

# Hospital Patient Flow Capacity Planning Simulation Models

Ernest Wu, Amanda Yuen  
Vancouver Coastal Health  
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## Vancouver Coastal Health



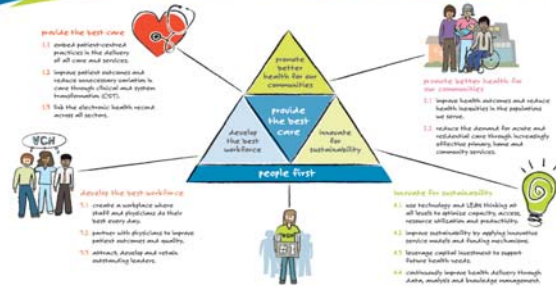


## VCH Quick Facts

- Annual funding \$3.4 billion
- 3 million+ patient days of care
- See 356,000+ people in emergency departments, that's one person every two minutes
- See 845,000+ visits to clinics
- Provide 89,000+ same day surgical visits
- Conduct 82,000+ inpatient discharges
- Provide 2.3 million+ residential care days
- Provide 1.9 million+ home support hours
- Provide 199,000+ home nursing visits



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We will be leaders in promoting wellness and ensuring care by focusing on quality and innovation

## Lions Gate Hospital

- Located in North Vancouver
- 255 funded beds, operates at 285-290
- 8 operating rooms
- 1 of only 5 neurosurgery centers in BC
- 1 of 2 inpatient acute rehabilitation units in BC



## VCH Decision Support

- The data, analytics, reporting, evaluation, and modeling hub.
- Run major projects to improve information availability and the use of information to make decisions.
- We ensure that the organization is compliant with standard submissions to external stakeholders (e.g., Provincial Ministry of Health, Canadian Institute of Health Information (CIHI)).



## Project Background

- Challenges with publicly funded healthcare system
  - Increased demand: ED visits 4-5% increase / year
    - Population aging
    - New medical technologies
  - Limited resources: funded beds unchanged for 15 years
  - Challenges with acute facilities
    - High costs
    - Slow patient flow due to residential care and community care capacity
- Governments designed incentive-based funding scheme, care quality and patient flow: Pay-for-Performance (P4P)
  - ED waiting time
  - Total hospital census
  - Longer length of stay patients




## Video

<https://youtu.be/nimC9MVG0Tk>



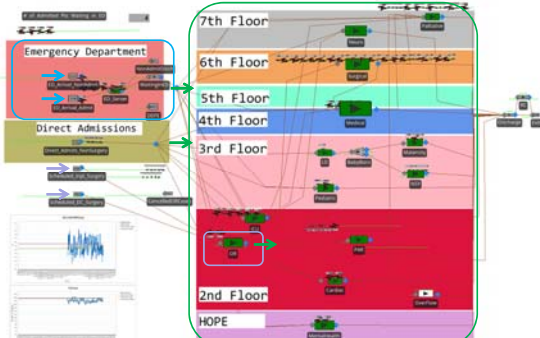
## Simulation Modeling

- A simulation model is a virtual representation of a real system that allows us to run **“what-if” scenarios** to determine optimal solutions to support operational and financial decisions
  - Conduct experiments and study the system’s performance
- Usually much easier, faster, cheaper, safer than playing with actual system
- Helps us analyze **complex** processes in which **variability** has a significant effect
  - Difficult to accurately represent complex systems using mathematical formulas....



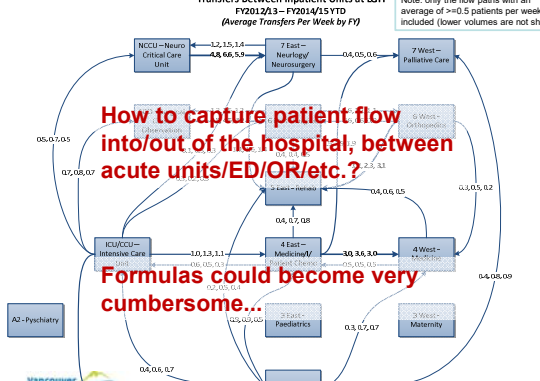
## Model 1 – LGH Facility

- All operating areas at LGH:




Transfers Between Inpatient Units at LGH  
FY2012/13 – FY2014/15 YTD  
(Average Transfers Per Week by FY)

Note: only the flow paths with an average of >=0.5 patients per week are included (lower volumes are not shown).



How to capture patient flow into/out of the hospital, between acute units/ED/OR/etc.?

Formulas could become very cumbersome...




## Model Scope

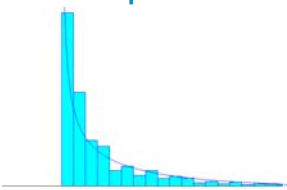
- Patient flow through LGH:
  - Admissions into ED/OR/inpatient units
  - Transfers between ED/OR/inpatient units
  - Discharges from ED/OR/inpatient units
- Inpatient units were grouped based on CapPlan groupings:

Unit Groupings	Inpatient Units
Cardiac	2E Med-Post Coronary Care, ECC Enhanced Cardiac Care
ICU	ICU Intensive Care Unit
LD	LD Labour & Delivery
Maternity	3W Maternity
Medicine	4E Acute Medicine, 4W Subacute Medicine, 5E Rehab
Mental Health	MIU Mental Health Inpatient Unit
Neurology	7E Neuroscience, NCU Neuro Critical Care Unit
Nursery	NSY Newborn Nursery, SCN Special Care Nursery
Palliative Care	7W Palliative Care
Pediatrics	3E Pediatrics, 3PO Pediatric Outpatient Observation
Surgery	6E Surgical, 6W Orthopedics, IPS Inpatient Surgery, SCO Surgical Close Observation

- Historical data were analyzed and used as data inputs in the model



### Data Inputs – Statistical Distributions



- Represent **historical data** with statistical distributions
- Simulation will **randomly generate values** (inter-arrival times, length of stay times, etc.) based on these distributions
- Can choose from 2-3 best fit distributions
- Distribution fitting works for LOS and volume

← LOS distribution for Medicine units

Statistical Summary  
 Distribution Name: **Gamma**  
 Parameters: 5.989 + 142 \* WEIBULL(4.1, 4.10)  
 Mean: 10.0000  
 Std Dev: 4.00000

Chi-Square Test  
 Number of Observations: 50  
 Degrees of Freedom: 50  
 Test Statistic: 100.0  
 Corresponding p-value: 0.000


Maximum Likelihood Test  
 Test Statistic: 5.128  
 Corresponding p-value: 0.020

Some Summary  
 Number of Data Points: 5000  
 Min Data Value: 1  
 Max Data Value: 143  
 Sample Mean: 10.4  
 Sample Std Dev: 11.4

Maximum Summery  
 Minimum Value: 5.989 to 143  
 Number of Observations: 50

### Patient Arrivals

- 5 streams of arrivals:
  - **ED\_Admitted**: patients who arrive at ED and are admitted into inpatient units
  - **ED\_NonAdmitted**: patients who arrive at ED and are not admitted into inpatient units
  - **DirectNonSurgPts**: non-surgical patients who are directly admitted into inpatient units
  - **SchedInptSurgery**: surgical patients who are admitted into inpatient units
  - **SchedDCSurgery**: surgical patients who are not admitted into inpatient units (daycare surgeries)
- **Hourly arrival schedules** are used to approximate arrival patterns, which vary by hour of day and day of week
  - Inter-arrival times are randomly generated using exponential distribution in the model



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### Patient Length of Stay

#### Inpatient Units

Inpatient Unit	Time Unit	Mean	Std Dev	Distribution
Cardiac	Days	6.06	7.88	1 + Random.Exponential(5.07)
ICU	Days	8.16	11.2	1 + Random.Exponential(7.16)
Maternity	Days	2.29	1.8	0.5 + Random.Gamma(1.72, 1.04)
Medicine	Days	13.4	17.4	1 + 142 * Random.Beta(0.44, 4.32)
Mental Health	Days	13.5	19.6	1 + Random.Exponential(12.5)
Nursery	Days	2.82	3.91	0.5 + Random.Lognormal(0.3, 0.91)
Neurology	Days	8.4	14	1 + 178 * Random.Beta(0.398, 7.78)
Palliative	Days	8.21	8.64	0.5 + Random.Exponential(7.71)
Pediatrics	Days	2.79	4.27	0.5 + Random.Lognormal(0.15, 1)
Surgery	Days	6.45	9.56	1 + 160 * Random.Beta(0.529, 17.4)

#### Emergency Department, Operating Rooms, Post-Anesthesia Recovery

Patient Type	Area	Time Unit	Mean	Std Dev	Distribution
ED Patient (non-admitted)	ED	Minutes	216	174	8+Random.Gamma(2.09, 99.5)
		Minutes	289	221	2 + Random.Gamma(1.93, 148)
ED Patient (admitted)	OR	Minutes	103	59.3	Random.Gamma(3.17, 32.5)
		Minutes	323	420	1 + Random.Exponential(322)
Scheduled Surgical Patient (inpatient)	OR	Minutes	103	59.3	Random.Gamma(3.17, 32.5)
		Minutes	323	420	1 + Random.Exponential(322)
Scheduled Surgical Patient (daycare)	OR	Minutes	42.7	30	9 + Random.Exponential(33.7)

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### Patient Specialties & Destinations

- Upon arrival, patients are assigned patient types based on point of origin
- Admitted patients are also assigned specialties and first acute unit based on historical probabilities:

#### Admissions via ED

Specialty	First Unit	Probability
Cardiac	Cardiac	9.08%
ICU	ICU	3.06%
Medicine	Medicine	34.94%
Mental Health	Mental Health	7.30%
Palliative	Cardiac	0.70%
Palliative	Medicine	2.51%
Palliative	Palliative	4.21%
Palliative	Neurology	0.67%
Pediatrics	Pediatrics	3.94%
Surgery	OR	23.97%
Neurology	Neurology	8.16%
Neurology	OR	1.48%

#### Direct Admissions

Specialty	First Unit	Probability
Cardiac	Cardiac	0.63%
ICU	ICU	3.26%
Maternity	Labor & Delivery	59.44%
Medicine	Medicine	5.10%
Mental Health	Mental Health	5.79%
Palliative	Palliative	9.65%
Pediatrics	Pediatrics	15.57%
Neurology	Neurology	0.53%

#### Admissions via OR

Specialty	First Unit	Probability
Surgery	Surgical	91.79%
Maternity	Maternity	8.21%

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## Model Process Logic

- Logic can be built into the model to reflect real-life processes. Some examples:

Process	Description
DDFE	The <b>longer</b> that a patient waits for an inpatient bed, the <b>more likely</b> that they will be discharged directly from ED. <ul style="list-style-type: none"> <li>Patients waiting between 1.5-2 days = 15%, patients waiting between 2-3 days = 30%, patients waiting for &gt; 3 days = 40%</li> </ul>
Newborns	Newborn babies are generated at the time when the moms exit <b>Labour &amp; Delivery</b> . Moms then go to <b>Maternity</b> and babies go to <b>Nursery</b> .
OR cancellations	Patients are <b>removed</b> from the OR queue when the following conditions are met: <b>available capacity</b> in OR and other downstream inpatient units is low, the number of <b>patients waiting in ED</b> is high. When these no longer apply, the patients are <b>placed back</b> in the queue.



## Model Validation

- Process of **testing the model** to ensure that it simulates the real system as accurately as possible
  - Compare model outputs with actual historical patient flow data, perform sensitivity analysis to ensure that model performs as expected
  - Manage exceptions, adjust input parameters
- The model is validated based on the following model outputs:
  - % of ED patients admitted within 10 hours
  - Average daily census at the facility level
  - Number of off-service surgical patients



## What-If Scenario: Discharge Target

- What if we target **one additional discharge** each day?

	Overall Census	ED 10hr%
Actual	283	52.2%
Model Baseline	280	52.3%
Model Scenario		
One additional discharge each day at 4E&2E	269	54.5%
Two additional discharge each day at 4E&2E	269	57.0%
One additional discharge each day at 4E,2E,6E,6W&7E	257	61.6%
Two additional discharge each day at 4E,2E,6E,6W&7E	242	67.0%



## What-If Scenario: Protected Surgical Beds

- What if we implement **protected surgical beds**?
  - Impact of reserving x number of the 60 surgical beds for surgical patients only

	ED 10-Hr	Overall Census	# Off-Service Surgical Patients (1 year)
0 protected beds	50.2%	278	511
50 protected beds	47.7%	277	460
55 protected beds	47.7%	274	389
58 protected beds	46.6%	273	253
60 protected beds	42.0%	264	0

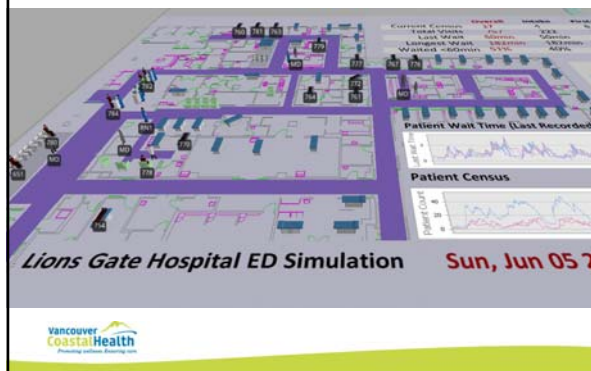


## Project Value

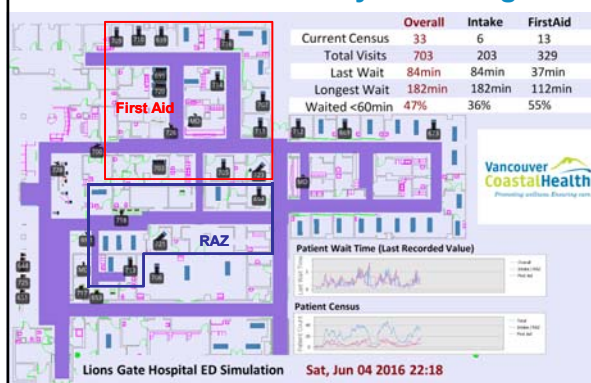
- ✓ Quantifying the impact of operational changes
- ✓ Motivating front-line staff in their daily work
- ✓ Validating the decisions made by operational leaders



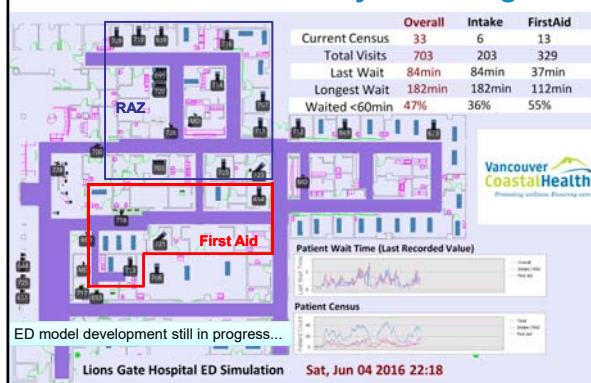
## Model 2 - LGH ED



## What-If Scenario: Layout Change



## What-If Scenario: Layout Change



## Demo



## Next Steps/Projects

- Running scenarios on activity reductions related to a major IT project, and impacts on P4P
- Hospital new med/surg tower planning



## Insights

- A powerful tool to add value to high strategic priority initiatives
- Identify the right project with the right scope
- Engage and communicate with key users, and manage their expectations
- And... plan for resources



## Questions?

