Health Systems Qualifying Exam
September 2010

Rules: Closed book closed notes
Faculty coordinator for exam content: Alagoz & Brennan & Zimmerman
PROCEDURE: Answer all of the following FOUR questions in the blue book provided.

1. [BRENNAN] Information systems are an innovation believed to enhance the quality and efficiency of health care. The US Federal Government is establishing policies that will provide hospitals, clinics and physicians with incentive payments for making meaningful use of information technology.
   
   a. Describe the current state of information technology deployed in health care systems in the United States
   
   b. Provide plausible explanations for the current state of health information technology deployment
   
   c. Identify one ISyE method or technique that could improve the uptake of health information technology
2. [ZIMMERMAN] There is a sign on the public message board at University Hospitals and Clinics (UWHC, commonly known as “University Hospital”) that says: “UWHC has been named as one of the ‘most wired and wireless’ hospitals in the country.” Someone walked by the sign and said “How can they know if they are one of the most ‘wired’ and ‘wireless’ hospitals in the country”?

That is a good question. Discuss how one would design a study to determine how “wired” and “wireless” UW Hospital is.

- Are “wired” and “wireless” different characteristics? Explain. Then choose either “wired” or “wireless” as a concept, and answer the following questions:
  
  - What measures would one use to evaluate how “wired” (or “wireless”) UW Hospital is?
  - What design considerations would be most important in objectively evaluating this claim? How would you go about achieving adequate internal validity of the study?
  - What quantitative and qualitative methods should be used to evaluate the claim?
  - Let’s assume we determine that UW Hospitals is one of the most wired hospitals? So what? What difference does it make? Discuss.
3. [ALAGOZ] Please answer the following three questions.

(a) Consider two competing programs, program A and program B with different costs and effectiveness. Under what scenarios for their costs and effectiveness (i.e. more or less expensive and more or less effective), the use of cost-effectiveness analysis is beneficial?

(b) In a cost-effectiveness study of a health-care problem, when would a Markov process be preferred over a traditional decision tree? Give an example for its use.

(c) What is the sensitivity and specificity of a diagnostic test? Provide the exact formula to calculate them. Suppose there is an opportunity to improve either the sensitivity or the specificity of a diagnostic test (such as mammography for breast cancer screening) equally, which of the two should we be improving? Why?
4. [BRENNAN] Review the attached abstract and answer the following questions:

a. Draw a diagram depicting the system simulated in this problem

b. Write a three-five sentence summary and interpretation of Table 1 that could form the basis of a report to the ER Manager

c. According to Table 1, which arrival rate and resource mix yielded the greatest contribution margin?

d. The abstract states that inter-arrival times followed an exponential distribution. Explain what this. Show the steps (i.e., analytical methods) that the authors might have used to arrive at this determination.

e. The manager wants to use this simulation to help plan for what she anticipates being a busy holiday weekend. The ER is short staffed at present and there is no chance of increasing staffing for the holiday weekend, even though increased demand for services is expected. What will be the likely consequence of this plan to patients and to the ER?
Using Discrete Event Simulation to Study Patient Length of Stay

Henneman PL, Beck E, Balasubramanian H, Li H, Campbell MM, Osterweil LJ/ Tufts-Baystate Medical Center, Springfield, MA; University Massachusetts, Amherst, MA; Baystate Medical Center, Springfield, MA

Background: Emergency department (ED) crowding is common. Crowding results in increased patient length of stay (LOS). Minimizing LOS would improve patient flow and reduce crowding.

Study Objective: To create a reproducible model of emergency care that supports using discrete event simulation (DES) to study how arrival rate, resource management, process changes, and task prioritization affect patient LOS.

Methods: The distribution of inter-arrival rate between 2 consecutive ED patients was determined during a one-month period at a site with >100,000 annual visits. Task time distributions (median, 25%, 75% interquartile range) were determined in a convenient sample of ED staff. Arena DES was used to determine patient LOS (arrival to discharge) and contribution margin (CM, net revenue minus direct clinical costs) for 200 patients with 5 patient-activities, acuity-based resource utilization, arrival rates of 1 to 16 patients per hour, and triangular task time distributions. Direct clinical costs (staff, supplies, and testing) and net revenue by acuity level were institution specific. LOS and CM are expressed as means from 200 replications of each simulation with 95% confidence intervals less than ±3% of mean. Ideal LOS was defined as minimal LOS (no waits) plus 20%. A crowded ED scenario was created by increasing each arrival rate by 30% without increasing resources. An open bed scenario was created by doubling the number of beds in the crowded ED for each arrival rate.

Results: Inter-arrival times between 9348 consecutive ED patients had an exponential distribution for all arrival rates and each hour of a 24 hour day. 860 task times were measured (average 26/task). The minimal LOS per patient for 200 patients (10% level 1, 10% level 2, 30% level 3, 25% level 4, 25% level 5, 1 hr boarding) was 115 minutes. Table 1 shows the resource mix and CM by patient arrival rate that generated an ideal LOS with our model of care.

The crowded ED scenario increased LOS from 137 to 194 minutes, increased the wait for bed from 18 to 71 minutes, and increased CM from $4,593 to $17,800. The open bed scenario reduced LOS in the crowded ED from 194 to 142 minutes but did not significantly change CM. Bedside registration for all patients minimally increased LOS in the ideal scenario from 137 to 146 minutes but increased LOS in the crowded ED from 194 to 228 minutes. In the open bed scenario, bedside registration had no impact on LOS. Prioritizing initial assessment or discharging an existing patient had little or no impact on LOS in all scenarios.

Conclusions: Discrete event simulation allows one to study the impact of arrival rate, resource management, process changes, and task prioritization on ED patient LOS. In our computer model, we found that 1) ideal LOS can be maintained for increasing arrival rates by increasing resources; 2) increasing arrival rates without increasing resources results in increased waiting times for beds and increased CM; 3) adding additional beds to a crowded ED scenario offsets increases in LOS caused by increased arrival rates but does not change CM; and 4) bedside registration for all patients and prioritization of either initial assessment or final discharge does not reduce LOS.

<table>
<thead>
<tr>
<th>Arrival Rate Per Hour</th>
<th>Resources B/MD/RN/C1</th>
<th>Mean LOS (minutes)</th>
<th>Contribution Margin ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5/1/3/1</td>
<td>132</td>
<td>-8,685</td>
</tr>
<tr>
<td>2</td>
<td>7/2/5/1</td>
<td>137</td>
<td>5,246</td>
</tr>
<tr>
<td>4</td>
<td>12/3/10/1</td>
<td>137</td>
<td>13,067</td>
</tr>
<tr>
<td>8</td>
<td>19/7/20/2</td>
<td>137</td>
<td>4,638</td>
</tr>
<tr>
<td>16</td>
<td>35/10/35/3</td>
<td>138</td>
<td>8,701</td>
</tr>
</tbody>
</table>

B beds, MD doctors, RN nurses, Clk clerks

This is the end of the test