COACH Clinician Forum 2015

Making Connections: Trends & Tempos in Clinical Informatics & Professional Practice

Big Data, Cognitive Computing and the Impact on Clinical Decision Support

May 31st, 2015

V2.0
Three IT shifts are candidates to enable healthcare transformation—enabling a “Clinic without Walls” – a future based on ‘extended reach’, ‘vertical integration’ and ‘smarter care’.

**Data** is the new basis of strategic advantage

Data is becoming the world’s new natural resource, transforming industries and professions.

**Cloud** is the path to new business models

The emergence of cloud is transforming IT and business processes into digital services.

**Engagement** requires a systematic approach

Mobile is transforming individual engagement – increasing ability to deliver value via “extended reach”.

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Create a new vision for health systems – Systems of Insight and Engagement are mandatory to complement our investments in “Systems of Record”.

- Create care coordination models
- Create Consumer Advocates
- Improve IT economics
- Optimize operations – patient flow
- Manage risk
- Appropriate Standardized Process

Systems of engagement
Systems of insight
Systems of record
Systems of Insight – analytic capabilities and health data scientists will redefine Clinical Decision Support.

- EMR Summary of treatment
- Checking to prevent errors – “doing it right”
- EMR Summary of what was done
- Retrospective Knowledge
- Knowledge enabled by Referral
- EMR Summary of Risks
- Suggestions / Actions – “doing the right things”
- EMR summary of what is missing
- Real-time best evidence
- Democratization of Knowledge
Agenda

• Shifting Sands – Healthcare and Big Data
• Knowledge and Data-driven Analytics
• Watson and Emergence of Cognitive Computing
• Discussion
Global trends are forcing integration of health care and social services delivery – and segmentation of populations based on social determinants of health.

### Aging Population
66%

2 million aged over 65 in UK will lack informal care from adult offspring by 2030...a 66% increase from 1.2 million in 2012

### Increasing Costs
$7 trillion+

The cost for health and social programs worldwide – health is 50% of Ontario’s budget squeezing out other programs

### Chronic Disease
1 out of 4

1 in 4 Canadians – and 2 of 3 over the age of 65 – have multiple chronic conditions. 5% of Ontario patients consume 66% of health costs
Health ecosystems are responding to be more proactive, driving the need to identify patients at risk, and intervene in time.

Reduce costs and improve quality with proactive care

Rising costs:
- Aging populations
- Chronic disease
- Complex conditions

Evidence-based care protocols
- Promote healthy behaviors
- Proactive early detection
- Best practice care protocols
- Manage Closer to Home
- Care coordination for complex conditions

Costs increase along the continuum of care

Shift Resources
Path Toward Personalized Medicine


Change in personalized healthcare investment from 2005 to 2010

↑ 75%

Biopharmaceutical companies investing in personalized healthcare research in 2010

94%

Prominent personalized medicine treatments & diagnostics available

13 → 113

in 2006 in 2014

1 Tufts Center for the Study of Drug Development, 2010; 2 Personalized Medicine Coalition, 2014
Decreasing Cost of Genome Sequencing

Source: National Human Genome Research Institute” http://www.genome.gov/images/content/cost_per_genome.jpg; Adapted by IBM Research.
Health data from new sources is exploding – and forcing reconsideration of investments that are aligned with future potential....

**Exogenous determinants**
- **60%**
  - Impact on individual health from behavior and environment

**Genomic determinants**
- **30%**
  - Impact on individual health

**Clinical determinants**
- **10%**
  - Impact on individual health

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**1,100 Terabytes**
Generated per lifetime

*Volume, Variety, Velocity, Veracity*

- Fitbits, Home Monitoring Systems, Educational records, Employment Status, Social Security accounts, Mental Health records, Caseworker files and more...

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**6 TB**
Generated per lifetime

*Volume*

**0.4 TB**
Generated per lifetime

*Variety*

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For Healthcare, harnessing Data as a new ‘natural resource’ to strategic advantage means managing the ‘Four Vs’.

**Volume**

Data at Rest

Terabytes to exabytes of existing data to process

**Velocity**

Data in Motion

Streaming data, 1000’s per millisecond with seconds to respond

**Variety**

Data in Many Forms

Structured, unstructured, text, multimedia

**Veracity**

Data in Doubt

Data inconsistency & incompleteness, ambiguities, latency, deception, model approximations
Agenda

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• Knowledge and Data-driven Analytics

• Watson and Emergence of Cognitive Computing

• Discussion
Systems of Insight have the potential to redefine clinical decision support in the context of both Knowledge-driven and Data-driven Analytics.

**Knowledge-Driven**
- Published Knowledge
  - Journals
  - Books
  - Guidelines

**Data-Driven**
- Observational Data
  - Longitudinal records
  - Claims, Rx, Labs
  - Genomics
  - Exogenous

- Discovery Advisor
- Oncology Advisor
- Engagement Advisor
- Clinical Trials Matching
- EMR Assist
- Genomics Advisor
- Patient similarity
- Predictive modeling
- Real World Evidence
- Genomics
- Visual analytics
Insights also means moving from retrospective to predictive – e.g. monitoring of premature infants - predicting onset 24 hrs in advance.

- Research Project between University of Ontario Institute of Technology (UOIT) & IBM Research - Monitors infants in the Hospital for Sick Children NICU

- Manages 100’s data values per second – applies context and evidence-based rules

- Measures trends in multiple readings and based on combination of subtle changes, predicts adverse event 24 hours before onset.
Watson’s Text Analytics Natural Language Processing

- Manages abbreviation, negation, ambiguous phrases
  - “55%” = LVEF
  - “Patient does not show signs” = Negative Symptom

Pre-built Watson Annotators for Care Management

- Infer meaning from non-contextual content
  - “Cut back from two packs to one per day” = Smoker
- Identify, normalize, and code medical and social facts in unstructured content including:
  - Diagnosis, procedure, allergy, medication, labs, lifestyle

A 42-year old male presents for a physical. He lives alone and recently cut back from 2 packs to 1 pack per day. He recently had a right hemicolecotony invasive grade 2 (of 4) adenocarcinoma in the ilioceleal valve was found and excised. At the same time he had an appendectomy. The appendix showed no diagnostic abnormality.

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age: 42</th>
<th>Gender: Male</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smoker: Yes</td>
<td>Living Arrangements: Alone</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hx Procedure</th>
<th>hemicolecotony diagnosis: invasive adenocarcinoma anatomical site: ileocecal valve grade: 2 (of 4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hx Procedure</td>
<td>appendectomy diagnosis: normal anatomical site: appendix</td>
</tr>
</tbody>
</table>
For example, using both structured and non-structured data, a predictive model identifies patients at risk for developing CHF.

9000 patients identified for at-risk care management program

Improves patient satisfaction and delays or prevents chronic disease onset

Reduces Costs of care management through prioritization of resources

Business Challenge: The problem is identifying those patients at risk before the onset of the disease and before diagnosis so that preventative steps can be taken.

The Smarter Solution: IBM built and deployed a predictive model that achieved an accuracy score of 85% in its ability to identify those patients at risk for developing CHF in a 1 year timeframe.

The model leveraged structured data from the EPIC EMR system and also incorporated unstructured clinical notes that helped the model better identify patients with the condition, increasing its accuracy.
Systems of Insight and Data-driven Healthcare Analytics means Building Capabilities.

IBM’s Track Record in Healthcare Analytics
- Over 50 publications in 4 years
- Over 30 patents filed
- Nominated for best paper: AMIA 2010, AMIA Summit 2014
- Received NIH grant for CHF prediction (2013 – 2016)

Data Driven Healthcare Analytics Framework

Data
- Patients
- Providers
- Payment

ANALYTICS
- Predictive Modeling
- Risk Stratification
- Clinical Pathway Mining
- Utilization Analysis
- Translational Medicine
- Disease Progression Modeling

Patient Similarity

VISUAL ANALYTICS
- Visualization for Patient Clusters
- Visualization for Patient Evolutions
Large Scale Patient Similarity Analysis

**Challenge:** identify the measure of clinical similarity between patients

**Approach:** machine learning algorithms to automatically learn the best metric from observational data and labels provided by experts or derived from data

**Patient similarity assessment in clinical factor/feature space**

```
\{ (x_1^1, x_2^1, \ldots, x_N^1), (x_1^2, x_2^2, \ldots, x_N^2), \ldots, (x_1^K, x_2^K, \ldots, x_N^K) \}
```

Often > 10,000 dimensions

**Outcomes Analysis**
- Best Treatment=?
- Prognosis=?
- Diagnosis=?

**Treatment Comparison**
- Disease Progression

**Clinically similar to**
IBM Watson Health

IBM Research has evolved a Decision Support Tool for Clinical Care – visualizes what happened to patients “just like yours”

• **Key capabilities**
  – Uses Patient Similarity Analytics to find clinically similar patients.
  – Extracts historical event trails and patient characteristics relevant to the condition targeted.
  – Provides a Visual Summary of the evolution of clinical pathways of the similar patients, based on relevant to events.
  – Relates outcomes to pathways, to help identify most desirable and most problematic pathways to inform clinical decisions.
IBM Watson Health

IBM Research has evolved a Decision Support Tool for Clinical Care – visualizes what happened to patients “just like yours”
Transforming Skin Cancer Detection using Data-Driven Learning

Today

Diagnosis

Manual Inspection

ABCDE
Asymmetry
Borders
Color
Diameter
Evolution

Unknown Images

• Inaccurate Diagnoses from Limited Samples and Modalities
• Subjective Evaluation

Transformation 1 (Current)

Computer Analysis

Ensemble Classification

Segmentation and Visual Feature Extraction

Unknown Images

• Higher Accuracy (1K’s training)
• Improved Consistency
• More Contextual Data (modalities)

Transformation 2 (Future)

Deep Learning

Convolutional Neural Network (CNN) Discrimination and Feature Learning

Unknown Images

• Highly Accurate (1M’s training)
• Continuous Learning from Data
• High Density Samples (space/time)
Using Systems of Insight to “know your customers” – segment patients – similar to Catalunya, Spain who have risk profiled based on 8 Clinical Risk Groups.
Agenda

- Shifting Sands – Healthcare and Analytics
- Knowledge and Data-driven Analytics
- Watson and Emergence of Cognitive Computing
- Discussion
Knowledge-driven Analytics – and emergence of Cognitive Computing – Learning Systems - to address the challenges of healthcare

- Watson focuses on “Knowledge Management”
  – EMR investments focus on record management

- 800,000 publications per year catalogued by the US Library of Medicine
Starting in 2006, our investments have led to Watson for Healthcare - integration of knowledge with data to drive better decisions and outcomes.

1. Understands natural language and human speech

2. Generates and evaluates hypothesis for better outcomes

3. Adapts and learns from user selections and responses
Watson’s Cognitive Computing capabilities allows you to Ask, Discover, and Decide.

**ASK**
Watson Engagement Advisor
to transform interactions and experiences with consumers and patients

Emerging Technologies
Watson Paths

**DISCOVER**
Watson Discovery Advisor
Watson Analytics
Watson Explorer

Emerging Technologies
Watson EMR Assistant

**DECIDE**
Watson Oncology
to assist in identifying individualized treatment plans and clinical trials..
IBM Watson for Oncology
Trained by Memorial Sloan Kettering

Business challenge:
• Ability to assess quickly the best treatments for an individual patient based on latest evidence and clinical guidelines

Watson solution:
• A tool to assist physicians make personalized treatment decisions
  − Analyzes patient data against thousands of historical cases and trained through thousands of Memorial Sloan Kettering MD and analyst hours
  − Suggestions to help inform oncologists’ decisions based on over 290 medical journals, over 200 textbooks, and 12M pages of text
  − Evolves with the fast-changing field
  − Currently supports first line treatment (Breast, Lung, Colorectal cancers)
61 y/o woman s/p mastectomy is here to discuss treatment options for a recently diagnosed 4.2 cm grade 2 infiltrating ductal carcinoma…

1. Extract key attributes from a patient’s case

2. Use those attributes to find candidate treatment options as determined by consulting NCCN Guidelines

3. Search a corpus of evidence data to find supporting evidence for each option

- Inclusion / exclusion criteria
- Co morbidities
- Contraindications
- FDA risk factors
- MSK preferred treatments
- Other guidelines
- Published literature - studies, reports, opinions from Text Books, Journals, Manuals, etc.
- …

4. Use Watson’s analytic algorithms to prioritize treatment options based on best evidence.

Watson Oncology Overview
Clinical trials are an equivalent option to the top-ranked treatment plan shown and should always be considered.

- **Preferred**
  - 5-FU/Leucovorin (fluorouracil/leucovorin)
  - Cape celibine

- **Acceptable**
  - Observation
  - Referral to surgery

- **Not Recommended**
  - FOLFOX (fluorouracil/leucovorin/oxaliplatin)
  - CapeOX (cape celibine/oxaliplatin)
  - FLOX (fluorouracil/leucovorin/oxaliplatin)

- **Contraindicated or Unsafe**

### Supporting
Clinical data supporting the treatment:
- This treatment is designated Category 1 by the NCCN.
- This treatment is designated as a preferred treatment by the NCCN.

### Refuting
Clinical data not supporting the treatment:
- oxaliplatin: may not be optimal for high risk stage II patients

### Additional Clinical Data
Clinical data needed to clarify whether the treatment is appropriate:
- None
**Adjuvant Therapy for completely resected Stage II Colon Cancer**

Alvaro Figueredo, Megan E Coombes, Sam Mukherjee. Adjuvant Therapy for completely resected Stage II Colon Cancer. Cochrane Database of Systematic Reviews, 2006 Jul.

Relevance: ★★★★☆ Strength: ★★★★☆

Adjuvant therapy for completely resected stage II colon cancer Colon cancer is the second most common cause of cancer deaths in the Western world. A large proportion of colon cancer patients can be cured by surgical resection alone. For those patients with lymph node positive (stage III) disease, the recurrence rate can exceed 50% and adjuvant chemotherapy has been shown to significantly reduce the risk of recurrence. In patients without lymph node involvement (stage I and II), the prognosis is quite good with surgery alone, with survival rates of 75% to 95% at 5 years. However, some patients with high risk stage II disease have a relapse rate approaching that of stage III colon cancer patients. Due to the effectiveness of systemic chemotherapy in stage III disease, a similar approach has been considered for patients with stage II disease. We performed a systematic review looking at all randomized clinical trials evaluating stage II colon cancer patients and adjuvant therapy versus surgery alone. Our review found that adjuvant therapy—either systemic or regional chemotherapy or immunotherapy—can improve the outcomes of stage II patients. In counseling individual patients, the advice given should be conditioned by the patient's age and comorbidities. In addition, the high risk features of the tumour should also be considered when contemplating the benefits of systemic therapy in patients with stage II colon cancer. Further investigation is needed to elucidate which patient and tumour factors can be used to select stage II colon cancer patients for adjuvant therapy. There also exists a need to continue to search for other adjuvant therapies which might be more effective, shorter in duration and less toxic than those available today.

Clinical Trial Matching is being used by The Mayo Clinic to increase participation rates in clinical trials.

**Business challenge:**
- Clinicians have no easy way to search across eligibility criteria of relevant clinical trials for their patient;
- 30% of sites for clinical trials fail in enrolling even a single patient

**Watson solution:**
- Use patient data to instantly check eligibility across all relevant clinical trials
Department of Veterans Affairs will assess Watson technology in pilot study that could benefit 8.3 million veterans requiring care each year.

**Challenges**

- The amount of medical data doubles every three years
- Size and complexity associated with patient data in EMRs is overwhelming
- The potential of EMRs has not been realized given the discrepancies of how the data is recorded, collected and organized across healthcare systems

**Success Value**

During the pilot, Watson will base clinical decisions on realistic simulations of patient encounters – pre-visit, visit and post-visit situations.

“Physicians can save valuable time finding the right information needed to care for their patients with Watson technology…A tool that can help a clinician quickly collect, combine and present information will allow them to spend more time listening and interacting with the Veteran.” – Carolyn Clancy - Interim Undersecretary for Health - VA

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New York Genome Center and IBM Watson launched an initiative to accelerate a new era of genomic medicine

As the cost of Next Generation Sequencing decreases, there will be an increase in tumor genome sequencing resulting in massive quantities of genetic data to analyze.

It can take on an average from 4-6 weeks to analyze and interpret genetic data manually.

Complexity of matching genetic mutations of individual’s tumor with molecular targeted therapies using multiple data sources.

“With this [genomics] knowledge, doctors will be able to attack cancer and other devastating diseases with treatments that are tailored to the patient’s and disease’s own DNA profiles. This is a major transformation that can help improve the lives of millions of patients around the world.”
– Dr. John E. Kelly, Senior Vice President, Solutions Portfolio & Research

Secured Beta testing relationships with 13 Cancer and Academic medical centers

“Applying the cognitive computing power of Watson is going to revolutionize genomics and accelerate the opportunity to improve outcomes for patients with deadly diseases by providing personalized treatment.”
– Robert Darnell, M.D., Ph.D., CEO, President and Scientific Director of the New York Genome Center
Continued growth in the amount and complexity of medical knowledge – leverage Watson to scale expertise.
Recap: Systems of Insight – Knowledge-driven and Data-driven – shifting clinical decision support.

- EMR summary of Risks
- Suggestions / Actions – “doing the right things”
- EMR summary of what is missing
- Real-time best evidence
- Democratization of Knowledge
- Cognitive Computing
Discussion
Together with our Cloud investments, we were positioned to enable IBM Watson Health

1. **Data** - HIPAA-enabled, standards-based, massively scalable, open repository of data on all dimensions of health

2. **Insights as a Service** providing knowledge and actionable information through advanced analytics and cognitive capabilities

3. **Solutions** from IBM and ecosystem partners improves the overall experience and increases the quality of outcomes -- where it matters and when it matters
IBM Watson Health consists of

**Acquisitions**

IBM Cúram
- Smarter Care
- Social Programs

IBM Research
- Assets

**Partnerships**

IBM organic innovation

**Data and solutions**
- Massive big data management
- Solutions for population health and patient engagement

**Insights**
- Population health
- Patient engagement

**Insights and solutions**
- Care management
- Human services delivery