
University *of* New Haven

**INDE-6681 SYSTEMS SIMULATION**

PROJECT REPORT

# Simulation and Analysis of a Pharmacy Prescription and Vaccination System to identify Bottlenecks and Enhancing Efficiency

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## ABSTRACT

This report focuses on simulating a real-world pharmacy prescription and vaccination system using the software Arena to identify bottlenecks and propose solutions for optimizing the Pick-Up, Drop-Off, and Vaccination processes. Through Arena simulation, inefficiencies were analysed, and recommendations for improvement were developed. The analysis revealed that the Drop-Off Process has the longest wait times, with an average queue time of 7.57 minutes and a maximum of 26 minutes, primarily due to high pharmacist utilization at 76.7%. Conversely, the Pick-Up Process demonstrated greater efficiency, with minimal queue times averaging 0.05 customers. The nurse's utilization, at 34.6%, highlighted spare capacity, indicating opportunities for cross-training and improved resource allocation. Recommendations include redistributing tasks to reduce Drop-Off bottlenecks, leveraging the nurse's idle time, promoting mobile app adoption to streamline interactions, and staggering staff breaks to maintain service during peak hours. These strategies aim to enhance workflow efficiency, reduce wait times, and ensure excellent customer service while maintaining employee satisfaction.



**Keywords**: Pharmacy Simulation, Process Optimization, Arena Modeling, Resource Allocation, Queue Management, Customer Experience, Employee Efficiency.

## 1. INTRODUTION

Time is a precious commodity, and with increasingly packed schedules, customers expect quick and efficient service, especially in healthcare, an area often known for its delays. Long wait times and inefficiencies in service delivery can lead to customer dissatisfaction, reduced loyalty, and operational strain. Pharmacy prescription pick-ups and vaccinations processes are at the same place in a pharmacy, and an unpredictable experience: sometimes fast, but other times frustratingly slow. To address these, this project simulates the prescription pick-up process at a busy Pharmacy on Main Avenue in Norwalk, CT, focusing on identifying bottlenecks and opportunities for improvement. By modeling each stage of the process, from customer arrival and service to check-out, this study will provide valuable insights into optimizing the customer experience.

## 2. OBJECTIVES

### 2.1 GENERAL

To simulate and analyse the prescription pick-up and vaccination process at a Pharmacy to identify bottlenecks and provide actionable insights aimed at optimizing customer experience through reduced wait times and improved service efficiency.

### 2.2 SPECIFICS

a. **Identify Bottlenecks**: Analyze each stage of the prescription pick-up and vaccination process (check-in, queuing, prescription filling process, vaccination process and check-out) to locate bottlenecks that cause delays in service.
b. **Optimize Staff Allocation**: Find suggestions on staff allocation strategies that minimize customer wait times.
c. **Evaluate Queue Dynamics**: Assess the impact of customer arrival rates on queue lengths and wait times, and identify effective ways to manage queues to improve customer flow.
d. **Recommend Improvements**: Provide evidence-based recommendations to enhance overall pharmacy service efficiency, particularly in terms of customer throughput and satisfaction.

## 3. MODEL DEVELOPMENT AND APPROACH

### 3.1 DATA COLLECTION

The data collection for this project was conducted on October 25, 2024, from 8:00 AM to 4:00 PM at the Pharmacy located at 327 Main Avenue, Norwalk, CT. Observations were made throughout the day to capture a comprehensive view of the prescription pick-up and vaccination process, including customer arrival time, service durations, and queue lengths during these hours.

The data collection focused on observing key pharmacy stations, each serving a unique role in the prescription and vaccination process:

a. **Pick-Up Station**: This area is dedicated to customers collecting their prescriptions.

b. **Vaccination Check-In Station**: Here, customers who have scheduled vaccinations check in, complete required paperwork, and then they are directed to the vaccination booth..
c. **Drop-Off Station**: This area handles new prescription submissions, refills and any issue that happens in prescription pick-up. Please refer to pictures 1 - 4 below, which illustrate each station's layout and function.


**Picture 1 -** Pick-Up Station


**Picture 2 -** Vaccination Check-in Station


**Picture 3 -** Vaccination Booth


**Picture 4 -** Drop-Off Station

The data collection focused on capturing customer arrival patterns at the pharmacy over 8 hours. A total of 120 customers were observed. Peak and non-peak activities can be seen in Chart 1. Notably, a high influx of customers at 1:00 PM may be attributed to individuals utilizing their lunch breaks for pharmacy visits, as the pharmacy itself has a break from 1:30 PM to 2:00 PM.

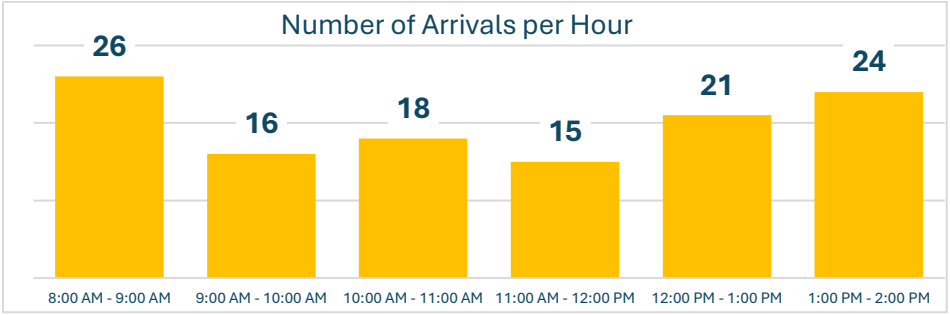


**Chart 1** – Arrivals Per Hour

The observed data also highlights that the majority of customers visited the pharmacy for prescription pick-up, making it the most frequent activity. See Chart 2.

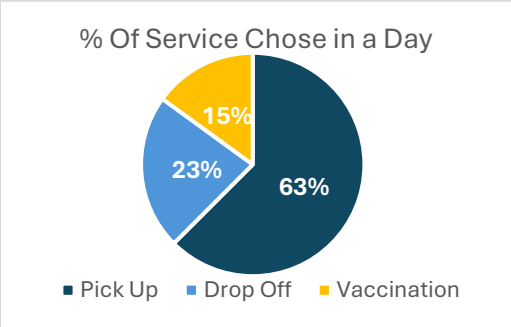


**Chart 2** – Percentage of Processes Chosen by Customers

With the collected data the average inter-arrival time (IAT) for all customers throughout the day was obtained. The data also includes detailed information on assigned services and service durations for pick-up, drop-off, and vaccination processes. Service times are modelled using triangular distributions as you can see in Table 1.

**Table 1** – Customer Arrival and Service Time Distributions

| **Average Inter-Arrival-Times** |
|---|
| 3.12 min |
| **Pick-Up** |
| TRIA(1,4,6) |
| **Drop-Off** |
| TRIA(5,8,12) |
| **Vaccination** |
| TRIA(5,6,12) |

## 3.2 ASSUMPTIONS AND CONSIDERATIONS

To complete this project, data was collected through observation, as the pharmacy did not provide specific operational details. Consequently, several assumptions were made to simulate the system accurately in Arena:

a. **Staffing Levels**: Two technicians handle pick-ups, one nurse handles vaccinations, and one pharmacist handles drop-offs.
b. **Simulation Timeframe**: Runs from 8:00 AM to 5:00 PM, but no new customers arrive after 4:50 PM.
c. **Service Completion**: All customers in the queue by 4:50 PM are serviced before the process ends.
d. **Prescription Readiness**: 90% of prescriptions are ready; 10% require additional resolution.
e. **Problem Resolution**:
   - 95% of customers attempt to resolve issues the same day.
   - 40% of problems are successfully resolved.
f. **Customer Departure**: Some customers leave without prescriptions if issues or refills are not resolved or if customer decides not to solve the issue in the same day.

### 3.3 PROCESS FLOWCHART

The flowchart provides a detailed representation of the customer journey within the pharmacy, covering all key processes and decision points. See Flow Chart 1 below.

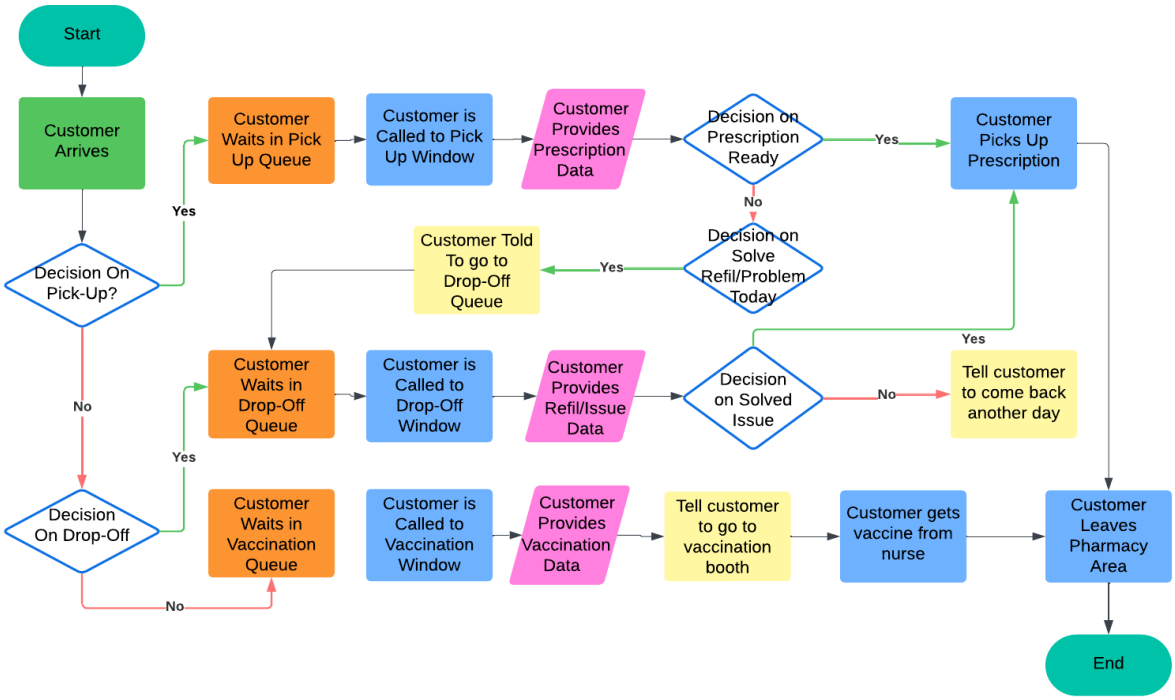


**Chart 3** - Pharmacy Customer Service Process Flowchart

The first decision node reflects the proportions observed during data collection, while the others where assumed through data observation.

- The **Pick-Up Process** accounts for the majority of customer interactions, representing 63%
- The **Drop-Off Process** constitutes 23%
- The **Vaccination Process** represents 15%

## 4. SIMULATION ANALYSIS RESULTS

The simulation was run for 9 hours, capturing customer interactions and process efficiencies. Performance metrics were collected to evaluate system bottlenecks, staff utilization, queue lengths, and overall workflow efficiency. Simulation screenshot is displayed in the appendix.

The simulation produced key findings that provide insights into process efficiencies, bottlenecks, and opportunities for improvement.

### 4.1 CUSTOMER TOTAL TIME

This table summarizes the average total time customers spend in each process, including minimum and maximum values.

**Table 2 –** Customer Average Total Time

| Process | Averge Total Time (min) | Minimum Time (min) | Maximum Time (min) |
|---|---|---|---|
| Pick-Up Process | 6.9 | 3 | 38.4 |
| Drop-Off Process | 18.2 | 8.9 | 35.8 |
| Vaccination Process | 13.1 | 7.9 | 30.5 |

### 4.2 QUEUE WAITING TIME

This table shows the time customers spend waiting in queues before receiving service.

**Table 3 –** Customers Wait Time in Queue

| Process | Average Total Time (min) | Minimum Time (min) |
|---|---|---|
| Pick-Up Process | 0.2 | 3.1 |
| Drop-Off Process | 7.57 | 26 |
| Vaccination Process | 4.08 | 22.4 |

### 4.3 STAFF UTILIZATION

This table shows the time customers spend waiting in queues before receiving service.

**Table 4 –** Employee Utilization

| Staff Member | Utilization Rate |
|---|---|
| Pharmacist | 76.7% |
| Alice (Technician) | 41.5% |
| Jake (Technician) | 38.8% |
| Nurse | 34.6% |

### 4.4 WORK-IN-PROGRESS

This table summarizes the average and maximum number of customers in progress at each stage.

**Table 4 –** Work-In-Progress

| Process | Average (customers) | Minimum (customers) |
|---|---|---|
| Pick-Up Process | 1.52 | 5 |
| Drop-Off Process | 1.22 | 4 |
| Vaccination Process | 0.6 | 3 |

### 4.5 QUEUE LENGTH

This table outlines the average and maximum number of customers in queues.

**Table 5 –** Queue Length

| Process Queue | Averge Total Time (min) | Maximum Time (min) |
|---|---|---|
| Pick-Up Process | 0.05 | 2 |
| Drop-Off Process | 0.69 | 3 |
| Vaccination Process | 0.19 | 2 |

## 5. OBSERVATIONS AND RECOMMENDATIONS

### 5.1 OBSERVATIONS

The Drop-Off Process exhibits the longest total and wait times, with a queue average of 7.57 minutes and a maximum wait time of 26 minutes. This highlights a need for optimization in this process.The Pharmacist's high utilization rate of 76.7% indicates a potential bottleneck, suggesting a need for additional support or task reallocation, while the Nurse's utilization of 34.6%, indicates spare capacity. The Pick-Up Process has minimal queues with an average of 0.05 customers, reflecting efficient service delivery. However, Drop-Off and Vaccination Queues show higher waiting times and WIP, suggesting room for improvement in workflow and resource allocation.

### 5.2 RECOMMENDATIONS FOR PROCESS ENHACEMENT

To improve efficiency and address bottlenecks, several recommendations can be implemented. Increasing support for the Drop-Off Process by redistributing tasks or adding staff during peak hours can help reduce delays. The vaccination workflow could be optimized by leveraging the nurse's spare capacity to handle additional tasks or assist during high-demand periods. Streamlining the Drop-Off Process by evaluating task dependencies and identifying steps that can be automated or expedited will also enhance workflow efficiency. To address the pharmacist's high utilization, strategies should be implemented to reduce their involvement in non-critical tasks, allowing them to focus on high-priority activities. Additionally, rerunning the simulation with adjusted staff allocation, suggested different break times instead of closing the pharmacy completely between 1:30 and 2:00 PM, can provide further insights. For instance, deploying two technicians at the Pick-Up station during peak hours and having one assist other stations during slower periods could balance workloads. Cross-training the nurse to support Pick-Up or Drop-Off tasks during idle times would further improve resource utilization.

A crucial addition to these efforts is leveraging the pharmacy's mobile app capabilities. The app allows customers to view their prescription status, make payments, and even provide their signatures electronically, enabling them to scan and leave quickly upon arrival. The pharmacy should promote this feature more effectively to increase customer awareness and adoption. By integrating this digital solution into the workflow, the pharmacy can significantly reduce in-store wait times and enhance customer convenience.

## 6. CONCLUSION

Optimizing the pharmacy's operations requires a balanced approach that enhances efficiency while maintaining excellent customer service and employee satisfaction. Addressing bottlenecks in the Drop-Off Process, leveraging underutilized resources like the nurse, and promoting the pharmacy's app for streamlined customer interactions can significantly reduce wait times and improve workflow. Implementing these recommendations, alongside adjusted staff allocation and staggered break schedules, will create a more efficient, customer-focused environment. By prioritizing both customer satisfaction and employee well-being, the pharmacy can achieve sustainable operational improvements.

## 7. REFERENCES


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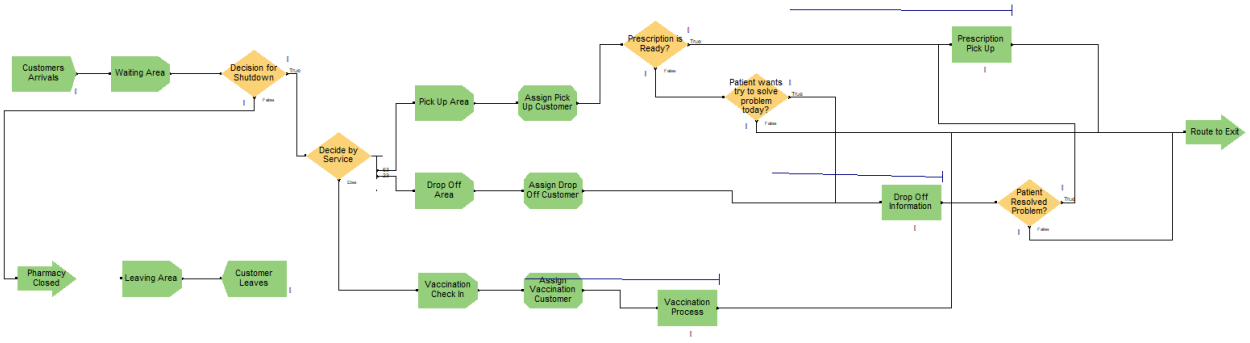
## APPENDIX

Arena Simulation Pharmacy Process Chart




Arena Simulation Pharmacy Process Animation