A Discrete Event Simulation Model for Outpatient Appointment Scheduling

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Agenda

• Problem Introduction and Background
• Why AnyLogic?
• Model
• Results
• Benefits Achieved
  o Demo
• Recent Work
Clinic Overview

- Indiana University Health Arnett (IUHA) is an integrated healthcare system serving Tippecanoe County and the surrounding area.
- Partnership with Indiana University School of Medicine.

- **Total admissions:** 136,371
- **Total outpatient visits:** 2,638,074
- **Total Physicians:** 2,111
- **Total team members:** 29,395
Business Challenge Solved

• **Problem:** Tasked with creating a model to generate a predictive schedule to account for a high number of patients that do not show up to their appointments (**no-shows**).

• **Limitations:** Physician schedule and patient policy

• **Goals:** Increase physician utilization, decrease physician overtime, and decrease patient waiting time
Why AnyLogic?

- Offers a systematic approach to the problem
- Makes implementing discrete events possible
- Gives the option to monitor discrete event measurable such as utilization, time in system, wait time, etc.
- Easy for others to use/learn
- Engaging interface options
- Versatility allows for multi-method simulation model extensions
Model Components

1. Home Screen (initialized)

2. Input Screen – takes input from the user on the clinic capacity preferences, no-show rates, patient mix, and more

3. Model – shows the model’s code, sequence of operations, and more

4. Output Screen – shows the model results and performance measures for a simulation run
# Model Input

## USER INTERFACE

### Appointment Request

<table>
<thead>
<tr>
<th>Time</th>
<th>Requests per Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:00 - 11:00</td>
<td>2</td>
</tr>
<tr>
<td>11:00 - 14:00</td>
<td>2</td>
</tr>
<tr>
<td>14:00 - 17:00</td>
<td>2</td>
</tr>
</tbody>
</table>

### No-Show Rate

<table>
<thead>
<tr>
<th>No-Show Rate</th>
<th>0-1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>.10</td>
</tr>
</tbody>
</table>

### Sick Patients

<table>
<thead>
<tr>
<th>Percentage</th>
<th>To NP</th>
<th>To MD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20.0%</td>
<td>80.0%</td>
</tr>
</tbody>
</table>

### New Patients

- STOP scheduling new patients
- START scheduling new patients

### Patient Characteristics

<table>
<thead>
<tr>
<th>Category</th>
<th>Proportion</th>
<th>Treatment Time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Oct - Mar</td>
<td>Apr - Sep</td>
</tr>
<tr>
<td>Sick</td>
<td>35.20%</td>
<td>23.48%</td>
</tr>
<tr>
<td>Tier 1 New</td>
<td>1.232%</td>
<td>1.522%</td>
</tr>
<tr>
<td>Tier 1 ReCheck</td>
<td>14.96%</td>
<td>17.60%</td>
</tr>
<tr>
<td>Tier 2 New</td>
<td>3.697%</td>
<td>4.567%</td>
</tr>
<tr>
<td>Tier 2 ReCheck</td>
<td>44.90%</td>
<td>52.82%</td>
</tr>
</tbody>
</table>

### MD's Working Schedule

<table>
<thead>
<tr>
<th>Day</th>
<th>Total Number of Work Hours per Day of Week</th>
<th>Preferred Total Number of Patients excluding sick</th>
<th>Preferred Max Number of New Patients</th>
<th>Preferred Max Number of Sick Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mon</td>
<td>8</td>
<td>18</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Tue</td>
<td>8</td>
<td>18</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Wed</td>
<td>8</td>
<td>18</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Thu</td>
<td>8</td>
<td>18</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Fri</td>
<td>8</td>
<td>18</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>
Model Demonstration

Model available at:

OUTCOME DASHBOARD

Total Patient Discharges (by visit type)
- Sick: 178
- NewTier1: 77
- ReTier1: 220
- NewTier2: 161
- ReTier2: 641

Patient Request-to-Appointment Wait Time (in days)
- New Tier 1
- New Tier 2
- ReCheck Tier 1
- ReCheck Tier 2

100% Daily Capacity
- Monday: 26
- Tuesday: 26
- Wednesday: 26
- Thursday: 26
- Friday: 26

MD Time Utilization

MD Overtime per Day (hrs per day)

Sick Patient Discharges
- Seen by MD: 178 ( )
- Seen by NP: 75 ( )
Why is this Significant

- Presents a method to test theories before implementing them in the clinic
- Offers low risk, low cost way to get theoretical results
- Gives different forecasts to help the clinic prepare for the future such as when the clinic will reach maximum capacity
- Outputs include several different ideas to back up any recommendations
Benefit Achieved

- Can determine patient-type capacity settings for physician schedule
- Results include how long, on average, each patient waits between scheduling their appointment and being seen by the physician
- Shows the number of sick patients seen by the nurse as opposed to the doctor
- Increases the utilization of the physician and decreases the patient waiting time
Update

• Unfortunately, the model was never utilized by IUHA
• Currently extending the model to a new setting for the Diabetes Health and Wellness Institute (DHWI)
  o 2 graduate students
  o 1 senior design team (4 undergraduates)
  o Exploring new scheduling policies
  o Results of the new analysis at DHWI will be implemented in their clinic setting January 2016
References

• [1] Li, Yan et al. “Clinic Scheduling – Boustany – Purdue Healthcare Advisors.”
  http://www.runthemodel.com/models/924/

Questions?

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Q&A

- Was the model utilize by IUHA and what benefit was achieved?
- Why was this model a discrete-event model as opposed to a agent-based model?
- Have you thought about allowing the user modify the NP’s working schedule?
Executive Summary

- The system consists of a full service acute care hospital and a multispecialty clinic with approximately 200 providers at multiple locations.
- IUHA seeks to develop a scheduling methodology that provides same day access for a designated patient population while allowing acceptable access to the remaining patient population.
- Currently provider schedules are being driven by individual preference which leads to increased variation in scheduling rules that fail to meet employer or patient expectations.
- To address the challenge in appointment scheduling at IHUA, we developed a discrete-event simulation model using AnyLogic to predict the operational performance of the clinic under different demand patterns and staffing scenarios.
- Specifically, decision-makers can input population characteristics (e.g., arrival rate, probability of no-show, composition of different patient types) of the specific clinic and the physician work schedules.
- The model will then predict performance measures such as the average patient request-to-appointment time, clinic utilization, and physician working overtime for up to two years.
- The simulation model provides a great tool for IUHA to improve its operational efficiency and patient satisfaction. This model could also be used to help appointment scheduling in other outpatient clinics with similar settings.
% of Sick Patients to NP

Average MD Time Utilization

% of Time MD Busy for 50% of Day
Preferred Number of New and Sick Patients

# of New/Sick Patients Comparison

Average Lead Time (Days)

Preferred # of New/Sick Patients

New Tier 1
New Tier 2
Recheck Tier 1
Recheck Tier 2

% of time MD Busy for 50% of Day

Preferred Number Sick Patients and New Patients

Average MD Time Utilization

% of MD Busy

Preferred Number of New and Sick Patients

% of Time MD Busy for 50% of Day

Preferred Number Sick Patients and New Patients
Preferred Number of Patients (Excluding Sick)

- **Total # of Patients Comparison**
- **Average MD Time Utilization**
- **% of Time MD Busy for 50% of Day**
**Hours Worked Per Day**

**MD's Working Schedule Comparison**

- **Average Lead Time (Days)**
- **# Hours Worked in a Day**

Legend:
- New Tier 1
- New Tier 2
- Recheck Tier 1
- Recheck Tier 2

**% of Time MD Busy for 50% of Day**

- **Scheduled Hours to Work Daily**

- **Average MD Time Utilization**

- **% of Day MD Busy**
- **Scheduled Hours to Work Daily**
No Show Rate

No Show Rate Comparison

Average Lead Time (Days)

No Show Rate

Average MD Time Utilization

% of Time MD Busy for 50% of Day

% of time MD Busy for 50% of Day or More