Harnessing Cognitive Computing for Health

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Dartmouth

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Center for AI, Research and Evaluation (CARE) Goals

• To design, conduct, and disseminate results of rigorous scientific research related to Watson Health offerings
• To support collaboration among design / development teams, IBM Research scientists, academic institutions, and client partners
• To lead in the science of health informatics, especially artificial intelligence and implementation science
# Evaluation Framework

<table>
<thead>
<tr>
<th>Technical Performance Studies</th>
<th>Usability and Workflow Studies</th>
<th>Health Impact Studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>System and component performance</td>
<td>Effectiveness</td>
<td>Decision impact</td>
</tr>
<tr>
<td>Natural language processing (NLP) &amp; machine learning (ML) accuracy</td>
<td>Efficiency</td>
<td>Patient outcomes</td>
</tr>
<tr>
<td>Accuracy of system output</td>
<td>Satisfaction</td>
<td>Process outcomes</td>
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<td></td>
<td>Ease of Use</td>
<td>Cost effectiveness</td>
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<td></td>
<td>Learnability</td>
<td>Care variability</td>
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<tr>
<td></td>
<td>Utilization</td>
<td>Population impact</td>
</tr>
</tbody>
</table>
Evaluation Framework

Sequence is important to address confounders

- Technical Performance
- Usability & Workflow
- Health Impact

Repetition is important as conditions change
Tabulating Systems Era
1900 – 1940s

Programmable Systems Era
1950s – Present

Artificial Intelligence Era
2011 –

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What is AI/Cognitive?

Understands
Reads and understands data – both **structured** and **unstructured** – at a massive scale.

Reasons
Searches millions of pages of data in seconds and can **recognize context and interpret** the language of health and medicine.

Learns
Learns from **leading human experts and real world cases** and continues to improve over time and experience.

Empowers
Previously “**invisible**” **data and knowledge** are **delivered into actionable insights**. Cognitive and AI empowers humans and is transparent.
Humans excel at:

- Common sense
- Dilemmas
- Morals
- Compassion
- Imagination
- Dreaming
- Abstraction
- Generalization

Artificial Intelligence systems excel at:

- Natural Language
- Pattern Identification
- Locating Knowledge
- Machine Learning
- Reduce Bias
- Endless Capacity
IBM Leadership in AI and Health and the Birth of Watson Health

IBM developed and implemented an early EMR with Akron Children’s Hospital

IBM’s Deep Blue beat the world chess champion Garry Kasparov in a six-game match

Cognitive test case results in creation of Watson.

Richard Feynman urges creating quantum computer at MIT/IBM conference

The next GRAND CHALLENGE

IBM enables an “evidence-based healthcare ecosystem”
Precision Medicine in the AI Era
Staying Current with Genomic Information Needs a New Approach

3 million
growing number of publications related to cancer¹

9 times
NCCN Guidelines changed for NSCLC in 2017²

117
FDA-approved biomarker-based drugs for cancer³

~50%
Of new FDA-approved cancer therapies (2016-17) require specific molecular features⁵

600%
Increase from 2006 to 2018 in % of US patients with cancer estimated to benefit from genome-targeted therapy⁶

87%
Of Pharma pipeline is biomarker driven drugs targeting late-stage cancer⁴

25%
The percent of variants of uncertain significance (VUS) that were reclassified⁷

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2. Reily GR. Lung Cancer IASLC News. Accessed August 9th, 2018
Watson for Genomics
Leverage AI to provide expertly validated, up-to-date, comprehensive content to enable clinical reporting and precision oncology programs

Watson for Genomics
Leverages AI to extract unstructured data from peer-reviewed literature to continually grow its knowledge base. The literature selection, training, ingestion, validation and integration of new content are offline and ongoing processes, enabling Watson for Genomics to extract the most recent information as clinical trials become available and new research results are published. All content is validated by subject matter experts.

Confidence in clinical reporting
+ Rely on IBM Watson® for Genomics to provide clinical content that is up-to-date — based on the latest approved therapeutic options
+ Take advantage of the capabilities of AI to extract unstructured data from abstracts and full text articles to continually grow the knowledge base
+ Depend on a clearly defined, level-of-evidence model. All content is linked to the appropriate supporting evidence.
+ Save time across reports with rapid, consistent and efficient interpretation across cancer types.
+ Easily scale in terms of sample volume and complexity of gene panels — from targeted panels to whole genome


Mutations are prioritized

Interpretation Determine therapeutic, prognostic and diagnostic relevance

Annotation and prioritization of variants

Report generation
– Easy navigation of the mutational profile
– Clearly defined level of evidence model
– Report formats: JSON, PDF, HTML
**SUMMARY**

**DIAGNOSIS:** Breast Carcinoma ER(+) HER2(-)  
**AGE:** 47  
**GENERIC:** Female

The G715* mutation in gene BRCA2 is a strong predictive marker of response to treatment with olaparib. The G715* mutation in gene BRCA2 is a predictor of response to treatment with niraparib andrucaparib phosphate. In addition mutations in P53CA resulting in activation of the MTOR/PI3K signaling pathway and mutations in BRCA2 resulting in increased sensitivity to PARP inhibitors have been detected. Treatment strategies with drugs targeting one or both of these pathways may be therapeutic options for this patient.

A pathogenic mutation in BRCA2 gene has been detected. Pathogenic germline mutations in BRCA2 have been associated with hereditary cancer.*

Genetic alterations in FGFR1 predict poor prognosis in Breast Carcinoma.

*This analysis was performed by next-generation sequencing (NGS), which does not separate between germline and tumor-only mutations. Therefore, in the appropriate clinical context, germline testing is required.

1. **Automated annotation and prioritization of all genetic alterations**
2. **Automated case summary based on molecular profile**
3. **Clearly defined Level of Evidence Model**
4. **Biomarker based clinical trial matching**
5. **Speed and efficiency**
**The Oncologist:** Watson for Genomics found 99% of the actionable mutations identified by the molecular tumor board


Watson for Genomics took less than 3 minutes per case. Found 99% of the actionable mutations identified by UNC’s MTB and identified additional actionable mutations that the MTB did not in 32% of the cases (N = 1,018)

“Molecular tumor boards empowered by cognitive computing can significantly improve patient care by providing a fast, cost-effective, and comprehensive approach for data analysis in the delivery of precision medicine.” –The Oncologist

*excerpt from manuscript*
"We found that WGA was able to provide reports of potentially clinically actionable insights within 10 minutes, while human analysis of this patient’s VCF file took an estimated 160 hours of person-time." – Neurology: Genetics

Watson for Genomics completed analysis of whole genome and RNA-sequencing results in 10 min vs 160 hours of person-time

Significant decrease in time to discovery of potentially actionable variants
Clinical Insights for Hematological Malignancies from an Artificial Intelligence Decision-Support Tool

| Kim M et al. ASCO 2019.

54 South Korean patient cases with hematological malignancies were analyzed by Watson for Genomics (WfG):

- 71% of cases had at least one clinically actionable therapeutic alteration
- 33% of cases had genes that were targeted by a US FDA approved therapy
- 20% of cases without therapeutic alterations, WfG identified additional diagnostic or prognostic insights

10 cases were randomly selected for manual interpretation analysis:

- 90% of cases were concordant with WfG analysis

WfG identified 9 more (33%) clinically actionable variants not found in manual assessment

“WfG variant interpretation correlated well with manually curated expert opinion and identified clinically actionable insights missed by manual interpretation....WfG has obviated the need for labor-intensive manual curation of clinical trials and therapy, enabling our center to exponentially scale our NGS operations**”

* Excerpt from abstract
Comparative Analysis of Prognostic Molecular Signatures in Asian and Caucasian Acute Myeloid Leukemia (AML) Populations

Kim M et al. ASCO 2019

Watson for Genomics was used for variant interpretation and annotation in patients with AML:

- 23 East Asian patients
- 181 Caucasian patients

Watson for Genomics identified at least one clinically actionable therapeutic alteration in 70% of Asian cohort cases.

FLT3-ITD or TKD mutations were reported in 27% of cases in the Caucasian cohort but only 9% of the Asian cohort.

“...FLT3 and DNMT3A, predictors of poor prognosis in AML, demonstrated [changed] frequencies in South Koreans compared to Caucasians, suggesting that some mutational signatures that predict cancer outcome may vary by race.”

* Excerpt from abstract
Social Program Management Software to Optimize Benefit Application and Management

Recognizing a Growing Need

The Human Resources Administration, City of New York (HRA) is one of the largest Supplemental Nutrition Assistance Program (SNAP) and Cash Assistance (CA) program in the United States.

- **2 Million** New Yorkers served every month
- **25,000** new applications every month
- **40,000** recertifications every month
- **30 minutes to 3 hours** to fill out an application
- **40 – 50%** rejection rate of applications

Main reasons: miss interview or fail to provide a document
### NYC SNAP Recipient Demographics

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aged eighteen years or older</td>
<td>66.5</td>
</tr>
<tr>
<td>Female</td>
<td>57.3</td>
</tr>
<tr>
<td>Have at least a high school degree</td>
<td>17.9</td>
</tr>
<tr>
<td>Single / never married</td>
<td>73.7</td>
</tr>
<tr>
<td>Major ethnicities</td>
<td></td>
</tr>
<tr>
<td>- Black African American</td>
<td>27.8</td>
</tr>
<tr>
<td>- White and Hispanic</td>
<td>24.4</td>
</tr>
<tr>
<td>- White</td>
<td>14.6</td>
</tr>
<tr>
<td>- Black and Hispanic</td>
<td>10.4</td>
</tr>
<tr>
<td>- Asian</td>
<td>10.3</td>
</tr>
<tr>
<td>- Other</td>
<td>12.5</td>
</tr>
</tbody>
</table>
NYC HRA Objectives

Enhance SNAP benefit screening, application preparation and submission, and application profile management

- Migrate from a highly labor-intensive process to a user-centered online self-service web/mobile app
- Decrease Social Service Department administrative workloads
- Improve services and outcomes for clients
- Improve operational efficiency
SNAP Application and SNAP Recertification

SNAP Application - Next Steps

1. Success! Submitted on 4/17/2018 at 10:42AM
   Confirmation Number: 7098653762
   View a copy of your submitted form here. We’ve sent a copy to your email address if you gave us one.

2. Collect your documents
   - Proof of Income from Employment for Jon and Mary
     - Jon (2/2/1980)
     - Mary (2/2/1982)
   - Proof of Identity for Mary
   - Proof of Age for Jon
   - Proof of Citizenship for Jon

Welcome to ACCESS HRA, Jon!

Case Actions

- SNAP (Food Stamps)
  Case # 00456768511A
  SNAP Recertification Due!
  Do you want to start your online Recertification now?
  No
  Yes

Last Payment

- February 3, 2019
- Regular SNAP/Food Stamp: $175.00

Frequently Asked Questions (FAQ)

- How can I update my Contact Information?
Key Outcomes Improved Year-over-Year

The user-centered enhanced system was deployed in January 2019 with continued support for the seven languages (English, Spanish, Arabic, Chinese, Korean, Haitian Creole, and Russian) in the original system.

<table>
<thead>
<tr>
<th>Monthly System Metrics</th>
<th>April 2018 (Pre-deployment)</th>
<th>April 2019 (Post-deployment)</th>
<th>% Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logins (web + mobile)</td>
<td>915,532</td>
<td>1,684,248</td>
<td>84.0</td>
</tr>
<tr>
<td>Online applications / recertifications received</td>
<td>33,421</td>
<td>40,198</td>
<td>20.3</td>
</tr>
<tr>
<td>Document uploads</td>
<td>26,419</td>
<td>43,057</td>
<td>63.0</td>
</tr>
<tr>
<td>Profile update calls</td>
<td>9,696</td>
<td>17,547</td>
<td>81.0</td>
</tr>
</tbody>
</table>
Agency and Beneficiary Satisfaction Grew

- 20% reduction in application rejections due to failure to provide documentation
- 54% decrease in in-person center visits
- 27,128 survey response reviews of the application have been received with an average rating of:
  - 4.31 out of 5 (highest) for SNAP application
  - 4.44 out of 5 (highest) for SNAP recertification
Singapore was being hailed as one of the countries that had got its coronavirus response right

And then the second wave hit, hard:
  • Since March 17, number of confirmed coronavirus cases grew from 266 to over 5,900

Singapore also has advantages:
  - one major land border, with Malaysia, tight control on people entering by air
  - world-class health system
  - a system of rules and policing that can benefit a government response

So what went wrong? The answer appears to lie in overlooked clusters of cases among migrant workers living in cramped dormitories
Age-adjusted rates of lab confirmed COVID-19 non hospitalized cases, estimated non-fatal hospitalized cases, and patients known to have died 100,000 by race/ethnicity group as of April 16, 2020.

<table>
<thead>
<tr>
<th>Race/Ethnicity</th>
<th>Non-hospitalized</th>
<th>Non-fatal hospitalized</th>
<th>Known to have died</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black/African American</td>
<td>335.5</td>
<td>271.7</td>
<td>92.3</td>
</tr>
<tr>
<td>Hispanic/Latino</td>
<td>271.6</td>
<td>198.6</td>
<td>74.3</td>
</tr>
<tr>
<td>White</td>
<td>190.4</td>
<td>114.5</td>
<td>45.2</td>
</tr>
<tr>
<td>Asian</td>
<td>95.1</td>
<td>82.2</td>
<td>34.5</td>
</tr>
</tbody>
</table>

New York City Department of Health and Mental Hygiene
Social Isolation & Loneliness

62% – 70% ↑ mortality

Empowering Case Workers to Serve the Most Vulnerable

Recognizing an unmet need

To enable multi-disciplinary teams to deliver safety net services to Sonoma County residents with complex needs

Sonoma County, California Profile

- Population 500,000+
- 1 of 9 Bay Area Counties
- International Tourist Destination
- 50 Miles of Pacific Coastline
- 500 Wineries
- Tourism and Wine Industries $3 Billion Annually
- High Cost of Living
- Limited Housing
- Family of 4 is “Low-income” at $79,000 / yr
- 10.7% of Population Below Federal Poverty Level
- Neighborhoods with Low Human Development Index

Sonoma Complex Fires 2017
Sonoma Kincaid Fire 2019
ACCESS (Accessing Coordinated Care and Empowering Self-Sufficiency)
Sonoma Objectives

- Reduce Burden of Care
- Achieve System Integration
- Improve Client Stability and Self-Sufficiency
- Boost Operational Efficiency
ACCESS Sonoma – Innovation
Key elements of the integrated solution

Citizen provides consent to share information for improved service. MOU’s, policies and laws govern cross agency data sharing.

IBM Health and Human Services Connect360 allows secure sharing of client data across existing systems.

Access client data and information through Watson Care Manager and use case driven dashboards and portals.

Receive alerts and notifications. Identify cohorts and trends. Drill down to perform outreach.
Committed to designing better coordinated service delivery:

- Collaborate to provide care to shared clients
- Understand what services are being accessed in other departments
- Collaborate on creating an effective, efficient care management plan
- Working together on a client by client basis to provide holistic services for those in need
Use Case – Meet Sandy

Many clients face difficulty accessing and navigating across health, housing, and social service programs and support systems.

**Sandy is...**
- 69 year old homeless woman
- Physical and behavioral health needs
- Fleeing domestic violence
- Living in her car

**Sandy often...**
- Foregoes medical services
- Goes to sleep hungry
- Uses the Emergency Department as her first choice for her healthcare needs
- Struggles with trauma and mental health issues

**Sandy wants to...**
- Have a better life
- Be safe
- Find housing she can afford
- A care team that works together
Prior to ACCESS Sonoma, the pathway to services was complicated and siloed

Client’s pathway to services ...

- Housing
- Community Services & Supports
- Mental Health
- Human Services
- Medical Services
- Justice
- Child Support Services
- Aging & Independence
- Substance Use Disorder
With ACCESS Sonoma, services are tailored to Sandy

Food
- Coordinated immediate access to food bank
- Coordinated enrollment in food assistance programs

Shelter and Housing
- Secured access to shelter
- Secured short-term housing voucher
- Placed into permanent housing

Mental Health
- Conducted screening for mental health needs
- Connected to behavioral health provider
- Reduced isolation

Medical Services
- Supported connection to primary care provider
- Supported enrollment in health plan resulted in reduced out-of-pocket costs
77 complex-needs, fire cohort clients were managed from April 2018 to February 2019

- More than 4,000 fire victims initially housed in the shelter
- After week 2 of the disaster:
  - 300 individuals did not have the resources to leave the shelter for secure housing
  - Of the 127 individuals representing 95 households,
    - 42% were identified as precariously housed
    - 26% were homeless prior to the fires.
- 77 complex-needs fire cohort clients
  - Median age 54.5 years (29 – 84)
  - 58% female
  - IMDT discussed cases an average 2.9 number of times
- As of February 2019:
  - 34 cases are stable and intermittently monitored
  - 43 cases are actively managed
ACCESS Sonoma has served over 1,000 clients

<table>
<thead>
<tr>
<th>Intensive Case Management (n=79)</th>
<th>Alternate Service Delivery (n=875)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 years</td>
<td>44 years</td>
</tr>
<tr>
<td>99%</td>
<td>80%</td>
</tr>
<tr>
<td>97%</td>
<td>67%</td>
</tr>
<tr>
<td>100%</td>
<td>54%</td>
</tr>
<tr>
<td>100%</td>
<td>28%</td>
</tr>
<tr>
<td>82%</td>
<td>47%</td>
</tr>
<tr>
<td>60%</td>
<td>17%</td>
</tr>
<tr>
<td>17%</td>
<td>10%</td>
</tr>
</tbody>
</table>

- Average Age: 44 years
- MediCal Enrolled: 80%
- Mental Illness: 67%
- Homeless/At Risk: 54%
- Medical Condition: 28%
- Alcohol/Drugs: 47%
- High ER utilization: 10%
IBM’s Response to COVID-19

https://www.ibm.com/thought-leadership/covid19/

IBM’s response to COVID-19

To meet the global challenge of COVID-19, the world must come together. IBM has resources to share — like supercomputing power, virus tracking and an AI assistant to answer citizens’ questions.

Accelerate Discovery
- COVID-19 High Performance Computing Consortium
- World Community Grid
- Deep Search Service
- IBM’s Molecular Explorer Tool
- IBM Functional Genomics Platform

Trusted Information
- The Weather Channel Incidents Tracking and Interactive Dashboard
- MicroMedex and DynaMed for Clinicians
- Watson Assistant for Citizens

Resiliency and Adaptation
- Trusted Business Intelligence
- Call for Code
- Resources for Remote Learning
The Weather Channel
Incidents Tracking and Interactive Dashboard

Delivering Speed And Innovation

- Leveraging Watson & IBM Cloud to deliver timely, evidence & location-based information
- Providing public health departments advice, patient education materials, and locations of key healthcare providers
- Connecting users with ways they can help
If you’re impacted by COVID-19, IBM offers two ways to get started

You want to reach your audience with a virtual agent, voice or digital

**Watson Assistant for Citizens**

48 hours

Deployed live 48 hours

Providing a COVID-19 pediatric assessment tool to help parents with next steps, aligned with healthcare protocols.

You need help transitioning your agents to remote work

Agent@Home

with

**Watson Assistant for Citizens**

5 days

250 agents working from home

‘Smart Agent’ function allowing customers to ask a chatbot or live agent about measures the UK bank is taking during the Covid-19 pandemic.

TSB adds Covid-19 Smart Agent to site
3 Key Principles for the AI Era

PURPOSE = PEOPLE
“AI” = “Augmented Intelligence” and “Actionable Insights” to support what humans do, not replace them.

TRANSPARENCY = TRUST
Full transparency (aka, “glass box”) about how our systems are trained and the data & knowledge used to train them.

SKILLS = SYMBIOTIC with AI
AI systems are trained by and supporting human professionals and this will change the workforce and lead to “new skills” and “new collar” jobs.
THANK YOU!

@SnowdonJane

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