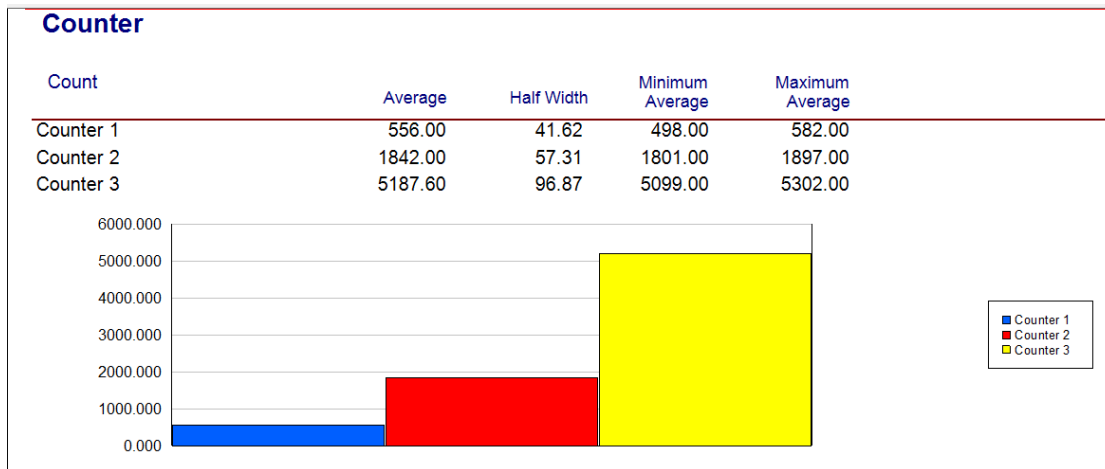
| Instantaneous Utilization | Average    | Half Width | Minimum Average | Maximum Average | Minimum Value | Maximum Value |
|---------------------------|------------|------------|-----------------|-----------------|---------------|---------------|
| Advance care              | 0.6873     | 0.02       | 0.6662          | 0.7099          | 0.00          | 1.0000        |
| Ambulance                 | 0.1028     | 0.01       | 0.0908          | 0.1067          | 0.00          | 1.0000        |
| Beds                      | 0.5841     | 0.02       | 0.5624          | 0.6067          | 0.00          | 1.0000        |
| Primary                   | 0.4022     | 0.01       | 0.3949          | 0.4069          | 0.00          | 1.0000        |
| Reception                 | 0.08586808 | 0.00       | 0.08446682      | 0.08698011      | 0.00          | 1.0000        |

After the improvements we made in the ambulance section and the advanced care section we notice that the utilization has become much better especially in ambulance section.

Before improvement:



## After improvement:



- *The new model of the system doesn't reject any patient even if there is no bed available.*
- *The patients who come and do not find a bed available, they will be transferred to the general hospital via clinic's ambulance.*

## Conclusion:

### **After analyzing the system, we found the following:**

- 1- Lots of patients being rejected due to the availability issue of the beds.***
- 2- Relatively poor utilization of the advanced care doctors.***
- 3- The number of the doctors in the advance care section is high in relation to the number of patients that come to the clinic.***
- 4- The ambulance waiting time is high, plus the path it takes to the general hospital is not the optimal one.***

**5- The waiting time in the primary care process is relatively high.**

**For these issues we recommend the following:**

- 1- Reducing the number of the advanced care doctors by 3, 1 from each shift, and involve the rest in the primary care process during their availability (this is as it's shown in the findings above will save a lot of money, increase the utilization of the advanced doctors and reduce the waiting time by huge amount of time in the primary care process)**
- 2- Rejecting no patients by transferring them to the general hospital when there is no bed available, and to make this possible in a good way we recommend to increase the number of ambulance stuff by one employee, and change their shifts to be only 2 shifts (12 hours a shift, and 2 employees in each shift), plus adding one car. We identified by observation and recording a new path for the ambulance that reduced the transportation time (the old path takes TRIA(18, 25, 45) minutes, while the new path takes TRIA(12, 21, 39) minutes), so that the transportation of all patients will be possible, the waiting time will even decreases very much and last but not least, as proven in the analysis above, the utilization will be improved.**
- 3- The current utilization of the beds is not high enough to increase it, but adding more beds is not a big issue as long as they are a fixed cost.**
- 4- In the original system, the employees are taking the full time break all the time, but we recommend that they just take what remains of the break time after finishing the current service (this action reduces the waiting time and**

*increases the utilization of employees as proven in the findings above).*

***The recommendations above are going to essentially contribute to:***

- 1- Save high amount of money***
- 2- Even increase the total money earned***
- 3- Develop a good reputation***