Beyond BI: Building a Rapid-Response Advanced Analytics Unit

Session 92, March 6th, 2018

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Conflict of Interest

Jeremy Petch, PhD

Has no real or apparent conflicts of interest to report.

Agenda

- Case study examining the business and technological architecture to establish a rapid-response advanced analytics unit at an academic hospital.
- Demonstrate one of the key tools we have developed to facilitate this approach, our analytic algorithm tool (interventional time series module).

Learning Objectives

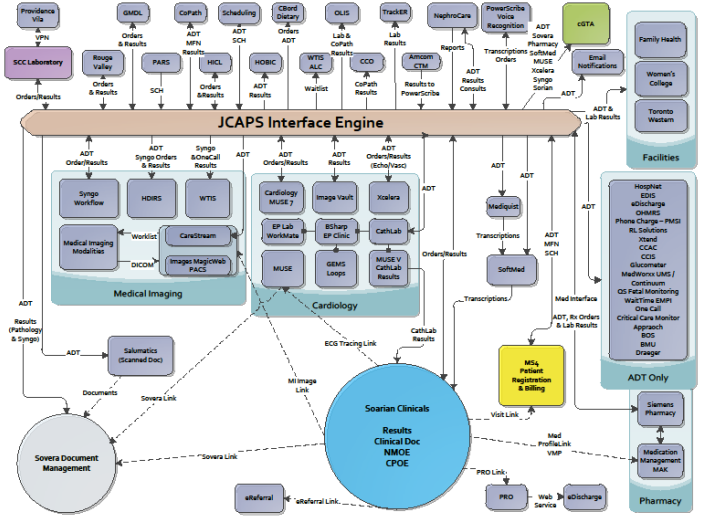
- Describe how an academic hospital has implemented a service-based advanced analytics unit to support clinical and executive decision-making
- Analyze the technological infrastructure needs for implementing advanced analytics
- Identify the business architecture features that can maximize the practical impact of advanced analytics

Setting: St. Michael's Hospital

- 463 bed tertiary care teaching hospital in downtown Toronto, Ontario
  - 6,000 staff
  - 800 physicians
  - 1,700 nurses
- Annual patient volumes
  - 75,000 ED encounters
  - 500,000 ambulatory encounters
  - 25,000 inpatient admissions

SMH data architecture, circa 2014

- “Best in Breed” clinical information system architecture
- Front-end integration, but data residing in silos
- Analysis required manual data integration, with a turnaround time of 3-8 weeks, depending on complexity
- Analysis purely descriptive



Vision

To enable advanced and predictive analytics to support **high quality patient care** and increase **operational efficiency**.

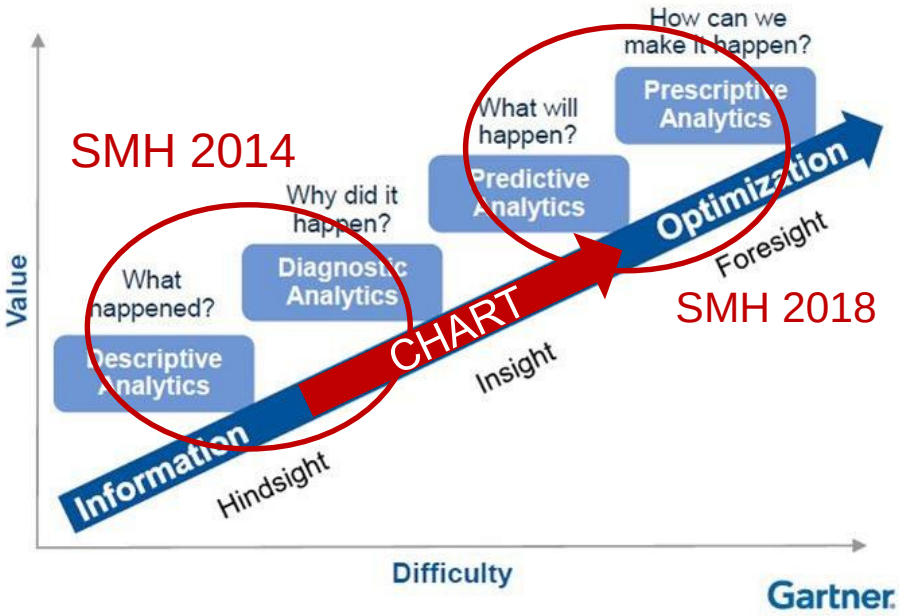
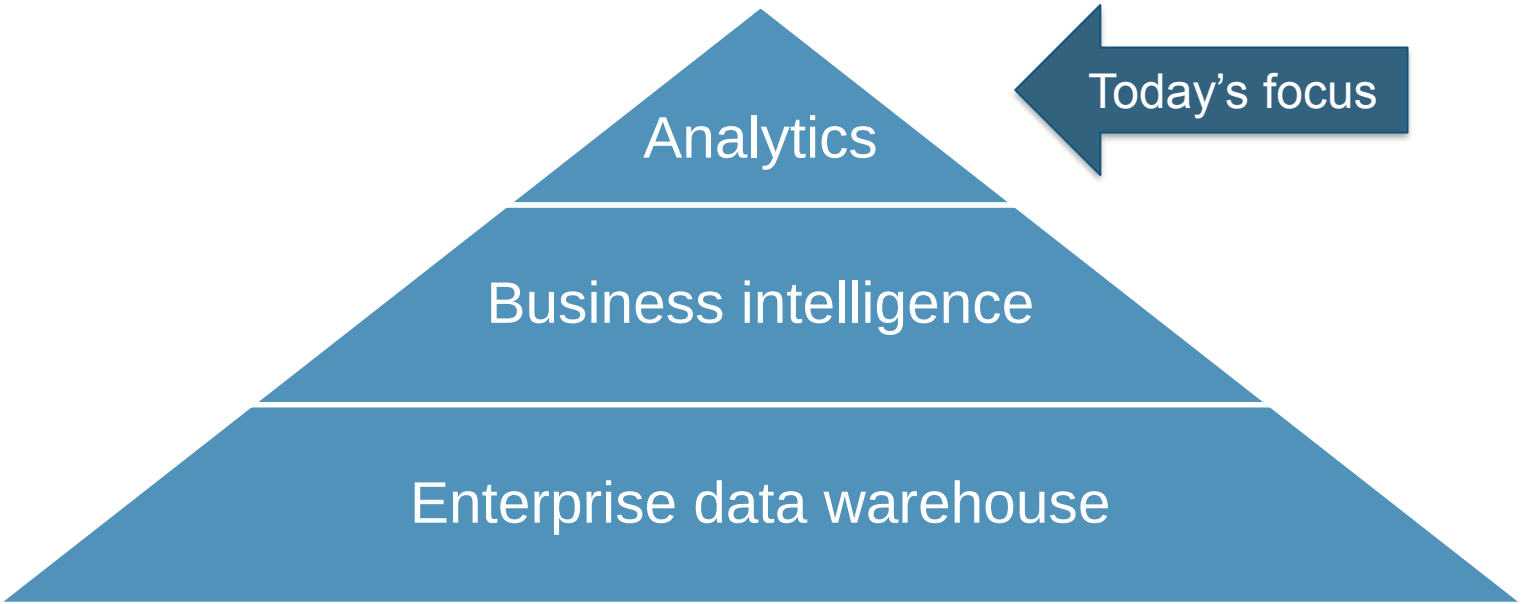


Image source: https://www.flickr.com/photos/27772229@N07/8267855748/in/photostream

Strategic components

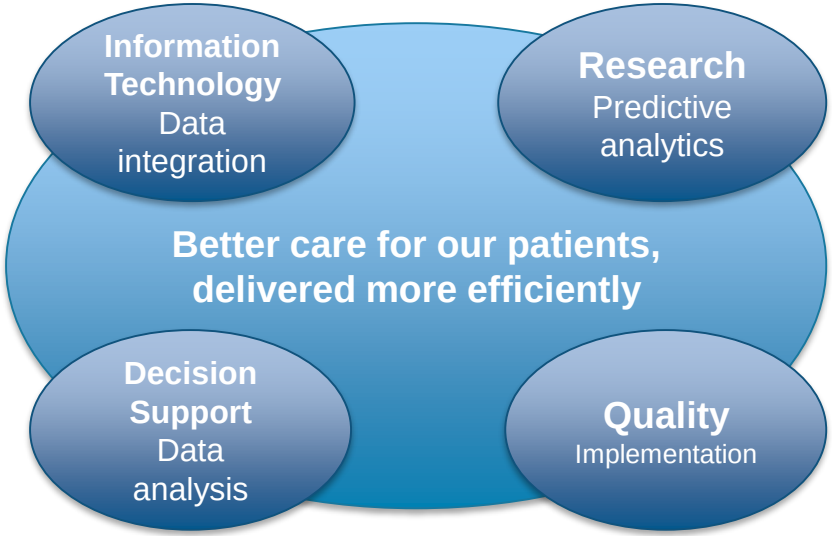


Advanced analytics unit

- CHART – Centre for Healthcare Analytics Research and Training
- Core competencies:
  - Data science
  - Biostatistics
  - Simulation modeling
  - Change management
- Mandate to work on projects that would both A) improve patient care, and B) improve operational efficiency

Business architecture

- The biggest business risk the unit faced was creating insights that were never actioned
- We therefore built unit on a partnership between knowledge generators and change makers
- Executive sponsorship across all domains



Technical architecture

- Another key risk the unit faced was not being able to respond quickly enough, or be flexible enough, to be of value to decision makers
- Three elements of our technological architecture were designed to address this:
  - Data integration solution
  - Advanced analytics tools
  - Algorithm-based analysis

Data integration solution

?

Advanced analytics tools

Best tool for advanced analytics?

Proprietary or Open Source?

Many tools will get the job done…

TensorFlow

sas

R

python™

SPSS

The challenge with all the tools we tried is getting results fast enough

Run App

```
    if(input$control != 'none') {
      control_ts <- control_time_series()$ts_df
    }

    N <- length(ts_df)

    int_date <- input$int_date2
    after_int <- time_seq > int_date
    after_int <- which(after_int == T)[1]

    pre.period <- c(1, (after_int - 1))
    post.period <- c(after_int, length(ts_df))

    if(input$control != 'none') {
      data <- cbind(as.numeric(ts_df), as.numeric(control_ts))
      y <- as.numeric(ts_df)
      x <- as.numeric(control_ts)

      post.period.response <- y[post.period[1] : post.period[2]]
      y[post.period[1] : post.period[2]] <- NA

      ss <- AddLocalLevel(list(), data)
      bsts.model <- bsts(y ~ x, ss, niter = 1000)

      impact <- CausalImpact(bsts.model = bsts.model,
                             post.period.response = post.period.response)


    } else {
      data <- as.numeric(ts_df)

      post.period.response <- data[post.period[1] : post.period[2]]
      data[post.period[1] : post.period[2]] <- NA

```

Algorithm-based analytic tool

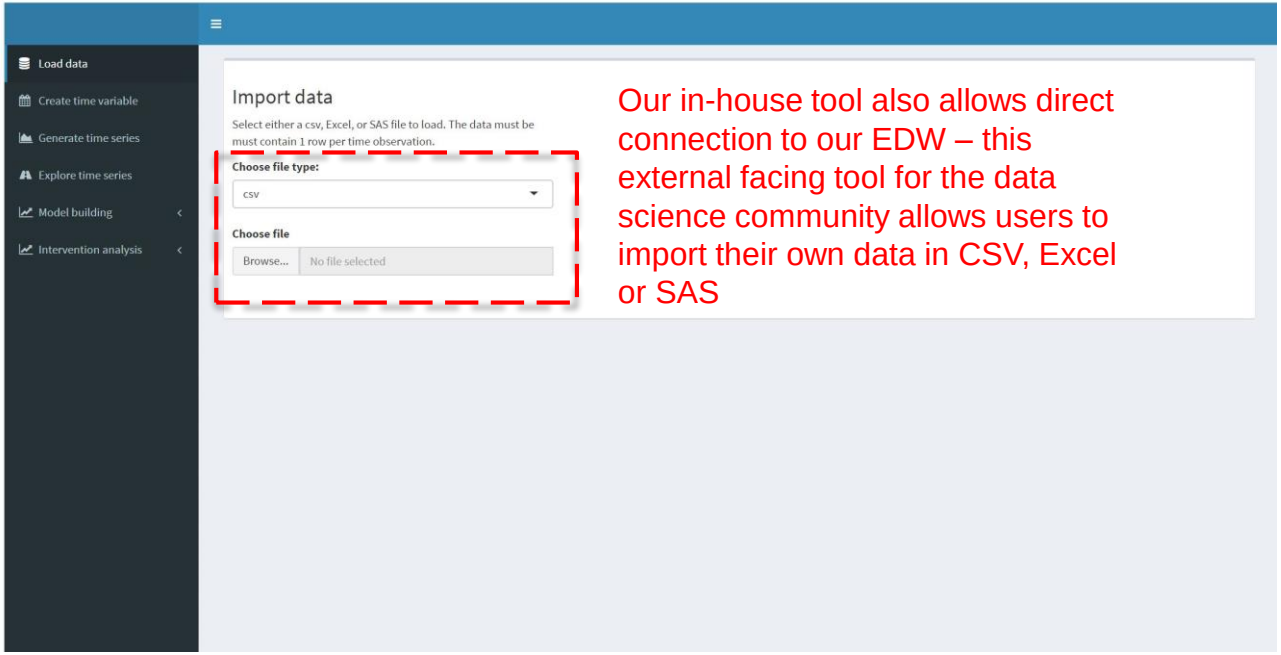
CHART forecasting tool

Demonstration

- Live demonstration begins here
- Link to program used for live demo: https://joshmurray.shinyapps.io/sas_style_tim
- Slides that follow illustrate the components of this demonstration as a backup in case of technical issues

Data import

CHART forecasting tool



Our in-house tool also allows direct connection to our EDW – this external facing tool for the data science community allows users to import their own data in CSV, Excel or SAS

Data display

CHART forecasting tool

- Load data
- Create time variable
- Generate time series
- Explore time series
- Model building
- Intervention analysis

Import data

Select either a csv, Excel, or SAS file to load. The data must be must contain 1 row per time observation.

Choose file type: csv

Choose file Browse... ed_volumes_month.csv

Upload complete

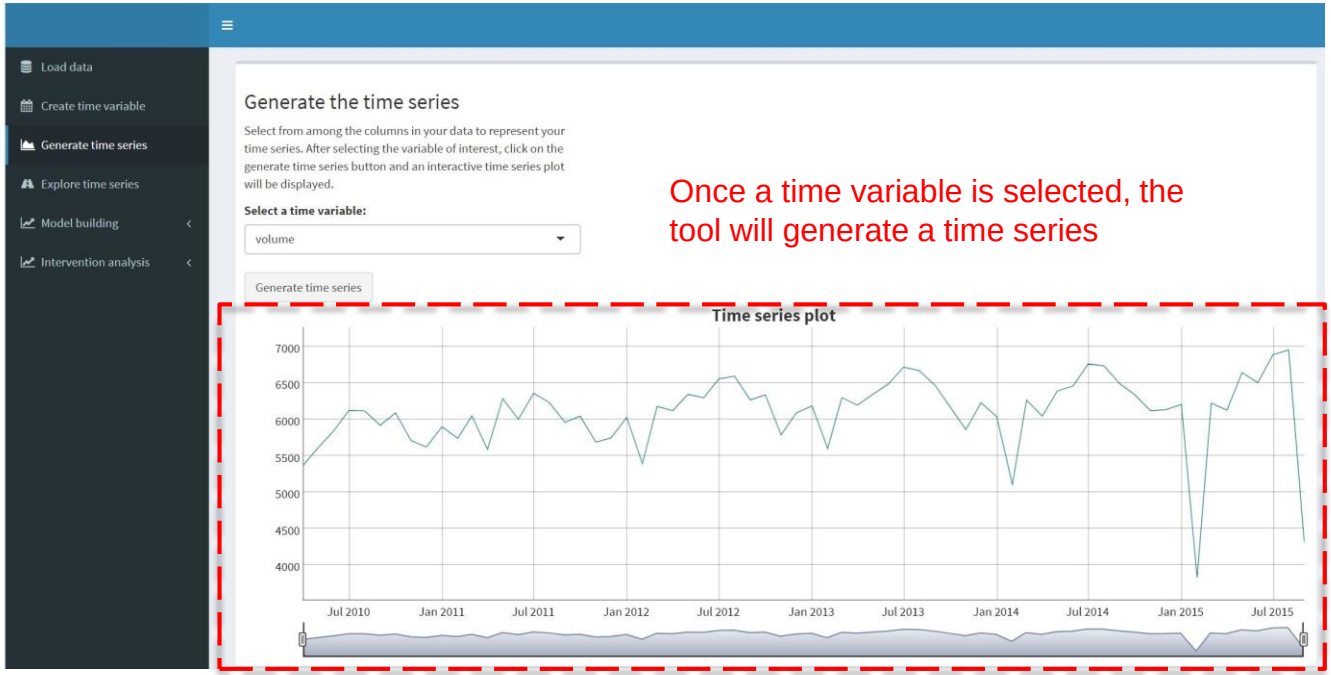
Once imported, tool displays data

Show 10 entries Search:

	month	volume	mean_los	mean_pia
1	2011-04-01	5362	0.19972622155912	87.5880268556509
2	2011-05-01	5606	0.211698144844809	86.3375557537913
3	2011-06-01	5839	0.214986401781127	86.0851464793558
4	2011-07-01	6119	0.207666693904233	85.4767898005884
5	2011-08-01	6113	0.206993800098151	81.7004743988222
6	2011-09-01	5916	0.219001301555105	90.5831643002028
7	2011-10-01	6087	0.195726499096435	85.2504107788367
8	2011-11-01	5705	0.224641840490798	81.8397896581946
9	2011-12-01	5618	0.194809896760413	76.656756275592

Generate your time series

CHART forecasting tool



Once a time variable is selected, the tool will generate a time series

Explore your time series

Tool allows multiple explorations of your time series, including a decomposed view, illustrating trend, seasonality and randomness

CHART forecasting tool

Forecasting component

- Key business application is predicting what will happen to support planning and management. For example:
  - Forecasting ED volumes to optimize staffing
  - Forecasting whether programs will meet quarterly or annual targets

Forecast model building

CHART forecasting tool

Tool allows user to build multiple customized models (or automatic generation for best-fit)

Tool allows user to build models using exponential smoothing or Arima

Forecast results

CHART forecasting tool

User selects number of periods to forecast and size of confidence intervals.

Forecast displayed in green.

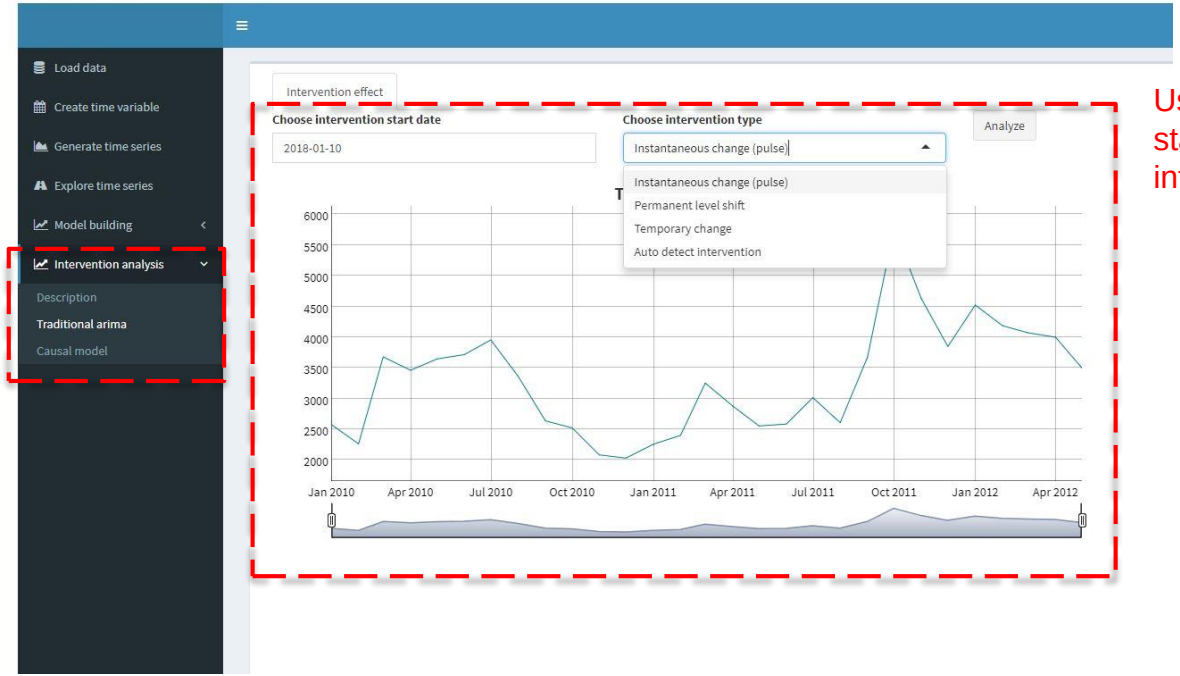
This forecast reflects very strong seasonal component of ED volumes.

Intervention analysis

- Business application is to retrospectively measuring the impact of an intervention
- Supports measuring a variety of intervention types:
  - Pulse: measure the impact of a very brief event, such as a disaster
  - Temporary change: measure the impact of short-term change, such as opening surge beds for flu season
  - Permanent change: measure the impact of a long-term change, such as a new screening protocol for VRE.

Building the analysis

CHART forecasting tool

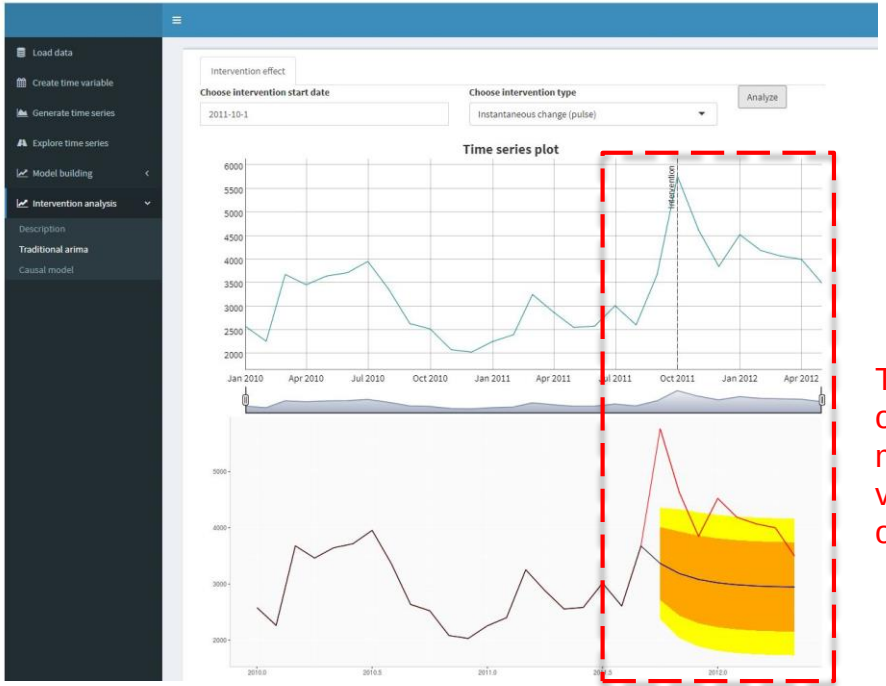


Tool supports traditional ARIMA or Causal Impact (an application from Google)

User selects intervention start date, and type of intervention (or auto-detect)

Analyzing results

CHART forecasting tool



Tool illustrates impact of intervention by modeling forecasted values against actual observed values

Sample projects underway

- **Operational** - ED early-warning system: Generalized Additive Model, integrating hospital data with geo-mapped local event data (marathons, concerts, etc) and weather data, to predict Emergency Department volumes in six hour increments, out to 72 hours in advance
- **Clinical** - ICU early-warning system: recurrent neural network using lab results and vital signs recorded in patient charts to generate predictions of patients at highest risk of being transferred to ICU to facilitate early intervention

Outcomes

- **Advanced analytic tool** has reduced time required to complete retrospective analysis from an average of 3 days to an average of two hours. This has allowed the unit to remain lean, while maintaining a level of responsiveness that has maintained executive buy in.
- **ED early warning** system has achieved a 6% error rate (MAPE)
  - With an volume of 200 visits in a day, margin of error is only +/- 12)
  - Because high variability in our ED volumes day to day (SD=40), this provides significant improvement in predictive power over a naïve approach

Questions

- Jeremy Petch, PhD
- petchj@smh.ca

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