

**Centre intégré
universitaire de santé
et de services sociaux
du Centre-Ouest-
de-l'Île-de-Montréal**

Québec 

So You'd Like To Know More About How Analytics Can Be Used To Improve Health Care Delivery

A Magical Mystery Tour Of The World Of Health Care Delivery Analytics

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- **“Any sufficiently advanced technology is indistinguishable from magic.”**

Arthur C. Clarke, Profiles of the Future (revised edition, 1973)

- **And while analytics may look like magic, as you learn about its capabilities and applications, you will see that it is just advanced technology**

The Presentation

- **System wide challenges facing health care delivery**
- **Bill 10**
- **Business Intelligence versus Data Mining versus Analytics**
- **Descriptive/Diagnostic Analytics**
- **Predictive Analytics**
- **Prescriptive Analytics**
- **The potential of analytics for improving health care delivery**
- **Analytics in our network**
- **Next steps**

System Wide Challenges Facing Health Care Delivery

- **The variability and lack of predictability in the day to day need for healthcare**
 - **Queueing effects due to variability**
 - **Difficulty in managing queueing effects due to lack of predictability**

System Wide Challenges Facing Health Care Delivery

- Health care delivery is not always well coordinated:
 - ED physician staffing
 - Patients waiting for a PICC line to be inserted to leave hospital
 - Patients waiting for a bed in rehabilitation facility to leave hospital

System Wide Challenges Facing Health Care Delivery

- Many healthcare delivery processes are poorly designed or implemented:
 - Many processes started off well designed but as volumes¹ grew . . .
 - Historically medical staff were not trained in process design

1 Reengineering Work, Don't Automate, Obliterate, Michael Hammer, Harvard Business Review, 1990.

System Wide Challenges Facing Health Care Delivery

- **Poor inventory management - not optimized to tradeoff costs of:**
 - **Stock outs**
 - **Holding inventory**
 - **Ordering**

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The Impact Of Bill 10

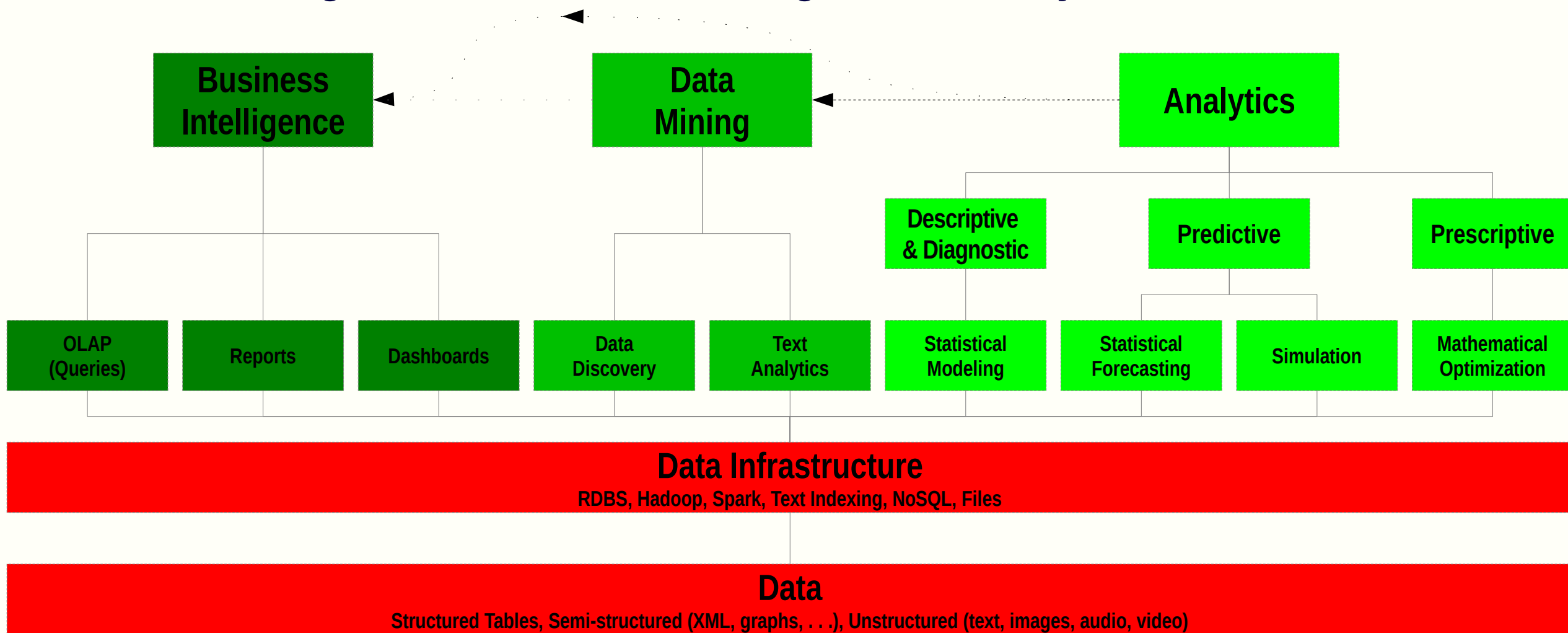
- **Passed in late 2014 Bill 10 mandated that:**
 - **Most healthcare institutions in Quebec be amalgamated into CISSSs**
 - **CISSSs be responsible for ensuring that the health and social service needs of the people in their territory were addressed**
 - **Directly by the CISSS**
 - **Via corridors to/with other CISSSs**
- **Management perspective – CISSS gives management the ability to specify:**
 - **Which services**
 - **Where within the CISSS**
 - **When**
 - **How much**

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- **So**
 - **What is analytics?**
 - **How can it be used to help address these challenges**

Business Intelligence Versus Data Mining Versus Analytics



Modified from <https://rapidminer.com/resource/introduction-advanced-analytics/>

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Descriptive Analytics – Measurement And Modelling

- **Measurement** - “I often say that when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely in your thoughts advanced to the state of Science, whatever the matter may be.”

Lord Kelvin, 1883

- **Modelling** - Identifying the relationships (if any) between measurable quantities

Using Descriptive Analytics To Measure & Model

- Healthcare outcomes
- Provided health care
- The resources needed to provide each unit of each type of health care
- The resources used to provide each type of health care
- The need for healthcare at an individual level (along with relevant demographic information such as gender age, occupation)
- Prescribed treatment and care pathways at an individual level
- Patient compliance with prescribed treatment and care pathways

Using Diagnostic Analytics

- **Using the measurements/models just discussed it should be possible to:**
 - **Identify quality issues such as diagnoses for which particular healthcare providers are not obtaining good outcomes**
 - **Compare resources needed to those consumed for current outcomes**
 - **Identify diagnosis and treatment types with poor patient compliance**
 - **Identify successful and cost effective integrated care pathways**

The Presentation

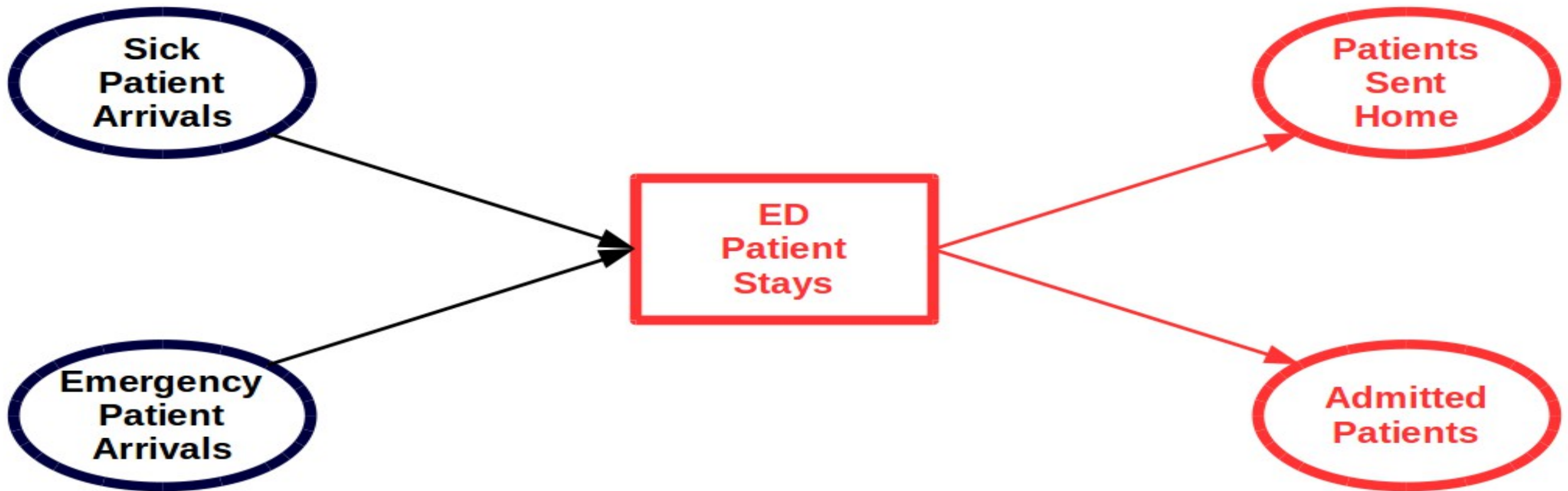
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Predictive Analytics

- **Tools**
 - **Statistical forecasting tools**
 - **Monte Carlo Simulation**
 - **System dynamics**
 - **Discrete Event Simulation**
 - **Agent based modelling**

Predictive Analytics

- **Statistical Forecasting Tools**
 - Quite helpful for predicting individual phenomenon
 - Harder to use to see effect of joint phenomenon



Predictive Analytics - Simulation

“Simulation is the process of designing a model of a real system and conducting experiments with this model for the purpose of either understanding the behavior of the system and/or evaluating various strategies for the operation of the system.”

Introduction to Simulation Using SIMAN (2nd Edition)

Predictive Analytics - Simulation Models



Predictive Analytics - Monte Carlo Simulation

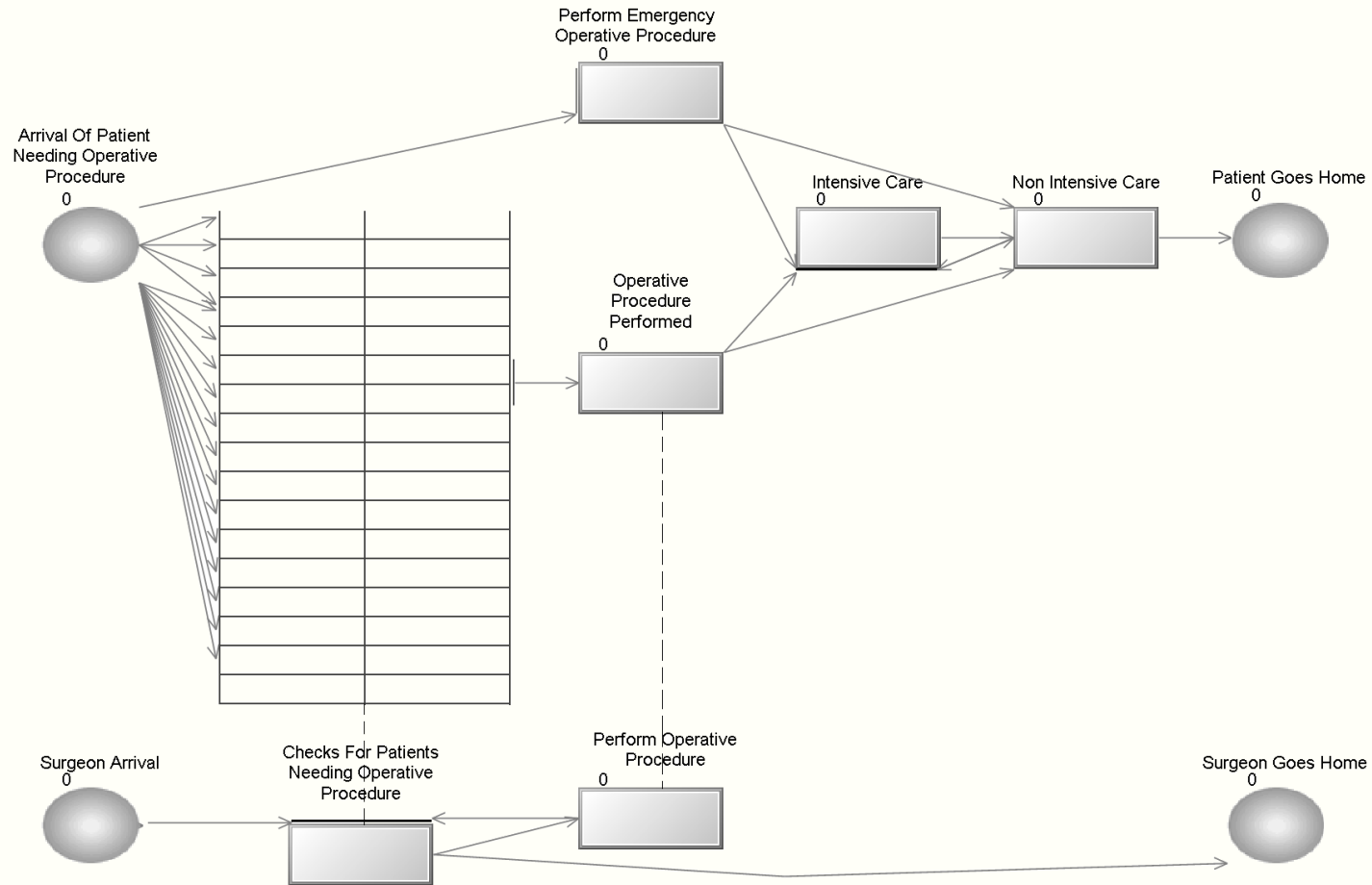
- *Build a model of a process or a system on a computer*
- *Run the model many times (usually on a computer)*
- *Each time use a different set of randomly selected values drawn from the family of values that underlies the real process*
- *Make sure that the average statistics match those in real life*
- *Modify the model to reflect proposed changes to the process or system*
- *Hypothesize the effect of the changes*
- *Measure the average statistics of the revised process*
- *Test the hypothesis with the statistics of the original process and the revised process*

The methodology underlying this approach, the Monte Carlo Method, was named by John von Neumann, Stanislaw Ulam and Nicholas Metropolis after the casino where Stanislaw's uncle frequently gambled.

Predictive Analytics - Simulation Example

- **Using Simulation To Determine The Need For ICU Beds For Surgical Patients At The Sir Mortimer B. Davis Jewish General Hospital, Presentation at the Central Surgical Association, Philip Troy and Lawrence Rosenberg.**
 - **At the time, there were frequent cancellations of operative procedures requiring immediate ICU stays**
 - **In particular, late in 2007 there was an extended period during which a very large number of cardiac surgeries needed to be postponed due to a lack of ICU beds**
 - **As a result, Dr. Rosenberg wished to determine the number of beds that would be needed if there were a surgery only ICU**

Predictive Analytics - Example



Predictive Analytics - Example

- Facilitates computation of statistics

Functional ICU Beds	Mean Wait (Days)	Mean Cancelled Blocks
6	535	473
7	411	404
8	304	336
9	207	262
10	131	195
11	79	136
12	43	88
13	24	50
14	13	24
15	9	12
16	7	5
17	7	2

Tactical Uses Of Predictive Analytics

- **Build a predictive simulation model of a part of (or all of) a health care delivery system:**
 - An ED
 - An IPU
 - A hospital's peri-operative processes
 - A (complex) clinic
- **Verify the model**
- **Validate the model**
- **Use the model to estimate:**
 - The cost of health care delivery to specific standards (now/in the future)
 - Health care delivery performance metrics for suggested alternatives

Operational Uses Of Predictive Analytics

- Typically for shorter term analysis, for example:
 - For the hospital's peri-operative processes:
 - Use current ICU and surgical bed statistics
 - Identify potential bottlenecks/issues that would be caused by a particular OR schedule for a particular day before finalizing that schedule

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Prescriptive Analytics

- **Use of algorithms/heuristics to:**
 - **Identify alternatives**
 - **Evaluate the performance of alternatives**
 - **Provide decision support for risky/high impact decisions**
 - suggest (several of) the best alternatives for management
 - **Make decisions for routine/low risk/low impact decisions**
- **Can be used for strategic, tactical and operational purposes**
- **Generally requires a mathematical statement of:**
 - **Goals**
 - **Constraints**

Prescriptive Analytics - A Simple Example

- The budget for hot dogs and soda for a holiday party at the CIUSSS is \$200
- Hot dogs each cost \$2
- Sodas each cost \$1
- There will be 30 people at the party
- There must be at least two hot dogs and one soda for each person
- The average satisfaction of people for hot dogs is 3
- The average satisfaction of people for sodas is 1

- How many hot dogs and sodas should be bought to maximize total satisfaction of the party goers while staying within the budget?

Prescriptive Analytics - A Simple Example

- We can state (or model) this problem mathematically with:
 - An objective function
 - Constraints
- Maximize $3 * \text{Hot Dogs} + 1 * \text{Sodas}$
- Subject to:
 - $\text{HotDogs} \geq 60$
 - $\text{Sodas} \geq 30$
 - $4 * \text{Hot Dogs} + 2 * \text{Sodas} \leq 200$
- Should we wish we can readily add other constraints and variables

Prescriptive Analytics - A Simple Example

- We can readily solve this problem using Linear Programming software (found in Excel for free for small problems and elsewhere for a fee for larger problems)
 - 35 Hot Dogs
 - 30 Sodas
- We can also readily determine the sensitivity of the solution to the parameters of the problem:
 - The budget
 - The minimum number of hot dogs and sodas
 - The satisfaction of eating a hot dog and drinking a soda

Prescriptive Analytics

- To perform prescriptive analytics we need goals and constraints
- Typical goals:
 - For businesses – maximize profits
 - For public health care:
 - Minimize costs
 - Maximize health care value
- Typical constraints:
 - Budget
 - Minimum and/or maximum resource usage
 - Minimum performance

Prescriptive Analytics - Health Care Value

- When using prescriptive analytics for health care delivery in a public system like that of Quebec, choosing an appropriate goal is important
 - We are not generally interested in profit
 - We would however like to maximize the value generated by the health care system

“In health care, value is defined as the patient health outcomes achieved per dollar spent.

Michael Porter, Supplementary Appendix 1 to Porter M.E., What is value in health care?, N Engl J Med 2010; 363:2477-81.

- Mathematically we often maximize value by setting our goal to maximize outcomes after adding a budget constraint

Prescriptive Analytics

- **Strategic applications**
 - **Services to be provided to align institutions in network to maximize outcomes related to their foundations' goals**
 - **Corridor arrangements with other networks**

Prescriptive Analytics

- **Tactical applications:**
 - **Which services**
 - **Where within the CISSS**
 - **When**
 - **How much**
 - **Scheduling**

Prescriptive Analytics

- **Operational applications:**
 - **Staff scheduling**
 - **Patient scheduling**
 - **Resource assignments**

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The Potential Of Analytics For Improving Health Care Delivery

- **The variability and lack of predictability in the day to day need for healthcare**
 - **Queueing effects due to variability**
 - **Difficulty in managing queueing effects due to lack of predictability**
- **To address this challenge:**
 - **We can apply insights from queueing theory to propose process changes**
 - **We can use predictive analytics to evaluate proposed process changes**

The Potential Of Analytics For Improving Health Care Delivery

- **Health care delivery is not always well coordinated:**
 - ED physician staffing
 - Patients waiting for a PICC line to be inserted to leave hospital
 - Patients waiting for a bed in rehabilitation facility to leave hospital
- **To address this type of challenge:**
 - We can use prescriptive analytics to propose process changes such as determining good times to change resources assigned to specific tasks
 - We can use predictive analytics to evaluate proposed process changes

The Potential Of Analytics For Improving Health Care Delivery

- **Many healthcare delivery processes are poorly designed or implemented:**
 - Many processes started off well designed but as volumes grew . . .
 - Historically medical staff were not trained in process design
- **To address this type of challenge:**
 - We can use prescriptive analytics in conjunction with lean to propose process changes
 - We can use predictive analytics to evaluate proposed process changes

The Potential Of Analytics For Improving Health Care Delivery

- **Poor inventory management - not optimized to tradeoff costs of:**
 - Stock outs
 - Holding inventory
 - Ordering
- **To address this type of challenge:**
 - We can use prescriptive analytics to determine optimal inventory parameters
 - We can use predictive analytics to evaluate proposed process changes

The Potential Of Analytics For Improving Health Care Delivery

- To use analytics we need:
 - An analyst with the tools
 - Managers
 - Who are able to identify potential applications of analytics
 - Who champion analytics projects

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Analytics In Our Network

- **In the department of quality, evaluation, performance, ethics and archives**
- **Currently staffed by a senior analytics advisor whose responsibilities include:**
 - **Building awareness of how analytics can be used (via the Analytics Lecture Series)**
 - **Acting as a resource to other analysts (via the Analytics Round Table)**
 - **If there is interest providing courses on analytics**
 - **Working on projects where analytics can positively impact health care delivery**

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Next Steps For You

- **Learn**
 - **Just enough about the techniques to be able to identify opportunities**
 - **What you need to know to manage analytics projects**
- **Look for approaches to combine analytics with lean**
 - **Use prescriptive analytics to fine tune/optimize new processes**
 - **Use predictive analytics to test proposed initiatives**

Next Steps For Me

- **Additional lectures:**
 - **Those Quantitative Analysts And:**
 - **Their Monte Carlo Simulation Predictive Analytics Models**
 - **Their Prescriptive Analytic Models**
 - **Their Data Mining Models**
 - **Managing Their Modeling Projects**
 - **Specific analytics projects**

Next Steps For Me

- **Analytics Round Table**
 - **For managers**
 - **For analysts**

Next Steps For Me

- **Being available to consult CIUSSS management on the possibilities for using analytics for their programmes**

- **Being available (subject to approval) for some analytics projects**

Questions