

# Simulation Based Process Analysis And Optimization For A Pre-Surgical Screening Clinic

## Presentation Outline

- **What I am doing in the PSS and elsewhere in the hospital**
- **What you might want to know about simulating hospital processes:**
  - **Why simulate hospital processes**
  - **What Monte Carlo Simulation is**
  - **What the critical components/factors needed for successful simulation studies are**

## Disclosure

- **Most of the work discussed in this presentation has been supported by the:**
  - **Sir Mortimer B. Davis Jewish General Hospital**
  - **The Jewish General Hospital Foundation**
- **I am the sole employee of Les Entreprises TROYWARE**

# Why Simulate The PSS (Or Any Other Hospital Process)?

## Why Simulate The Proposed PSS?

- **An average of around 50 patients/day will need to do some of the following:**
  - **Register for the clinic**
  - **View a video orientation dvd**
  - **See a pharmacist**
  - **Give blood and urine samples**
  - **Change into a gown**
  - **Have EKG taken**
  - **See a GP or internist**
  - **Get dressed**
  - **Receive group training**
  - **Receive individual training**
  - **Submit insurance information**

## Why Simulate The PSS?

- **Hospital management needs to determine:**
  - **The number of exam rooms**
  - **The number of nurses (and nurse training rooms)**
  - **The number of chairs in the waiting room**
  - **...**

## Why Simulate The PSS?

- **Complicating factors:**
  - **Randomness of time needed for each task for each patient**
  - **Randomness of tasks needed for each patient**
  - **Physicians don't want to wait between patients**
  - **Space in the hospital is limited**
  - **Would like to preclude or minimize overtime**
  - **Need to minimize patient overflow and dissatisfaction with long waits**
  - **...**

## Why Simulate The PSS?

- **To understand the effect of randomness consider a PSS in which:**
  - **One patient arrives every 7.5 minutes needing to perform the tasks listed below**
  - **There are 6 exam rooms, 3 nurses, 2 registration staff, and 2 physicians**
  - **It takes exactly:**
    - **15 minutes for patients to register and provide insurance info**
    - **15 minutes for patients to watch their orientation video**
    - **7.5 minutes for patients to get into their gown**
    - **7.5 minutes for patients to have their EKG taken**
    - **15 minutes for patients to be seen by a physician**
    - **15 minutes for patients to get out of their gown**
    - **30 minutes for groups of size 4 to be trained**
    - **15 minutes for individual training**
- **The only waiting will be for the group and individual training**



## Why Simulate The PSS?

- **Now consider the waiting in a PSS in which:**
  - **One patient arrives on average every 7.5 minutes needing to perform some tasks**
  - **There are 6 exam rooms, 3 nurses, 2 registration staff, and 2 physicians**
  - **On the average it takes:**
    - **15 minutes for patients to register and provide insurance info**
    - **15 minutes for patients to watch their orientation video**
    - **7.5 minutes for patients to get into their gown**
    - **7.5 minutes for patients to have their EKG taken**
    - **15 minutes for patients to be seen by a physician**
    - **15 minutes for patients to get out of their gown**
    - **30 minutes for groups of size 4 to be trained**
    - **15 minutes for individual training**
- **It's likely that queues, possibly large, will occur at every step of the process**

## Why Simulate The PSS?

- **Possible approaches to analyzing and making decisions for the PSS:**
  - **Spreadsheet or optimization software (e.g. Solver)**
  - **Queuing Theory**
  - **Monte Carlo Simulation Based Optimization (Using A Discrete Event Model)**

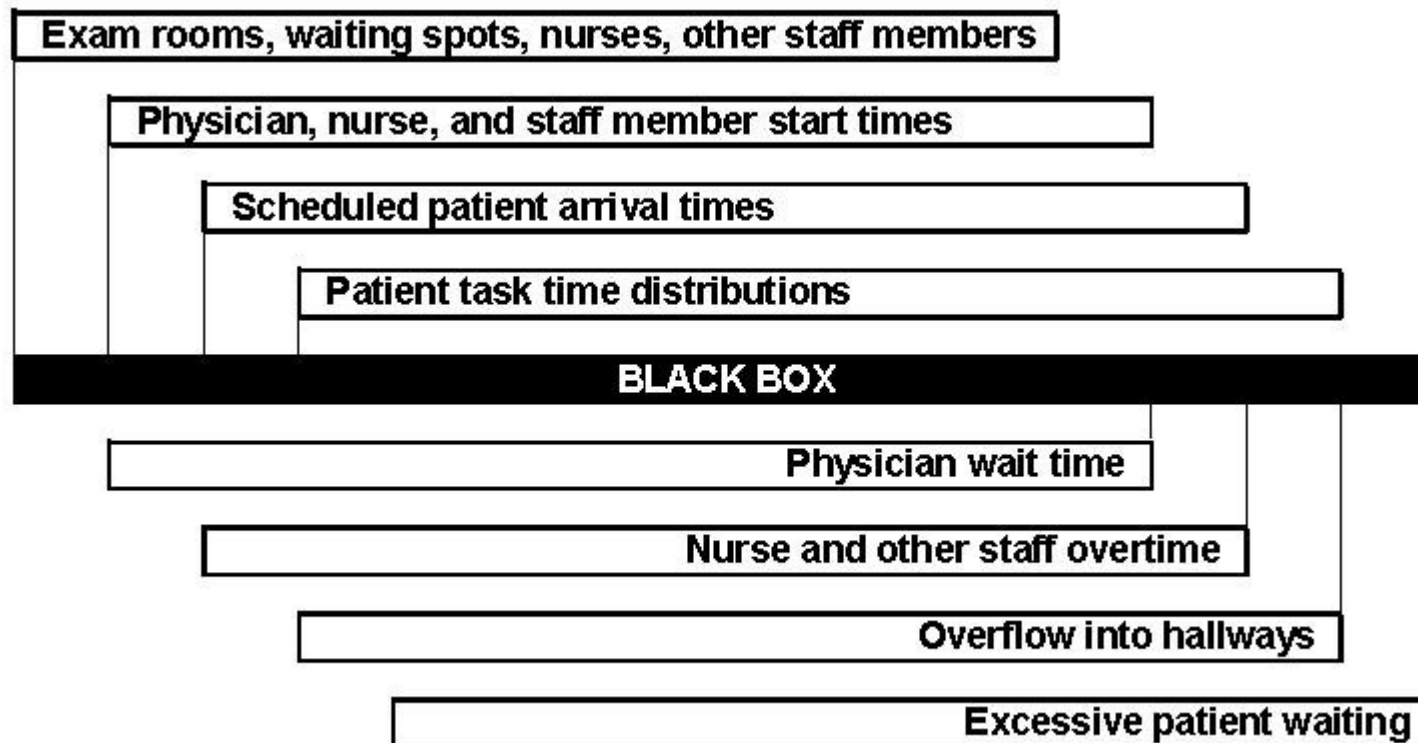
# What Is Monte Carlo Simulation (Using A Discrete Event Model)?

## What Is Monte Carlo Simulation?

- **It can be thought of as being statistical experimentation**
- **It entails:**
  - **Building a model of the processes to be analyzed**
  - **Repeatedly running the model with different random inputs**
  - **Tabulating the results from the different runs to identify process statistics**

## What Is Monte Carlo Simulation?

- For this problem, we can think of simulation as a black box with:
  - Inputs on the top
  - Outputs on the bottom



## What Is Monte Carlo Simulation?

- **Inside the black box is a genie that repeats the following steps for many days:**
  - **Generates (pseudo) random patients for each day**
  - **Generates (pseudo) random times for each patient's tasks**
  - **Moves patients through the PSS in first come first served order using those times**
  - **Gives breaks and lunches to the staff**
  - **Keeps track of all the output measures**

## What Is Monte Carlo Simulation?

- **Once working correctly, we can use the black box to try out different:**
  - **Staff levels**
  - **Number of exam rooms and waiting spots**
  - **Staff starting times**
  - **Patient arrival times (by patient need)**

## What Does It Mean To Use A Discrete Event Model?

- **There is more than one approach to building Monte Carlo Simulation models**
- **Discrete Event (Simulation) Models are those that focus on events, e.g.:**
  - **Staff arrivals**
  - **Patient arrivals**
  - **Task completion times**
  - **Break completion times**
  - **Lunch completion times**
- **Many Discrete Event Simulation tools animate those events**



## What Is Monte Carlo Simulation Based Optimization

- **Monte Carlo Simulation is only an analysis tool**
- **However it can be combined with optimization methods**
- **The basic concept is to:**
  - **Pick an initial set of values for the decision variables**
  - **Sample and summarize results of using those variables using simulation**
  - **Try a different set of parameters (in a structured manner)**
  - **Repeat previous two steps until no more improvement can be expected to be found**

# What Is Monte Carlo Simulation Based Optimization

- **For the PSS**
  - **The decision variables we can change are the:**
    - **Number of exam rooms and waiting spots**
    - **Number of staff members**
    - **Staff and patient arrival times**
  - **The outputs we wish to measure and minimize include:**
    - **Physician wait time**
    - **Staff overtime**
    - **Excessive patient waiting time**
    - **Patient overflow**

# What are the Critical Components & Factors Needed For Successful Simulation Studies?

# Critical Components & Factors Needed For Successful Simulation Studies

- **Understanding the organization's background, needs and culture**
- **Making sure there is a need for a simulation study**
- **Having a champion**
- **Access to data**
- **Good communication with stakeholders**
- **Good systems analysis**
- **An appropriate level of detail**
- **Making sure the simulation model is understood and accepted**
- **Careful statistical analysis of outputs**
- **Using the model to answer stakeholder questions**

# Pre-Surgical Screening Clinic Simulation Study

## PSS Clinic Simulation Study

- **Status**
  - **Parameterized model is close to completion**
  - **Has gone through preliminary validation**
  - **Task time distribution data is being collected**
  - **Optimization algorithm is being developed**

# Other Examples Of Hospital Process Simulation

## Hospital Process Simulation Examples

- **Robert B. Fetter, Yale University**
- **Brian Denton, North Carolina State University**
- **Franklin Dexter, University Of Iowa**
- **Martin Puterman, University of British Columbia**
- **Michael Carter, University of Toronto**
- ...



# Hospital Process Simulation At The JGH - ICU Surgical Bed Analysis

## • Background

- For many types of surgeries, patients need to go to ICU immediately after surgery
- Some patients develops complications for which it is best for them to go to the ICU
- Most hospitals in Canada use a single ICU for surgical and non-surgical purposes
- Not unusual for procedures to be canceled for lack of available ICU bed
- Surgery cancellations are:
  - Expensive in that they can result in lost revenue for the hospital & overtime
  - Very disruptive to patients' emotional health and surgeon schedules

# Hospital Process Simulation At The JGH - ICU Surgical Bed Analysis

- **Simulation study**
  - **Initial purpose of study was to determine the optimal number of beds; this didn't make sense as it required specifying cost of canceling/delaying surgeries**
  - **Instead built a simulation that analyzed tradeoff between:**
    - # of ICU beds
    - Average patient delay for different types of surgeries requiring ICU beds
    - The amount of time that patients were sent to the PACU because the ICU was full
    - The utilization of the ICU beds
  - **(Not unexpectedly) It was found that more beds led to:**
    - Shorter delays
    - Smaller fractions of time in which patients were sent to the PACU
  - **Possible next steps:**
    - Looking at alternative approaches for mixing surgical and non-surgical ICU beds
    - Look at alternative operative procedure scheduling approaches for leveling demand

## Hospital Process Simulation Examples - In Progress At The JGH

- **Simulation model of complete set of peri-operative processes:**
  - **Initial patient visit with surgeon including surgeon surgery request**
  - **Pre-surgical screening**
  - **ED to OR patient flow**
  - **Scheduling**
  - **Surgery**
  - **Recovery in ICU**
  - **Recovery in surgical wards**
- **Goals:**
  - **Synchronize different processes so as to improve patient flow**
  - **Determine future capacity requirements**

## Hospital Process Simulation Examples - In Progress At The JGH

- **Simulation model of the emergency department**
- **It would be very helpful if the two could be integrated**

## Hospital Process Simulation Examples - In Progress At Other Hospitals

- **Current student projects:**
  - **Royal Victoria Reproductive Center**
  - **St. Justine's Laboratories**

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