# Modeling and Simulation: Toddlers Consultation Queueing

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***Abstract*— Improving service quality for doctors and children to increase clinic efficiency and productivity. The clinic is concerned about toddler queue productivity and time. Clinics must always enhance their service quality to increase their performance. In this study, we focus on modeling using Anylogic and analyzing Toddler Consultation Queueing The study is divided into (3) phases: (i) analyze clinic queueing sequences (ii) simulate clinic queueing sequences (iii) assess and improve system service quality.**

***Keywords — Patient queue, patient waiting time, patient flow, staff scheduling.***

## I. Introduction

The supply of healthcare services is influenced by a complex set of political, social, epidemiological, demographic, and economic factors. Variations in mortality, age, sex, and population density; education and affluence; patient visit patterns; geography; and ease of access to these services all influence the demand for health care services and medical personnel in each country. Patients are expected to receive treatment and services from the Public Centre Infirmary. However, the queueing in many public Centre has been a big issue to the public. This is due to the long waiting time to receive health services. Additionally, a patient's health status may worsen because of the very long waiting period for treatment, which reduces the effectiveness of the treatment efficiency due to patients may not be attended and end up going home without receiving care [1].

## II. PROPOSED METHODOLOGY

Given that the Public Infirmary's toddler patients are more eager to receive care and that this is one of the key problems affecting the quality of its services, a discrete event simulation approach was established to take care of them. The waiting time is one of the biggest issues the Infirmary's toddler patients deal with. The simulation inputs are described in detail; conceptualization of patient flow in a Public Infirmary; and the three (3) flowchart simulations for different events.

### *A. Input Analysis*

| Month of February | |
|---|---|
| Number of Toddler patient per day : | 10 patient |
| Number of Toddler patient per week : | 93 patient |
| Number of Toddler patient per month: | 150 patient |
| Age of the patients specifically for toddlers: | 1 to 3 y/o |
| Services offered for toddlers: | Dental check up, Out Patient & Emergency services |

Table 1. Infirmary Data

A data collection from the month of February 2022 that contained details on 150 patients was subjected to an extensive data analysis. The DES model's inputs are derived from this data set and include the number of patients visited, the age of the patients, the services provided, and the accommodation time per service.

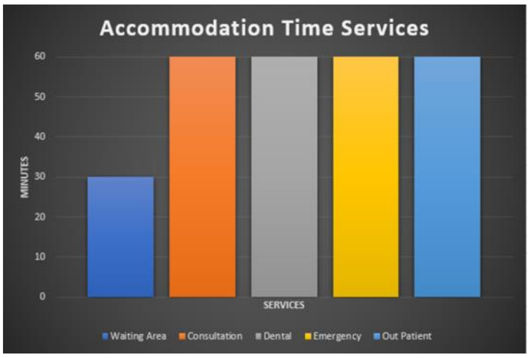


Figure 1. Accommodation Time Per Services

The following table shows the difference in hours per accommodation time to be used properly in DES: The waiting period lasted 30 minutes. One hour was allotted for the consultation, one for the dental work, one for the emergency, and one for the outpatient treatment.

### *B. Discrete Model Conceptualization*

In Discrete Event Simulation (DES), a computerized simulation of virtual modeling, interactions between patients and environments can be modeled based on the various chains of events that occur in real-world practice. To address the outpatient waiting time at Infirmary, a data-driven DES model is developed using the Anylogic simulation modeling program [5].

The DES technique has proven to be a useful tool for tackling several healthcare conditions. Health system operations research accounted for the largest share and the greatest growth among all DES applications in the healthcare industry. The second most popular DES in the field of healthcare was Health Economic Evaluation (HEE), with consistent rather than rising numbers of publications (Zhang, 2018) [3].

### *C. Flowchart of the Dental Service Simulation*

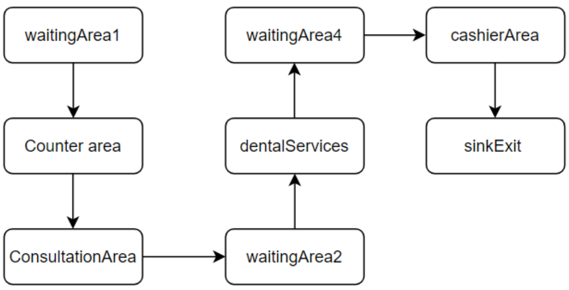


Fig. 2. Dental Service Flow in the Infirmary

In Figure 2, the patient will first enter the infirmary and then wait in the "waitingArea1". After a couple minutes of waiting, the patient will proceed to the "Counter area" and ask questions regarding what they need to do for dental services like if they need to make an appointment or proceed to the doctor and so on, and this will be called "Dental Service".

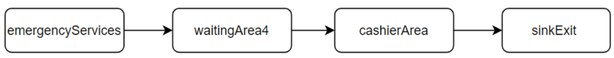


Fig. 3. Emergency Service Flow in the Infirmary

In this flowchart, the patient does not need to go through the appointment, he will just be directed to the “emergencyServices” to perform the service needed for the patient. After he recovers, he will be directed to the "waitingArea4" to wait and proceed to the “cashierArea”. Then he will proceed to “sinkExit”.

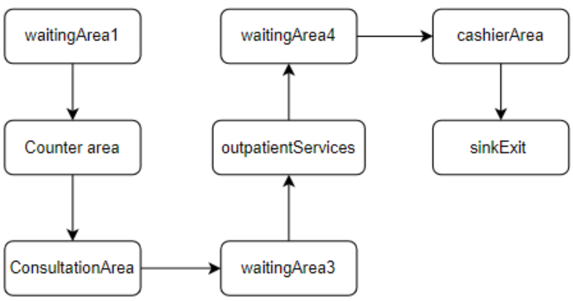


Fig. 4. Outpatient Service Flow in the Infirmary

In Figure 4, To ask a question, the patient must still pass through "waitingArea1" and wait for a while. He will then proceed immediately to the "ConsultationArea" to speak with the doctor and determine what the patient should do. He will then be told to wait once again in "waitingArea3" because the previous patients must complete first. He will wait before going into the "outpatientServices." After that, he will be sent back to "waitingArea4" to wait and then pay for the fees of the services at "cashierArea," and after doing so, "sinkExit" will be the last simulation for the patient to exit.

A technique known as discrete event simulation (DES) is used to simulate real-world systems that may be divided into several logically distinct processes that advance independently across time. Each event takes place on a certain process and is given a logical time (a timestamp). One or more other processes may receive an outcome from this occurrence. The outcome's content might lead to the creation of brand-new events that will be handled at a specific future logical time. The first part provides labels for the objects that constitute a system to be simulated. The second part is defined as the operations in which objects are engaged over time [2].

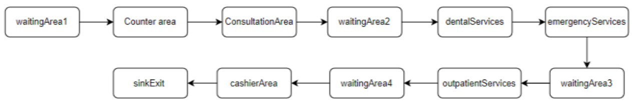


Fig. 5. Infirmary State Diagram

#### *a. Objects of the system*

Entity: These are the ones being simulated. During a simulation, entities can move across a network of servers, switches, gates, and queues. They are the "toddler patients" from the Public Infirmary in our scenario.

#### *b. The Organization of Entities*

*Classes*: These are permanent collections of entities that are the same or similar. Classes in this simulation include "toddler patients," "cashier," and "doctor."

*Sets*: These are the ones that represent the states or queues for the entities that are included in the simulation. The sets that we are using are the following:

- waitingArea1- These are intended for those patients who are waiting to go to the Counter area
- waitingArea2 - These are intended for those patients who are waiting to go to the dentalService
- waitingArea3 - These are intended for those patients who are waiting to go to the outpatientService
- waitingArea4 - These are intended for those patients who are waiting to go to the cashierArea

*Attributes*: These are details that are specific to each entity and are used to: first, distinguish amongst entities that belong to the same class; and second, to control the behavior of an entity. The "intended service the patient wants" is used as an attribute.

*c. Operations of the Entities.*

The entities will cooperate during the simulation, changing their states as a result. Here, some terminologies as well as the simulation's time sequence must be presented.

*Event*: This is the instant of time where the significant state of the system changes. For this simulation, we have three events: the first is when the patient chooses only dental service; the second is for emergency purposes; and lastly, the outpatient service has other concerns.

*Activity:* These are the entities that move from set to set where the operations are engaged. There are several activities used for each entity: “waitingArea1”, Counter area, ConsultationArea, “waitingArea2”, dentalServices, “emergencyServices”, sinkExit, “waitingArea3”, “outpatientServices”, “waitingArea4”, cashierArea.

*Process:* This is often used to represent all or part of the life of temporary entities. In this simulation, the process is divided into three: first is "Dental Service", the second is for getting into "Emergency Service", and lastly, the Outpatient Service".

*Simulation Clock*: This refers to the point reached by the current simulated time in a simulation. In this simulation, we use the time unit "minutes," hence the test "is clock = 240 minutes."

### D. Data Collecting

For the preparation of the dataset, data from the Infirmary is used for the month of February 2022. The overall data set consists of Five main categories of features:

a. Demographic-category: Toddler Patient's Age
b. Number of Patients per day for the month of February
c. Number of Patients for the whole month of February
d. Services Offered by the Infirmary
e. Accommodation Time per Services

### E. Dental Clinic Discrete Event Simulation Model

Using the DES virtual modeling system, to examine existing performance standards and the potential for changes and gather data that might help in enhancing services in a public infirmary. The performance measures that are needed to relate to patient care, including patient wait time, and resource utilization, including time efficiency, appointment system use, and doctor and nurse availability [3].

With the help of a computerized virtual modeling technique called discrete event simulation, decisions about how to improve the quality of care can be made by simulating how patients interact with their environments.

Fig. 6. Infirmary Discrete Event Simulation Model

Using the Anylogic simulation, we’ve created the simulation model for the Infirmary as shown in Figure 5.

## III. Experimental Method

### A. Experimental Setup

The Anylogic Simulation Software is used to simulate the Infirmary on a standalone AMD Ryzen 5 R5-3550H Processor, GeForce GTX 1650 Graphics, 8GB DDR4, 256GB PCIe SSD, Windows 10 64-bit operating system

### B. Dataset

A real-world dataset of 150 patients' data was obtained from the Infirmary, consisting of 3 toddler patient flowcharts, namely Dental Service Flow, Emergency Service Flow, and Outpatient Service Flow in the Infirmary, one demographic profile, and the service accommodation time.

### C. Probability

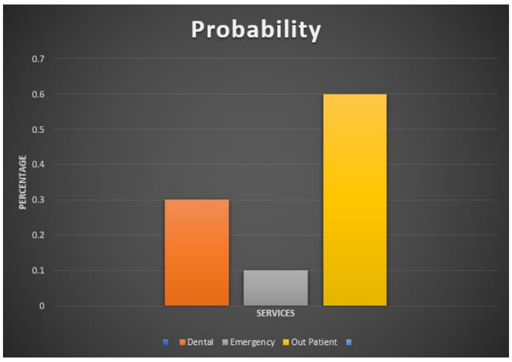


Fig. 7. Probability of toddler patient

In this figure, we used 3 different probabilities for the Discrete Event Simulation of toddler patients in the infirmary using Anylogic based on our services and the average number of toddler patients per day. First at 0.3 percent is dental service, followed by emergency service at 0.1 percent and outpatient service at 0.6 percent.

### D. Model Validation

We utilized Ttest and P-Value to evaluate our model using the data. Considering data from toddler patients, we simulate it using DES (Discrete Event Simulation). The public infirmary in Kasiglahan Village, Rodriguez, Philippines, released the actual patient data for the month of February 2022. On the basis of Table 1, additional simulation parameters were defined.

## IV. RESULTS

### A. Validation Results

| | Average per day 20 days operation (1 Month) | 10 Runs |
|---|---|---|
| | 7.5 | 9 |
| | 7.5 | 7 |
| | 7.5 | 15 |
| | 7.5 | 12 |
| | 7.5 | 16 |
| | 7.5 | 8 |
| | 7.5 | 8 |
| | 7.5 | 7 |
| | 7.5 | 7 |
| | 7.5 | 8 |
| **Total** | | 97 |
| **Mean** | | 9.7 |

Table 2. Validation Discrete Event Simulation

In order to validate the data using the data given for the month of February 2022, we performed the simulation for 10 iterations. According to the data obtained on the toddler patients in the infirmary, there are approximately 7.5 Average per day on a 20-day operation (1 Month) from the 150 toddler patients throughout the entire month of February. While an average of 9.7 toddler patients are present in each simulation. Using the statistical difference method, we validated the infirmary's simulated data against the actual data.

### B. Results Analysis

The p-value is the probability that, if the null hypothesis is correct, each test will result in a t-value with an absolute value at least as great as the one we observed in the sample data. The t-value is a way to measure the difference between population means [4].

We reject the null hypothesis of the test if the p-value is less than a specified limit (for instance, 0.05) [4].

| | |
|---|---|
| **Ttest Result=** | 0.035559654 |

Table 3. T-Test

In table 3, The T-Test shows a result of 0.035559654. Therefore, there is no significant difference between the result of the simulation and the actual data.

| t-Test: Paired Two Sample for Means | | |
|---|---|---|
| | *Variable 1* | *Variable 2* |
| Mean | 7.5 | 9.7 |
| Variance | 0 | 11.56666667 |
| Observations | 10 | 10 |
| Pearson Correlation | #DIV/0! | |
| Hypothesized Mean Difference | 0 | |
| df | 9 | |
| t Stat | -2.04559 | |
| P(T<=t) two-tail | 0.071119 | |
| t Critical two-tail | 2.262157 | |

Table 4. T-test: Paired Two Sample for Means

The t-Test: Paired Two-Sample for Means between Variable 1 (Real Data) and Variable 2 is displayed in Table 4 (simulated data). The simulated data have a mean of 9.7 while the real data have a mean of 7.5. Both real and simulated data have the same value for the observation, which is 10. The result of P(T=t) two-tail has a value of 0.071119309.

Since this p-value is higher than 0.05, we cannot reject out the null hypothesis.

## V. CONCLUSIONS

The goal of the project is to create a simulation that addresses the productivity and efficiency of a public infirmary. Its goal is to raise awareness of toddler queueing productivity and time as well as the fact that public clinics must constantly improve their services in order to perform and provide better services.

Additionally, Discrete-event simulation has become a popular and effective decision-making tool to improve patient flow, allowing decision-makers to quickly determine the existing problem.


## ACKNOWLEDGEMENT

First and foremost, we would like to express our heartfelt gratitude to Prof. Jan Eilbert Lee for his unwavering support of our subject named Modeling and Simulation, as well as his patience, encouragement, passion, and vast expertise. His counsel was invaluable during the study and development of our idea. For our Modeling and Simulation, we couldn't have asked for a greater mentor.


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