Emergency Department Triage Process Improvement

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Industry and Academic Sponsors

Industry Sponsors
- Larry Carpenter
- Rachael Rowland

Academic Sponsors
- Dr. Fredericks
- Dr. Butt
Ascension Borgess Hospital in Kalamazoo
Flow Chart of Emergency Department

Patient Enters → Check-in → Triage → Room → Lobby

Discharge → Admit
Triage Process

Patient’s entering the hospital are given an **acuity level**

Based on:
- Severity of symptoms
- Number of resources needed
**Project Objectives**

**IMPROVE**
- Patient Experience
- Safety and Quality
- Profitability
- Staff Satisfaction

**REDUCE**
- Patients leaving without being seen (LWBS).
- Patient length of stay (LOS).
- Ineffective use of staff.
Data Collection

• Observations
  ❖ Customer Needs
  ❖ Questionnaires

• Time studies

• Hospital database
Building Current State Model:

Layout

Lobby

Triage

Rooms:
- Trauma
- Standard
- Fast Track
- Behavioral Mental Health (BMH)

Entities = Patients

Arrival Cycles

% per hour (weekly)

Resources = Hospital Staff

Entities = Patients

Stat::Fit.

Student

Timeblocks (1 - 40), 5 hours each

Resources = Hospital Staff
Final step, processing:

Flight Risk:

- 24% of patients

Max wait time:

- Acuity 2 - 185 min
- Acuity 3 - 147 min
- Acuity 4 - 21 min
- Acuity 5 - 18 min

Processing Code

```cpp
Wait_time = Clock() - Start_time
If LWBS > 76 Then
    //1
    If Patient_Type = 2 Then
        //Left Without Being Seen
        If Wait_time > 185 Then
            Inc Exit_LWBS
            Inc Exit_No
            Inc AC_2_LWBS
            route 2
        Else
            route 1
    Else
        //2
        If Patient_Type = 3 Then
```
Final step, processing:

Processing Code

```c
Wait_time = Clock() - Start_time
If LWBS > 76 Then
  //1
    If Patient_Type = 1 Then
      //2
        If Patient_Type = 3 Then
          //3
            Left Without Being Seen
              Flight risk
            Care time
            Patient attributes
              Acuity
              Heart Conditions
              BMH
              Admit vs. Discharge
            Staff movement
            Room Placements
          
```

Finished “Base” Simulation Model
Validation and Verification

Visual Verification:
- Processing of entities and resources

Paired Sample T-Test Results:
- Total Output
- Admit vs Discharge
- Average Length of Stay
- LWBS

Stress Testing Results:
- Reasonable 8 year outcomes
### Outcomes
**Base Model: Current State of ED**

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients leaving without being seen (LWBS)</td>
<td>562/yr</td>
</tr>
<tr>
<td>Patient length of stay (LOS)</td>
<td>296 min</td>
</tr>
<tr>
<td>Ineffective use of staff</td>
<td>15.52%</td>
</tr>
</tbody>
</table>

**Base Simulation Model Metrics**
Approach to the Problem

Key Challenges in the ED:

1. Delays in services
2. Shortage of staff
3. Lack of beds for admitted patients

Model 1: Vertical Care

1. Delays in services
2. Shortage of staff
Simulation
Model 1: Vertical Care

- Designed for acuity 4 and 5
- Horizontal beds → vertical chairs
- Results pending area
- Reduces cleaning cost and time

Source: “To provide better, faster care, emergency department goes vertical” Susan Coppa April 2, 2018
# Outcomes

## Model 1: Vertical Care

<table>
<thead>
<tr>
<th>Base Simulation Model Metrics</th>
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<tbody>
<tr>
<td>LWBS: 562/yr</td>
</tr>
<tr>
<td>LOS: 296 min</td>
</tr>
<tr>
<td>Patients Blocked: 5%</td>
</tr>
<tr>
<td>Avg. Resource License Utilization: 15.52%</td>
</tr>
</tbody>
</table>

**LWBS:** 0%
**LOS:** 0%
**Blocked:** 0%
**Resource:** 0%

- **No change from current state**
- **Percent positive or negative change from current state**

16
Model 2: Check-in and Triage Changes

2. Shortage of staff
Recommended by triage nurses:

- Using two triage locations
- Full-time use of registration clerk
Outcomes
Model 2: Check-in and Triage Changes

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- LWBS: 13% (no change from current state)
- LOS: 0% (no change from current state)
- Blocked: 16%
- Resource: 5%

Percent positive or negative change from current state
Model 3: Proposed Lobby Layout

1. Delays in services
2. Shortage of staff
Proposed layout

- 4 Triage Bays
- Minimal waiting area
- Results pending area
- 3 Curtains for EKG’s use
- 2 Kiosks

Kiosk:

- Decrease by $7 per patient check-in

Source: “Touchscreen Check-In: Kiosks Speed Hospital Registration” Rhoads, J., Drazen, E. March 2009
# Outcomes

## Model 3: Proposed Lobby Layout

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- **LWBS:** 22%  
- **LOS:** 1%  
- **Blocked:** 20%  
- **Resource:** 33%

- No change from current state
- Percent positive or negative change from current state
Facilities Layout Improvements

- ProModel Outputs
- Systematic Layout Planning
  - From-To chart
  - Relationship chart

Proposed Layout

- 3 Triage Bays
- 1 Curtain for EKG’s
- Only 1 RN
- More waiting area for families
## Outcomes
Revised Lobby Layout

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<td>LWBS: 562/yr</td>
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**Metrics Changes:**

- LWBS: 37% (↓)
- LOS: 0% (↓)
- Blocked: 22% (↓)
- Resource: 5% (↑)

Icons:
- No change from current state
- Percent positive or negative change from current state
Model 4: Admit Holding Unit

3. Lack of beds for admitted patients
Simulation
Model 4: Admit Holding Unit

Temporarily holds admit patients


“The Economics of an Admissions Holding Unit” Schreyer, Kraftin. Martin, Richard 2017
Outcomes
Model 4: Admit Holding Unit

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- LWBS: 69%
- LOS: 2%
- Blocked: 40%
- Resource: 0%

No change from current state

Percent positive or negative change from current state
Comparing the Models
ANOVA Analysis

**LWBS**

<table>
<thead>
<tr>
<th>Statistically Significant from Base Model?</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acuity 1</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Acuity 2</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Acuity 3</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Acuity 4</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Acuity 5</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

**LOS**

<table>
<thead>
<tr>
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</tr>
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<td>No</td>
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</tr>
<tr>
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<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
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<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Acuity 4</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Acuity 5</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

**% Blocked**

<table>
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<th>Model 4</th>
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<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Acuity 3</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Acuity 4</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Acuity 5</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>
Cost Analysis

Patient Resource Usage Yearly Cost

Investment Analysis

<table>
<thead>
<tr>
<th>Cost Analysis</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Investment</td>
<td>$704,285</td>
<td>$73,515</td>
<td>$282,143</td>
<td>$1,812,860</td>
</tr>
<tr>
<td>ROI</td>
<td>30%</td>
<td>4%</td>
<td>30%</td>
<td>63%</td>
</tr>
<tr>
<td>Payback Years</td>
<td>3.2</td>
<td>2.0</td>
<td>3.2</td>
<td>1.7</td>
</tr>
</tbody>
</table>
Recommendations
Recommendations

Short-Term:

**Model 4 - Admit Holding Unit:**
- Greatest benefits to the system and cost

**Model 2 - Check-in and Triage Changes:**
- Small initial investment and proof of some system and cost benefits
Recommendations

Long-Term:

Model 3 - Proposed Lobby Layout:
  • High ROI and confirmed statistical difference for every acuity in ANOVA analysis

Model 4 - Admit Holding Unit:
  • Shows that underlying challenge is blockages from admitted patients
  • Recommendation: root-cause admission issues in hospital as an admit holding unit is a surface solution
Outcomes
Long-Term Recommendations

LWBS: 85%
LOS: 2%
Blocked: 58%
Resource: 5%

Yearly savings $1,268,258 in patient resource usage cost
Yearly increased revenue $900,000 in reduction of LWBS
After 1.8 year payback period
Questions?
Patients = Entities

How many?

Distributions

% ACUITY

1- Resuscitation 1%
2- Emergent 28%
3- Urgent 44%
4- Less Urgent 25%
5- Non Urgent 2%
Fitted Distributions:

- Lognormal(12.08, 7.7047)
- Lognormal(259.67, 1.102)
- Beta(0, 486, 24.6, 5.04)
- Lognormal(230.115, 1.207)
- Gamma(6.23, 3.7)
One week split into 168 hours

One week split into 40 time blocks (5 hours each)
Validating the Current State Model

Metric: Total Output

<table>
<thead>
<tr>
<th>Acuity</th>
<th>Raw</th>
<th>Simulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1- Resuscitation</td>
<td>1007</td>
<td>863</td>
</tr>
<tr>
<td>2- Emergent</td>
<td>20391</td>
<td>20301</td>
</tr>
<tr>
<td>3- Urgent</td>
<td>31752</td>
<td>32166</td>
</tr>
<tr>
<td>4- Less Urgent</td>
<td>18037</td>
<td>18013</td>
</tr>
<tr>
<td>5- Non Urgent</td>
<td>1805</td>
<td>1668</td>
</tr>
<tr>
<td>Grand Total</td>
<td>73667</td>
<td>73011</td>
</tr>
</tbody>
</table>

t-Test: Paired Two Sample for Means

<table>
<thead>
<tr>
<th></th>
<th>Raw</th>
<th>Simulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>14598.4</td>
<td>14602.2</td>
</tr>
<tr>
<td>Variance</td>
<td>172005353.8</td>
<td>177164023.7</td>
</tr>
<tr>
<td>Observations</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Pearson Correlation</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Hypothesized Mean</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>df</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>t Stat</td>
<td>-0.036</td>
<td></td>
</tr>
<tr>
<td>P(T&lt;=t) one-tail</td>
<td>0.486</td>
<td></td>
</tr>
<tr>
<td>t Critical one-tail</td>
<td>2.132</td>
<td></td>
</tr>
<tr>
<td>P(T&lt;=t) two-tail</td>
<td>0.973</td>
<td></td>
</tr>
<tr>
<td>t Critical two-tail</td>
<td>2.776</td>
<td></td>
</tr>
</tbody>
</table>
Current State - Monthly Metrics

<table>
<thead>
<tr>
<th></th>
<th>Arrive</th>
<th>Discharge</th>
<th>Admit</th>
<th>LWBS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>4017</td>
<td>2970</td>
<td>1047</td>
<td>47</td>
</tr>
<tr>
<td>Acuity 1</td>
<td>8</td>
<td>43</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Acuity 2</td>
<td>548</td>
<td>572</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Acuity 3</td>
<td>1286</td>
<td>428</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Acuity 4</td>
<td>984</td>
<td>4</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Acuity 5</td>
<td>97</td>
<td>0</td>
<td>2</td>
<td></td>
</tr>
</tbody>
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