An ED Simulation Fueled by Automated Data Collection

18th Annual Society for Health Systems Conference
February 10 – 12, 2006
The San Diego Marriott Hotel & Marina
San Diego, California
Who We Are

• Bill Ferris
  - Nine years experience in healthcare process improvement with Henry Ford Health System, HSE, and TefenUSA

• Tim Ward
  - Bio snippet
Presentation

- Rush University Medical Center Emergency Department
- Automating Data Collection
  - Clinical Information System
  - Infrared Patient Tracking System
- Data Analysis Issues & Challenges
- Simulation Model & Results
- Lessons Learned
- Future Uses
About Rush

- Rush University Medical Center is located in Chicago, Illinois
- The Emergency Department currently sees approximately 42,000 visits per year
Defining the Problem

• Future: RUMC planning to expand the emergency department & grow emergency services
  - What are the operational implications of increased volume?
• Current: How can the department improve staffing levels due to short term fluctuations in volume
  - How much does impact does the type of patient on workload?
Automating Data Collection – Why?

- Difficult to do observation based data collection in many healthcare settings
  - Significant patient/provider travel makes following simultaneous patients/providers difficult
  - Single encounters can often be very lengthy
  - Either sample sizes are small or observer time is large (sometimes both)
Automating Data Collection – Why?

- Manual collection using “self-reporting” has many issues
  - Accuracy and consistency of information
  - Legibility of information
  - Compliance is highly variable
Automating Data Collection

Patients

- RUMC has the benefit of an Emergency Department Information System (IBEX)
  - Captures relevant timing, location, and demographic information about patients
  - 3 years of historical data available
Automating Data Collection

Staff

- Installed ArialView Infrared tracking system
  - Receptors installed in each exam room and in work areas
  - IR tags given to each staff member
  - System captures the movement and stores all movement in a SQL Server database
- System was in place for 6 months
Automated Data Collection

The Results

- Sensors: 58
- Patients: 21,336 records
- Staff Records: 2,912,820 records (timestamps)
- Patient & Staff matched records: 374,484
- Now how to make sense of that much information…
Cleaning the Staff Data

- The IR data requires significant cleaning
- The IR system creates a record every time a tag is “found” or “lost” in the system
- Tags can become lost if they get accidentally covered
- The result is instances of lost time or redundant records
- Need an algorithms for filtering the data to accommodate the redundant
Cleaning the Data

- Staffing data is presented simply as tag id, location id, timestamp, in/out
- The goal is to get the data to:
  - Tagid
  - Locationid
  - Intime
  - Outtime
- Along the way many “extra” records need to be removed or combined
Preparing the Patient Data

• “In” and “Out” times were calculated for each patient at each location

• Patients were classified into buckets based on the following criteria:
  - Disease type: 25 categories
  - Acuity: High, Medium, Low
  - Age: Pediatric, Adult

• Arrival patterns and LOS were determined for each resulting patient type (100)
Putting the Staff & Patient Data Together

- Once the data is clean, need to determine how much time staff spent with patients
- A series of SQL queries were run to determine the times that patients and staff were co-located in the same location
- Direct patient-provider time was multiplied by a factor to determine workload by patient type
The Simulation Model

• Now that the data is collected, it is time to make the model...
What Does the Model Do?

- Calculates staffing requirements given different volumes and different patient type mixes (acuities, diagnosis groups)
- Physicians & Nurse Practitioners
- Nurses (RN)
- Patient Care Technicians (PCT)
Model Parameters

Patient Types

• 100 patient types based on the following combinations:
  - 25 Diagnosis Groups
  - 3 Acuities
  - Pediatric or Adult

• Patient volumes can be adjusted in the model
Model Parameters

Arrivals

- Patients in the model “arrive” according to historical distribution patterns

- Patient Type is assigned based on time of arrival within the week
  - i.e. Emergent patients represent a higher percentage of midnight shift arrivals than Urgent and Non Urgent patients
Model Parameters

Processing Times

- Four process intervals
  - Pre-Dispo: In-room time to Disposition Time
  - Admit: Disposition time to ED discharge for admitted patients
  - Discharge: Disposition time to ED discharge for discharged patients
  - Observation: Disposition time to ED discharge for patients in observation
Model Parameters

Processing Times

- Probabilistic distributions calculated for each interval and each patient type
  - 400 distributions total
- Distributions based on historical data (September 2001–September 2003)
Model Parameters

Staffing Ratios

- Staff times based on data from staff tracking system
- Average staff time for each patient type was calculated for each processing interval
- Average staff time was compared to average patient time to determine a “staff ratio”
  - Example: If a Non Urgent abdominal pain patient sees a physician for 10 minutes on average prior to disposition, and the pre-dispo process averages 40 minutes, the resulting ratio would be 0.25 physicians
- Resulting ratio is then applied to duration of the patient stay
Model Parameters

Staff Ratio Adjustments

- Staff tracking data only provides information when patient and provider are in the same location
- Need to account for “non-contact” time
- Inflation factor applied to each ratio to bring staffing requirements inline with current staffing
  - Physician=3 times direct patient ratio
  - RN=4.5 times direct patient ratio
  - PCT=2.5 times direct patient ratio
Model Assumptions

- Resident time is not included in the model
- Nurse Practitioners and Physicians are treated the same
- For the scenarios run to date, patient mix does not change as volume increases
Model Scenarios

- Eighteen model runs performed at increasing volumes from 40,000 annual visits to 80,000 annual visits
- Each scenario was run for one year or 52 one week replications
Model Validation

Census

Model Validation - Average Census by Time of Week

![Graph showing average census by time of week with blue and orange lines representing Model and Base respectively. The graph has time labels for Sunday to Saturday and patient counts ranging from 0 to 30.]
Model Results - Raw Staffing Requirements

Nurse Staffing by Hour of Week
## Results - The Staffing Grid

### Rush Recommended Physicians Core Schedule

| DOW  | 0000 to 0100 | 0100 to 0225 | 0225 to 0359 | 0359 to 0459 | 0459 to 0600 | 0600 to 0700 | 0700 to 0800 | 0800 to 0900 | 0900 to 1000 | 1000 to 1200 | 1200 to 1300 | 1300 to 1400 | 1400 to 1500 | 1500 to 1600 | 1600 to 1700 | 1700 to 1800 | 1800 to 1900 | 1900 to 2000 | 2000 to 2100 | 2100 to 2200 | 2200 to 2359 |
|------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| Mon  | 3            | 4            | 3            | 3            | 3            | 3            | 3            | 3            | 3            | 3            | 3            | 3            | 3            | 3            | 3            | 3            | 3            | 3            | 3            | 3            |
| Tue  | 5            | 3            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            |
| Wed  | 3            | 3            | 3            | 3            | 3            | 3            | 3            | 3            | 3            | 3            | 3            | 3            | 3            | 3            | 3            | 3            | 3            | 3            | 3            | 3            |
| Thu  | 4            | 5            | 6            | 5            | 4            | 4            | 3            | 3            | 3            | 3            | 3            | 3            | 3            | 3            | 3            | 3            | 3            | 3            | 3            | 3            |
| Fri  | 6            | 5            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            |
| Sat  | 7            | 6            | 5            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            |
| Sun  | 8            | 7            | 6            | 5            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            |

### Rush Recommended Registered Nurse Core Schedule

| DOW  | 0000 to 0100 | 0100 to 0225 | 0225 to 0359 | 0359 to 0459 | 0459 to 0600 | 0600 to 0700 | 0700 to 0800 | 0800 to 0900 | 0900 to 1000 | 1000 to 1100 | 1100 to 1200 | 1200 to 1300 | 1300 to 1400 | 1400 to 1500 | 1500 to 1600 | 1600 to 1700 | 1700 to 1800 | 1800 to 1900 | 1900 to 2000 | 2000 to 2100 | 2100 to 2200 | 2200 to 2359 |
|------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| Mon  | 8            | 7            | 6            | 5            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            |
| Tue  | 9            | 8            | 7            | 6            | 5            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            |
| Wed  | 8            | 9            | 8            | 7            | 6            | 5            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            |
| Thu  | 9            | 8            | 7            | 6            | 5            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            |
| Fri  | 9            | 8            | 7            | 6            | 5            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            | 4            |
| Sat  | 9            | 9            | 9            | 9            | 9            | 9            | 9            | 9            | 9            | 9            | 9            | 9            | 9            | 9            | 9            | 9            | 9            | 9            | 9            | 9            | 9            |
| Sun  | 9            | 9            | 9            | 9            | 9            | 9            | 9            | 9            | 9            | 9            | 9            | 9            | 9            | 9            | 9            | 9            | 9            | 9            | 9            | 9            | 9            |

### Rush Current Patient Care Technician Core Schedule

| DOW  | 0000 to 0100 | 0100 to 0225 | 0225 to 0359 | 0359 to 0459 | 0459 to 0600 | 0600 to 0700 | 0700 to 0800 | 0800 to 0900 | 0900 to 1000 | 1000 to 1100 | 1100 to 1200 | 1200 to 1300 | 1300 to 1400 | 1400 to 1500 | 1500 to 1600 | 1600 to 1700 | 1700 to 1800 | 1800 to 1900 | 1900 to 2000 | 2000 to 2100 | 2100 to 2200 | 2200 to 2359 |
|------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| Mon  | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            |
| Tue  | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            |
| Wed  | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            |
| Thu  | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            |
| Fri  | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            |
| Sat  | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            |
| Sun  | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            | 2            |
Future Modeling Scenarios

- Change patient type mix and see resulting staff requirements
- Further explore the correct mix of Nurse Practitioners and/or Physician’s Assistants
- Explore the staffing impact of standardizing practice patterns
- Further study Resident/Staff interactions
Lessons Learned

- Automated data collection is still a lengthy process, but the collection period is “offline”
- Total project time may be longer than a “manual” project, but project hours stand to be significantly less
- Requires significant data manipulation
  - A knowledge of programming and/or very strong SQL skills is required
  - The resulting code can be re-used for future projects
- Despite millions of records, the data isn’t perfect and assumptions still need to be made
- Strong physician leadership helps with compliance