

Assignment

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Project Title: Simulation Analysis of FairClinic Operations

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EXECUTIVE SUMMARY

FairClinic is a health facility that currently faces a lot of complaints from patients, primarily because of the length of time that one has to wait at the Nurse's Station and Exam Room. The report discusses the result of a simulation done in an attempt to analyze the existing operations at the clinic as well as three potential enhancements, including adding one more Nurse to the Nurse's station, adding a second nurse at the Nurse's Station, speeding up Exam Room service time by investment in equipment, that will speed up the exam room process, getting a new service time, which is going to be less than the original, expanding procedures in Exam Room, adjustment of the routing probabilities. Based on the simulation analysis, the best alternative to improve this operation will be to invest in equipment to speed up the process slightly in the exam room. This would dramatically reduce waiting times for the Exam Room and improve the throughput of the patients, along with an increment in the clinic's efficiency. This move will enable leveraging better patient satisfaction because of more optimal operations within the clinic.

MAIN REPORT

1) Problem/Current Situation

FairClinic, a 24-hour health care facility, is suffering from the problem of dissatisfaction amongst the patients because of increasing wait times and length of stays. Poor waiting experiences add to dissatisfied patients, therefore negatively impacting operating pressures. Significant causes of dissatisfaction amongst patients include:

- **Long waiting times:** Patients experience extended delays at several stations, including the Nurse's Station, Exam Rooms, and other areas such as the Check-Out and Lab/X-Ray stations.
- **Extended total clinic time:** From check-in to check-out, patients spend more time than expected in the clinic. This is because inefficiency has been observed at different steps of the patient journey.
- **Resource limitations:** The clinic has a skeleton staff of nurses, physicians, and support staff at each station. For example, the Nurse's Station is crewed by a single nurse, creating bottlenecks when the patient load becomes heavy during peak periods.

These operational inefficiencies reduce patient satisfaction and increase stress on the clinic staff, impacting long-term efficiency at the clinic. Thus, it is essential to identify solutions that reduce wait times and, overall, clinic visit times to improve patient outcomes with operational effectiveness.

The present analysis seeks ways to improve patient satisfaction by optimizing waiting times and reducing the total time spent in the clinic. It identifies and tests possible solutions through simulation, with the intention of proposing a sustainable improvement plan that balances patient satisfaction and operational efficiency.

2) Metrics Chosen

The following key metrics were selected to assess the current system performance and to evaluate potential improvements:

- **Average Waiting Times at Each Station:** This metric measures the time patients spend waiting during each stop: Sign-in, Nurse's Station, Exam Room, and Check-Out. By

focusing on each of these areas of the patient's waiting times, we can determine points through which delays can be minimized, once again enhancing the overall process of the patient flow perspective.

- **Utilization Rates of Various Stations:** The different usages, such as the nurse's station, exam rooms, and lab/X-ray, indicate the effective utilization of resources in the clinic. High utilizations in given stations could show resource bottlenecks, leading to a very long wait. It also tries to optimize resource utilization while minimizing wait times.
- **Patient Throughput:** This refers to the number of patients the clinic can process within a given period. Improving patient throughput without compromising care quality is essential for enhancing clinic efficiency and ensuring that more patients can be treated in a shorter period.

These metrics are selected because the level of patient satisfaction directly impacts them.

Reducing wait times and total clinic time while improving throughput and maintaining high resource utilization is critical to improving patient experiences and overall clinic performance.

3) Modeling Approach

Why Simulation Modeling Was Chosen

Simulation modeling was chosen because the clinic's operations involve many stochastic interacting components. Examples include patient inter-arrival times, service times, and probabilistic routing between different stations, all of which vary based on random distributions. Traditional analytical methods do not allow for the flexibility needed to model such complex and dynamic systems.

Simulation provides a strong tool to model these uncertain and probabilistic elements, enabling us to test various scenarios to determine the impact of potential changes without disrupting actual clinic operations. Using simulation, we can model the extended operation of the clinic. We can then take that model and see how different improvements affect key performance metrics.

Software Used

This was simulated in **Extendsim**, a discrete-event modeling environment suited to representing a complex system. **Extendsim** allows for a graphical user interface while building the simulation model, providing an appropriate platform for integrating stochastic variables and thereby modeling the clinic's operations.

This model was developed to simulate patient flow at the clinic, exceptional patient arrival at the sign-in station, routing to the nurse's station and exam rooms, and through other stations. In particular, random distributions were used in the model to simulate patient arrival times, service times at various stations, and probabilities for patient routing.

The simulation model used the following assumptions:

- **Patient Arrivals:** Patient inter-arrival times at the Sign-In station were modeled using an exponential distribution with a mean arrival rate of 5.95 minutes.
- **Service Times:** Triangular distributions for service times at each station, Sign-In, Nurse's Station, Exam Room were made as the problem statement gave it. An example would be TRIA (1,4,8) for Sign-In.
- **Probabilistic Routing:** Patient routing was based on defined probabilities. For example, 98.88% of patients were directed to the Nurse's Station, while 1.12% were routed to the Exam Room.

4) Alternatives Investigated

The following three improvement options were evaluated through simulation:

- **Option 1: Adding an Additional Nurse to the Nurse's Station**
 - The Nurse's Station is currently staffed with one nurse, leading to long waiting times when patient volume increases. By adding a second nurse to this station, we expected to improve patient flow and reduce waiting times at the Nurse's Station.
 - Expected Impact: Adding a second nurse would directly reduce waiting times at the Nurse's Station and could lead to faster processing of patients at this critical station. This should also improve overall patient throughput.
- **Option 2: Speeding Up the Exam Room Service Time**
 - The Exam Room service time is currently modeled as TRIA (4,7,13), meaning it can vary between 4 and 13 minutes. By improving the efficiency of the examination process, we aimed to reduce the service time to TRIA (3,5,12), effectively speeding up patient flow through this critical stage of their visit.
 - Expected Impact: This would reduce the time spent in the Exam Room, which could decrease total clinic time and improve patient satisfaction.
- **Option 3: Expanding Procedures in the Exam Room and Adjusting Patient Routing**
 - In this scenario, the service time in the Exam Room would increase to TRIA (5,9,15), allowing for expanded procedures. Simultaneously, the routing probabilities would be adjusted so that more patients are directed straight to Check-Out (increasing the probability by 10%) and fewer are sent to the Exam Room.

- Expected Impact: The goal was to improve the quality of care by expanding procedures in the Exam Room while adjusting routing to streamline patient flow. This option aimed to balance thorough care with reduced total clinic time.

5) Results

The simulation was run for a 30-day period to assess the impact of each of the three improvement options. The key findings from the simulation are as follows:

Baseline Scenario (Current Situation)

- **Average Waiting Times**

1. at the Nurse's Station: 3714.344 minutes for the 30-day period
2. at the Exam Room: 1522.655 minutes for the 30-day period

- **Patient Throughput:**

- **Input patients:** 9194 patients arrived
- **Output patients:** 6429 patients were served
- **Input/ Output ratio:** 69.93% of the patients who arrived were served and checked out

- **Patient Satisfaction:** Low due to long waiting times in the Nurse's Station and at the Exam Room.

Option 1: Adding an Additional Nurse to the Nurse's Station

- **Average Waiting Times**

1. at the Nurse's Station: 33.487 minutes for the 30-day period (99.09% reduction with respect to the Baseline)
2. at the Exam Room: 3725.52 minutes for the 30-day period (144.67% increase with respect to the Baseline)

- **Patient Throughput:**

- **Input patients:** 9288 patients arrived
- **Output patients:** 6394 patients were served
- **Input/ Output ratio:** 68.84% of the patients who arrived were served and checked out

- **Impact:** This option significantly reduced waiting time at the Nurse's Station but Exam room waiting time was also increased significantly. The overall clinic efficiency indicated a negative impact as the efficiency reduced from 69.93% to 68.84% due to the high overload of patients in the Exam rooms.

Option 2: Speeding Up the Exam Room Service Time

- **Average Waiting Times:**

1. at the Nurse's Station: 4126.232 minutes for the 30-day period (11.09% increase with respect to the Baseline)
2. at the Exam Room: 321.381 minutes for the 30-day period (78.89% reduction with respect to the Baseline)

- **Patient Throughput:** 7013 patients were served for the 30-day period (9.08% increase with respect to the Baseline)
 - **Input patients:** 9111 patients arrived
 - **Output patients:** 7013 patients were served
 - **Input/ Output ratio:** 76.97% of the patients who arrived were served and checked out

- **Impact:** This option significantly reduced Exam Room waiting time by 78.89% but increased the waiting time at the Nurse's Station by 11.09%. The overall improvement in efficiency was the highest of all the options with a 76.97% efficiency from the initial 69.93%.

Option 3: Expanding Procedures in the Exam Room and Adjusting Routing Probabilities

- **Average Waiting Times:**
 1. at the Nurse's Station: 3555.46 minutes for the 30-day period (4.28% reduction with respect to the Baseline)
 2. at the Exam Room: 1506.958 minutes for the 30-day period (1.03% reduction with respect to the Baseline)

- **Patient Throughput:**
 - **Input patients:** 9342 patients arrived
 - **Output patients:** 6820 patients were served

➤ **Input/ Output ratio:** 73% of the patients who arrived were served and checked out

- **Impact:** This option caused a 4.28% and 1.03% decrease in waiting time at the Nurse's Station and at the Exam Room respectively. This eventually caused an increase in overall efficiency from the initial 69.93% to 73%.

6) Recommended Course of Action

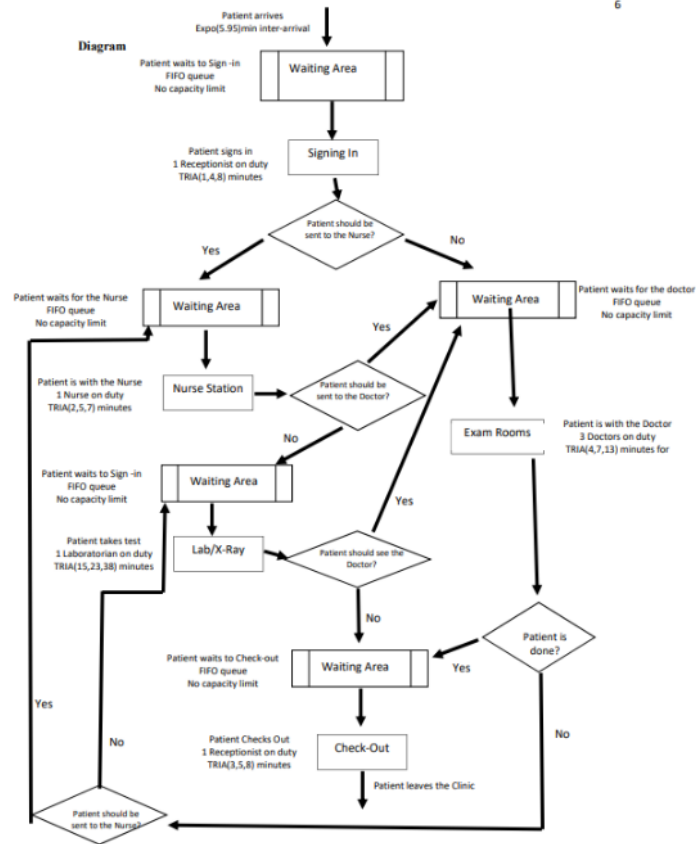
Based on the simulation results, **Option 2: Speeding Up the Exam Room Service Time** is the best course of action. This option leads to a very significant reduction in waiting times at the Exam Room. Despite increasing waiting time at the Nurse's Station, the overall efficiency of the clinic increases significantly as patients are attended to faster by the doctors at the Exam Room and the waiting times are reduced as compared to the initial waiting times. The improvement in patient flow through the Exam Room provides the largest benefit to patient satisfaction.

This solution balances improvements in patient satisfaction with operational efficiency, making it the most effective approach to address the clinic's current challenges.

APPENDICES

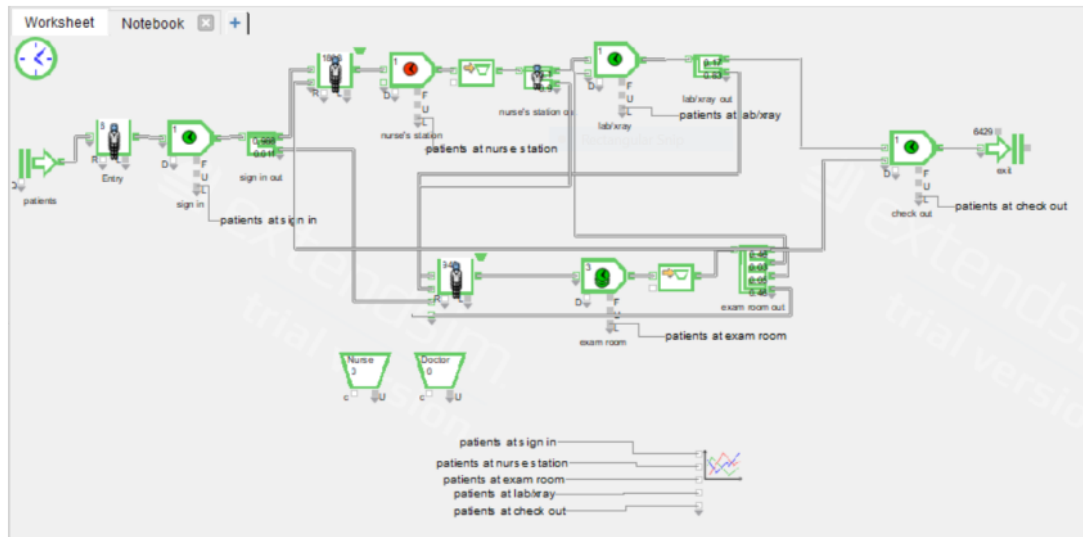
Appendix A: Flowchart of the Baseline Scenario

The flowchart below represents the baseline scenario which depicts patient movement through the various stations of FairClinic.



Appendix B: Extendsim Model

For every station in the clinic it is represented by an ‘activity’ item in Extendsim. After every station there is a ‘Select Item Out’ item that sorts the patients to their destinations based on probability. A ‘Resource Pool’ item was also used for the doctors and nurses so as to ensure each patient was attended to by one of the professionals at a time. The ‘Create’ item is where you specify the rate at which patients flow into the clinic while the ‘Exit’ item represents where the patients leave the clinic.



Appendix C: Experimental Design

Since the clinic runs for 24 hours a day and the specified period for simulation was 30 days, this amounted to 41760 minutes (the clinic closes for one day so as to allow maintenance and cleaning of the clinic so 24 hours was deducted).

For Option1, it required an additional nurse so the only change made was the addition of a nurse to the 'Nurse Resource Pool' to two nurses.

For Option2, the only change made was the service time of TRIA (3, 5, 12) to the 'Exam Room Activity' item input check box.

For Option3, a new service time of TRIA (5, 9, 15) to the 'Exam Room Activity' item was made and also changing of the probabilities of the 'Exam Room Exit' item box to the new values.

Appendix D: Output

	Average Waiting Time		Overall Clinic Efficiency
	At Nurse's	At Exam	
	Station(minutes)	Room(minutes)	
Baseline	3714.344	1522.655	69.93%
Option1	33.487	3725.52	68.84%
Option2	4126.232	321.381	76.97%
Option3	3555.46	1506.958	73.0%

Appendix E: Analysis and Sensitivity

For Option1, the average ²waiting time at the Nurse's Station is reduced by a significant margin this however increases the average waiting time at the Exam Room. This occurs because more patients are discharged quicker from the Nurse's Station but since the doctors' output at the Exam Room is constant they wait longer there. The overall clinic efficiency is slightly reduced due to all the waiting that is done at the Exam Room.

For Option2, the average waiting time at the Nurse's Station is slightly increased in comparison to the Baseline. However, the waiting time at the Exam Room is greatly decreased. This

eventually has a positive impact in the overall clinic efficiency as it increases. This would be the best solution for FairClinic because with this the overall waiting time is reduced while at the same time the clinic's efficiency is increased hence the clinic is able to handle more patients.

For Option3, both the waiting times at the Nurse's Station and at the Exam Room are slightly reduced. The overall efficiency of the clinic is also increased by a good percentage meaning more patients are attended to and discharged. The drawback to this option is that although the waiting times are slightly reduced they are still way too high and this would still cause customer dissatisfaction.

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