

From Population Health to Precision Health

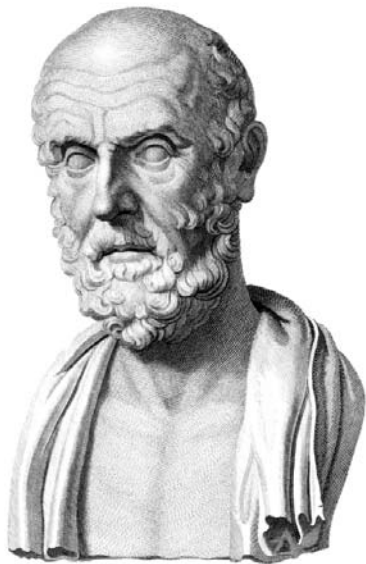
IBM **Watson Health**[™]

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Deputy Chief Health Officer

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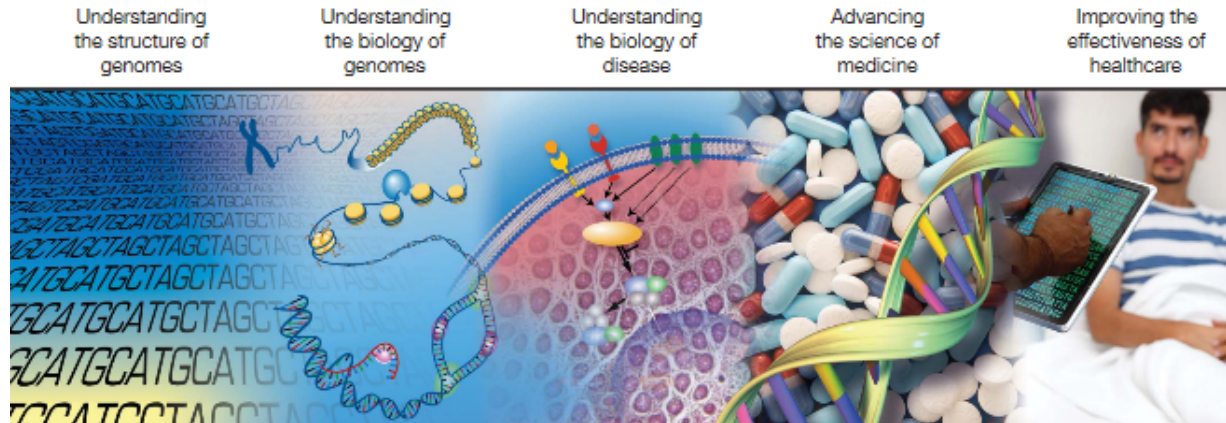




The current health system
faces serious challenges.

A New Era of Personalized Healthcare

Completion of Human Genome Project in 2003 led to expansion of research on the contributions of genomics in disease diagnosis, treatment, and prevention



Green, ED et al (2011). Charting a course for genomic medicine from base pairs to bedside. *Nature* 470: 204-213



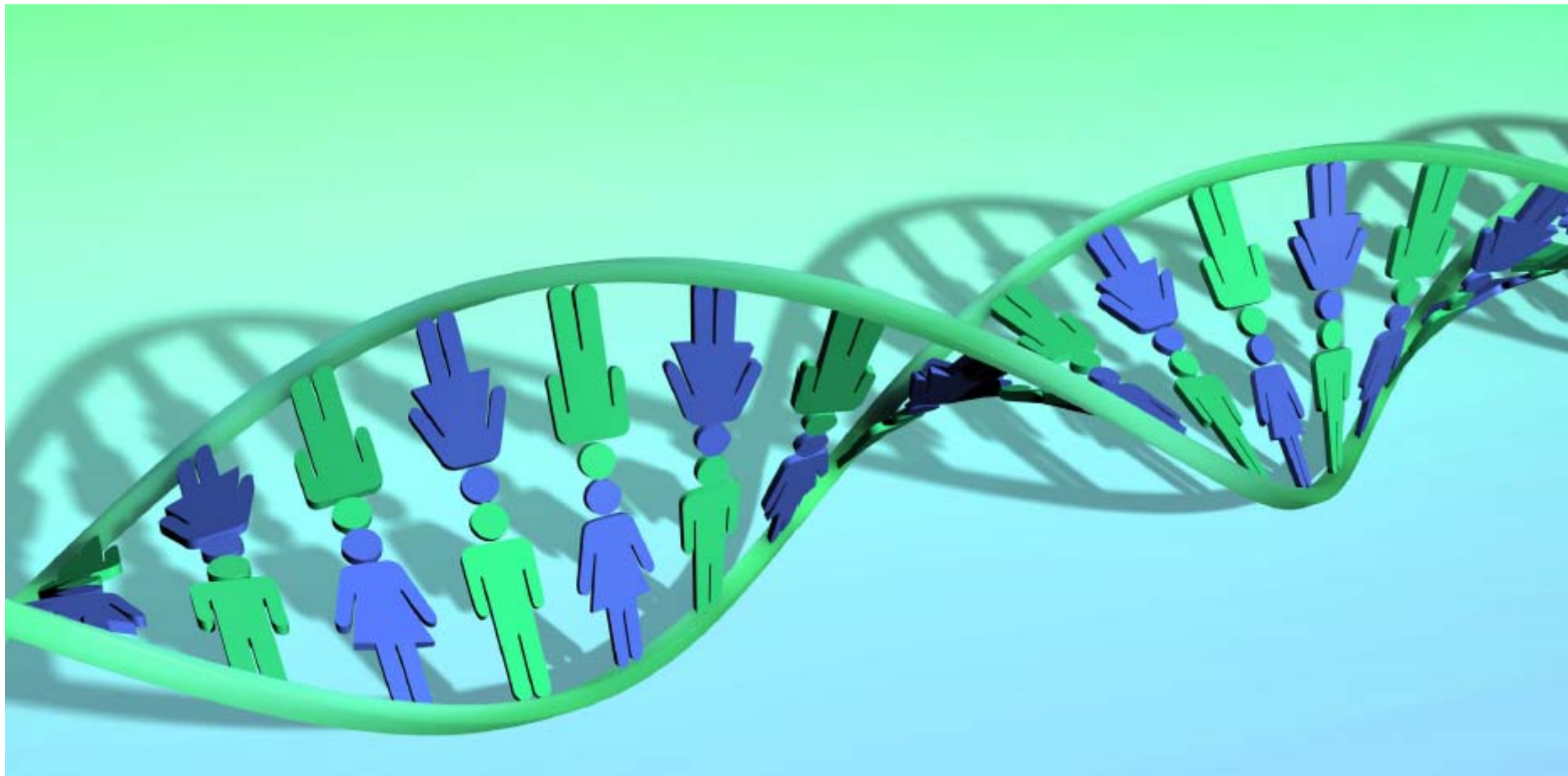
Early Discovery

What biological or environmental factors are causing disease? Can we design diagnostics and drugs to improve patient outcomes?



Clinical Genomics

What does my patient's genomic information tell me about the treatment I should select?



The Challenges of Big Data

Keeping up

There are **100,000+** clinical trials running in parallel.

A patient will generate **>12 TB** of personal health data in a lifetime (300 million books).

Medline: **424 million** published articles in **5600** journals

1.8 million new articles published annually

80% Unstructured

A typical high-need patient has a **100+ page** electronic health record.

Text where meaning is often derived from context

Images: X-rays, sonograms, electrocardiograms, magnetic resonance images, and mass spectrometry results

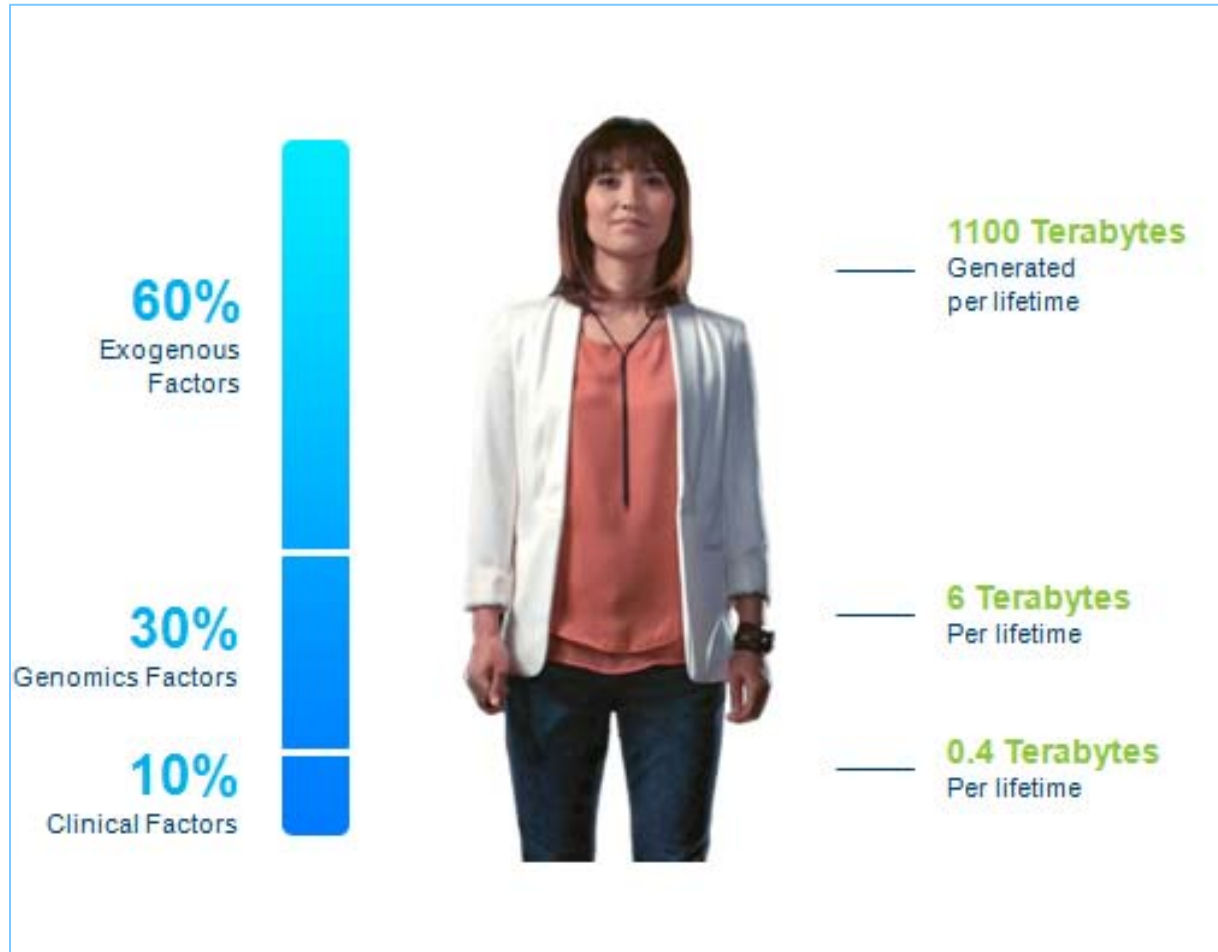
Noisy

Problems of scale: **finding the signal in the noise** when its buried in millions of pages across multiple silos

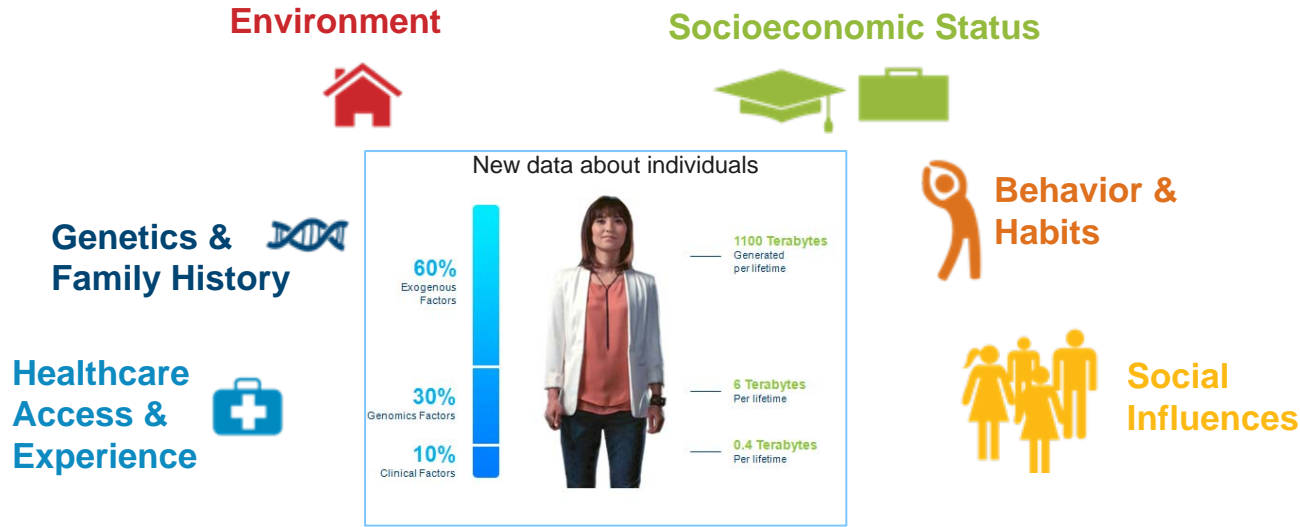
Humans must collect, organize data and evaluate evidence

Introduces **cognitive bias**



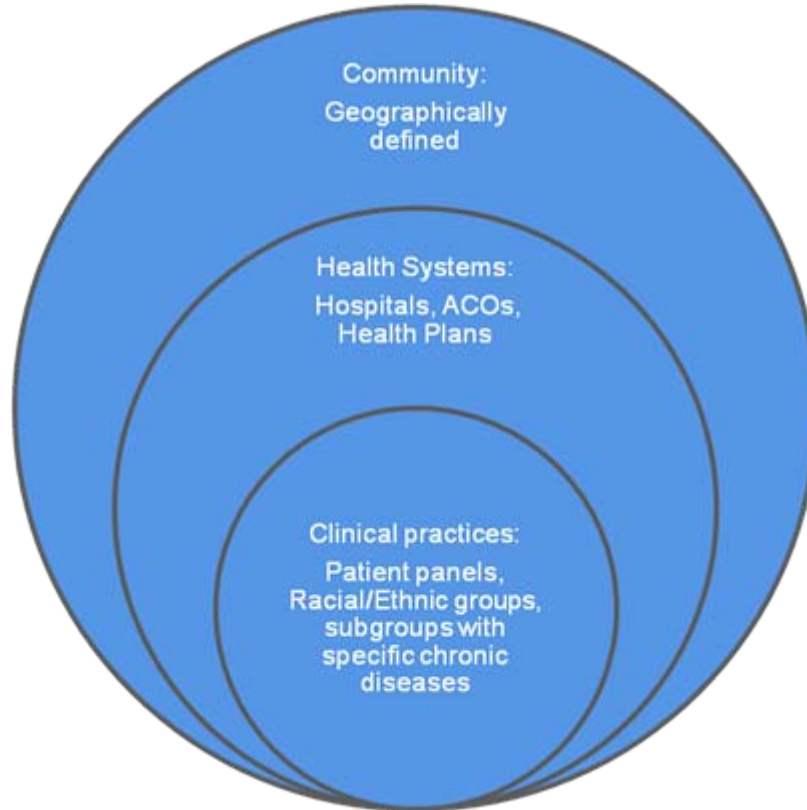


Only 10% of health outcomes are related to healthcare



It's critically important that we consider all influences and opportunities for positively affecting health choices.

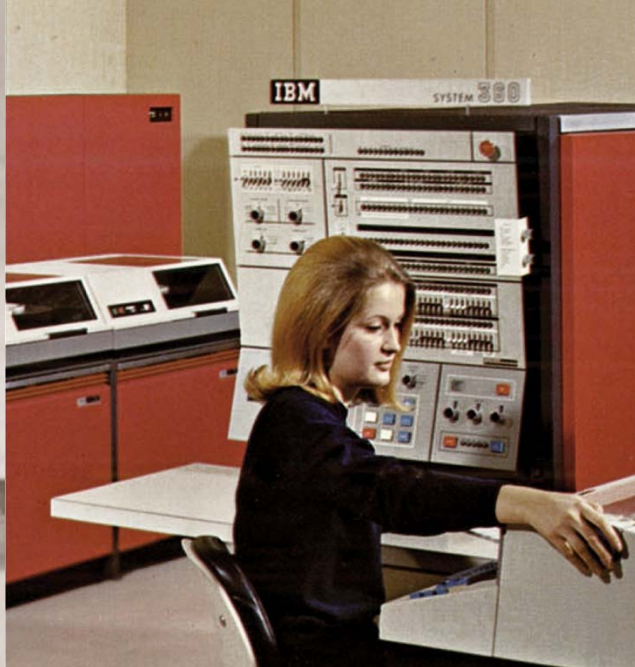
Reconciling the clinical perspective with a broader community perspective





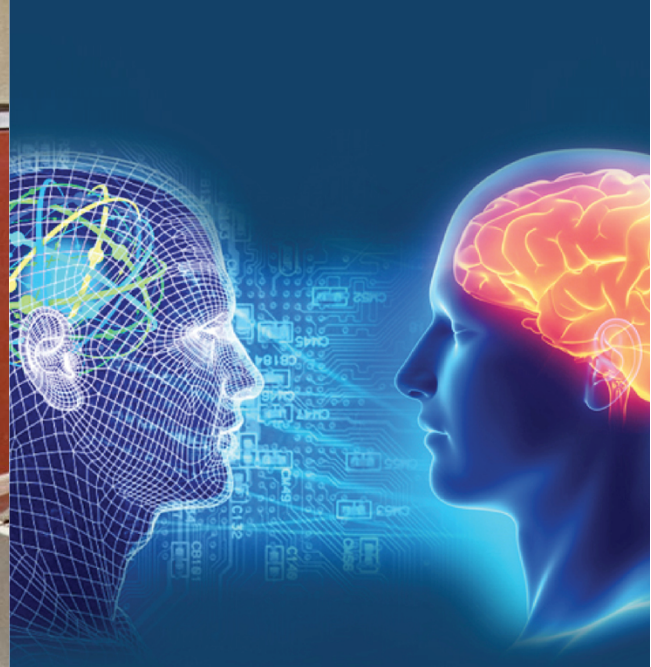
Tabulating Systems Era

1900 – 1940s



Programmable Systems Era

1950s – Present



Cognitive Computing Era

2011 –

What is a **Cognitive** System?

Understands

Watson can read and understand data – both structured & unstructured – at a massive scale.

Reasons

Watson can search millions of pages of data and can recognize context and interpret the language of medicine.

Learns

Watson learns from leading human experts and real world cases and continues to improve over time and experience.

Interacts

Previously “invisible” data and knowledge are delivered into actionable insights. Watson interacts with humans and is transparent.



Natural Language Processing

Reads unstructured documents, notes, patient history, lab reports ...

The screenshot displays a medical text document with various entities highlighted in different colors. The text includes patient history, physical exam findings, and treatment plans. A legend at the bottom left lists the categories of entities, and a tree view on the right shows the hierarchical structure of the ontology.

Legend:

Entity Type	Entity Name
Demographic	Firstname
FunctionalConcept	FunctionalConcept
GeographicArea	GeographicArea
HealthCareRelat...	HealthCareRelat...
IndicatorReagen...	IndicatorReagen...
IparAnnotation	IparAnnotation
LabValue	LabValue
Enzyme	Enzyme
GenderD	GenderD
GovernmentalOr...	GovernmentalOr...
Hormone	Hormone
IndividualBehavior	IndividualBehavior
ICategory	ICategory
LabValueNormal	LabValueNormal
Language	Language
EventMeeting	EventMeeting
Focus	Focus
GeneOrGenome	GeneOrGenome
GroupAttribute	GroupAttribute
Human	Human
InjuryOrPoisoning	InjuryOrPoisoning
IClueText	IClueText
Expression	Expression
Food	Food
GenericRelation	GenericRelation
HazardousOrPoi...	HazardousOrPoi...
IdeaOrConcept	IdeaOrConcept
InorganicChemical	InorganicChemical
LaboratoryOrTe...	LaboratoryOrTe...
Length	Length
Finding	Finding
Food	Food
GeneticFunction	GeneticFunction
HealthCareActivity	HealthCareActivity
ImmunologicFactor	ImmunologicFactor
IntellectualProduct	IntellectualProduct
LaboratoryProce...	LaboratoryProce...

Text Document:

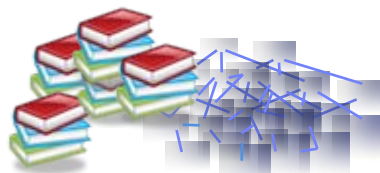
TTE done.
Eye exam done: reportedly fine.
Meds as of **DATE [Jan 29 2003]:
SYNTHROID 150mcg TABLET Take one (1) tablet daily.
Physical Exam:
Gen: alert, oriented, NAD, obese
HEENT: atraumatic, normocephalic, PERRL, EOM, sclera clear, conjunctiva pink, fundi crisp, TM's clear, nares normal, moist
mucous membranes.
oropharynx clear without erythema or exudate.
Neck: supple, no LAD, no carotid bruits, no JVD, GLOTER
CV: S1, S2 regular, 3/6 SEM at **NAME [ZZZ] SB
Resp: Clear to auscultation bilaterally, anterior and posterior, no wheezes, rales or rhonchi
Abd: +BS, soft, nontender, OBESSE, no hepatosplenomegaly
Ext: no cyanosis, no clubbing, no edema, warm and well perfused
Pulses: radial 2/2, brachial 2/2, ulnar 2/2, femoral 2/2, popliteal 2/2, dorsa lis pedis 2/2, posterior tibial 2/2
Skin: no rashes
Neuro: nonfocal
244.9 HYPOTHYROIDISM [ZZZ]
Note: pt is subtherapeutic on synthroid, will increase to 175mcg, follow up TSH in 3 months.
Plan: SYNTHROID 175mcg TABLET
250.0 DIABETES MELLITUS UNCOMP
Note: Newly diagnosed DM type 2. Will start glucophage.
Plan: Glucophage 500mg po bid
746.89 VSD
Note: TTE- preliminary results show: normal LV/RV function, mild RVH, small residual VSD with left to right flow, RVOT with subvalvular and valvular PS, trivial TR, trivial **NAME [YYY, XXX] has not seen peds cards since 1996, although well should fu.
Plan: CONSULT TO CARDIOLOGY: fu with Dr. **NAME [WWW] [peds cards]
272.4 HYPERLIPIDEMIA **INITIALS
Note: LDL 109, should start statin, but pt wants to try diet and exercise, will fu in 3 months and re check lipid profile.
Plan: lipid profile in 3 months.
**NAME [VVV UUU], MD
Examined patient and confirmed key findings on history and examination and **NAME [SSS M] as noted by Dr. **NAME [TTT UUU] above and added by me [MY COMMENTS].
Summary of my findings and impressions are as follows:
DM - is well controlled with diet alone. He has been losing weight and has lost about 15-20 lb over the last 2 years per the patient, by our [ZZZ] re

Ontology Tree:

- DiseaseOrSyndrome
 - DiseaseOrSyndrome ("diabetes mellitus")
 - begin = 56
 - end = 73
 - links = null
 - componentId = MedicalConceptAnnotator
 - mentionType = null
 - semanticType = dsyn
 - conceptName = diabetes mellitus
 - cui = C0011849
 - preferredName = Diabetes Mellitus
 - negation = null
 - mappings = null
 - generic = false
 - variants = [diabetes mellitus nos, diabetes, di]
 - isInsideCui = false
 - innerConcepts = FSArray
 - skipsTerms = false
 - confidence = 1.0
- XsgToken
- Symptom
- Predicate
- Term
- UmlsDictTerm
- Concept
- ClinicalFactor
- Focus
- XsgParse
- XsgTopParse
- GenericRelation
- XsgSentence
- Expression
- IClueText
- USMLEQuestion
- DocumentAnnotation
- SourceDocumentInformation

Combine Knowledge-driven and Data-driven Analytics to generate insights and identify potential outcomes

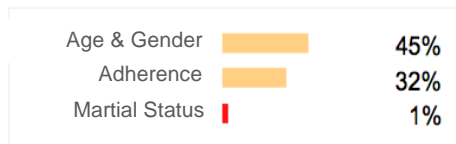
From population averages ...



- Scientific papers
- Books
- Guidelines



Knowledge-Driven Approach



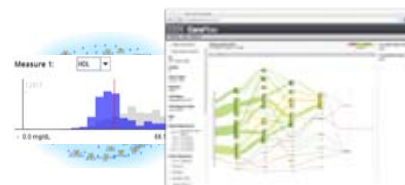
A 58-year-old woman presented to her primary care physician after several days of dizziness, anorexia, dry mouth, increased thirst, and frequent urination. She had also had a fever and reported that food would "get stuck" when she was swallowing. She reported no pain in her abdomen, back, or flank and no cough, shortness of breath, diarrhea, or dysuria. Her family history included oral and bladder cancer in her mother, Graves' disease in two sisters, hemochromatosis in one sister, and idiopathic thrombocytopenic purpura in one sister. Her history was notable for cutaneous lupus, hyperlipidemia, osteoporosis, frequent urinary tract infections, three uncomplicated cesarean sections, a left oophorectomy for a benign cyst, and primary hypothyroidism, which had been diagnosed a year earlier. Her medications were levothyroxine, hydrochlorothiazide, pravastatin, and alendronate. A urine dipstick was positive for leukocyte esterase and nitrites. The patient was given a prescription for ciprofloxacin for a urinary tract infection and was advised to drink plenty of fluids. On a follow-up visit with her physician 3 days later, her fever had resolved, but she reported continued weakness and dizziness despite drinking a lot of fluids. She has been better when lying down. Her supine blood pressure was 120/80 mm Hg, and her pulse was 92 beats per minute. A urine specimen obtained at her initial presentation had been cultured and grew more than 100,000 colonies of *Escherichia coli*, which is sensitive to ciprofloxacin.

To insights for individual patient!



- Longitudinal records
- Claims, Rx, Labs
- Patient reported data

Data-Driven Approach



Applications of Cognitive Analytic Techniques

Real World Evidence / Patient Similarity Analytics

Precision Cohorts: dynamic identification of “patients like mine”

Segmentation Analysis

Identifying & understanding the population: targeted care delivery and policies

Personalized Predictive Models

“Segment-of-one” predictive model

Data Visualization

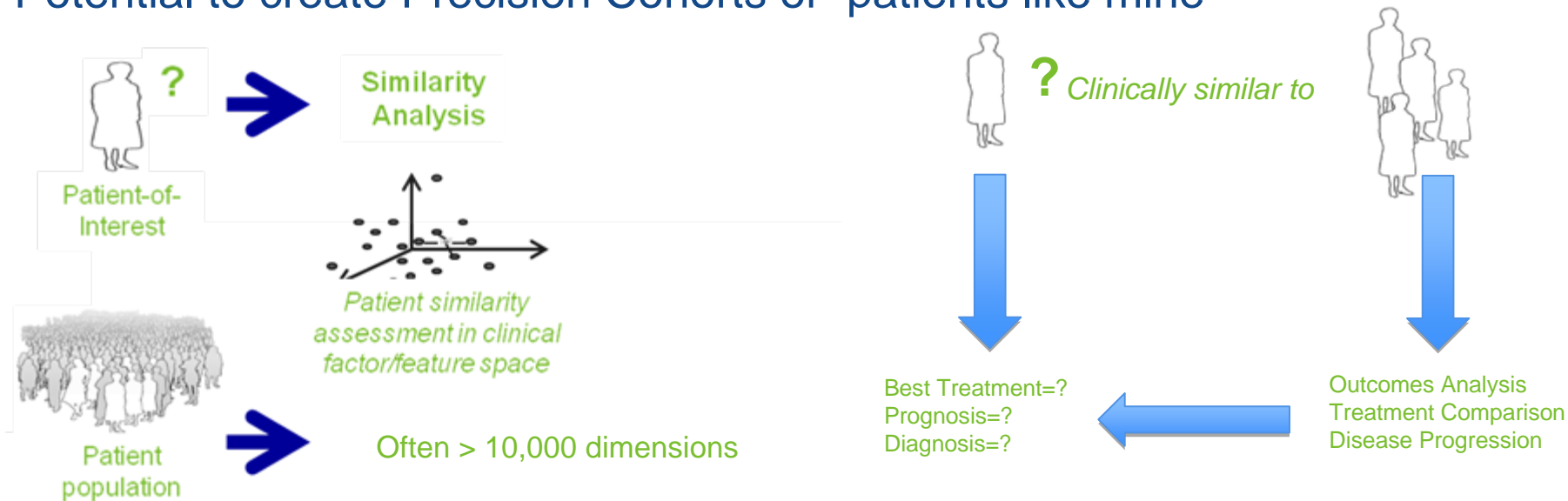
Care pathways and associated outcomes

Trade-off Analytics

Personalized shared decision making

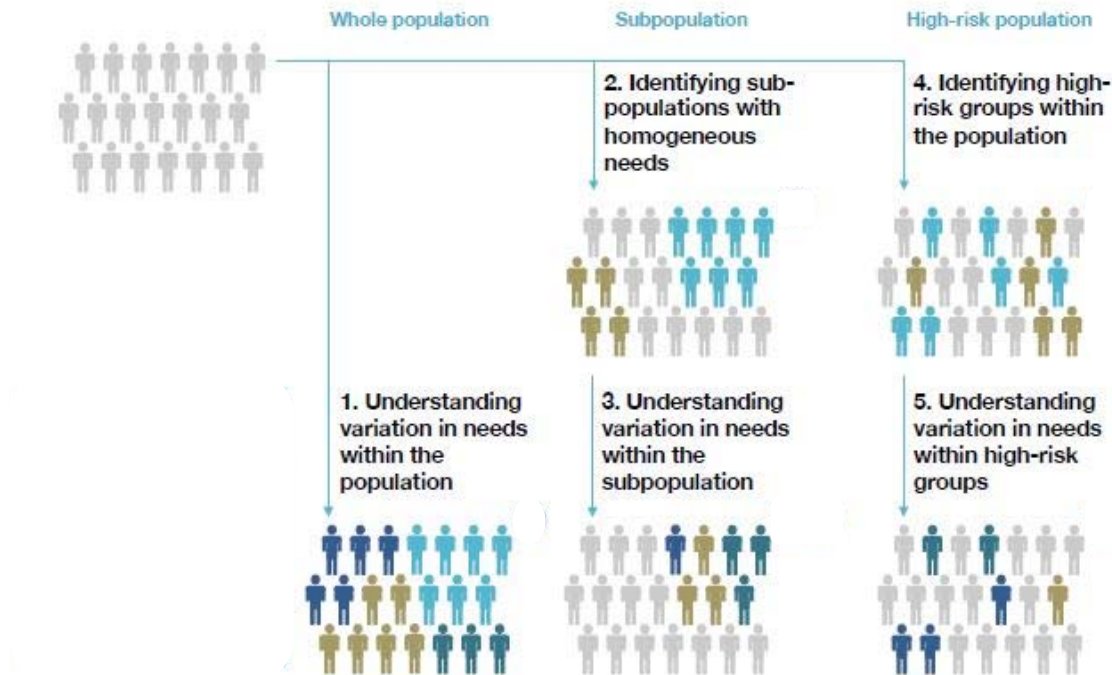
Patient Similarity Analytics

Potential to create Precision Cohorts of “patients like mine”



Machine Learning automatically learn the metric from observational data algorithms and labels provided by experts or derived from data

Segmentation Analysis

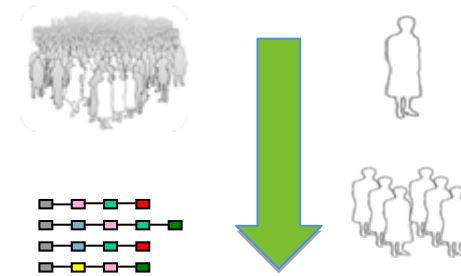


Care Path Flow

Potential to Visualize Care Pathways and Associated Outcomes

- **Patient Similarity Analytics** to find clinically similar patients
- Extract **historical event trails** and relevant patient characteristics
- **Visual Summary** of clinical pathways of similar patients, connected to relevant events
- **Outcomes related to pathways** - help inform clinical decisions with most-desirable vs most-problematic pathway

Clinical

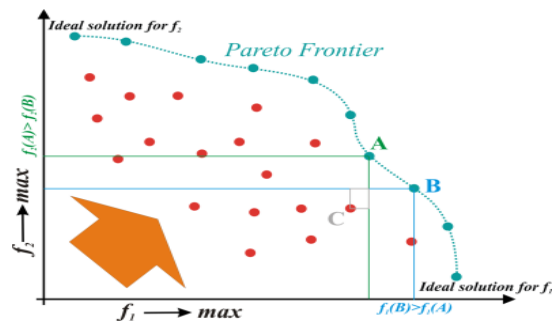


Care Path Visualization



Tradeoff Analytics:

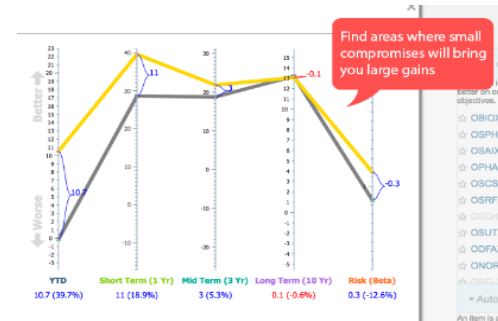
Optimize provider selection on service quality, proximity, license held, cost of service, and preferences



+



+



Personalized Predictive Models

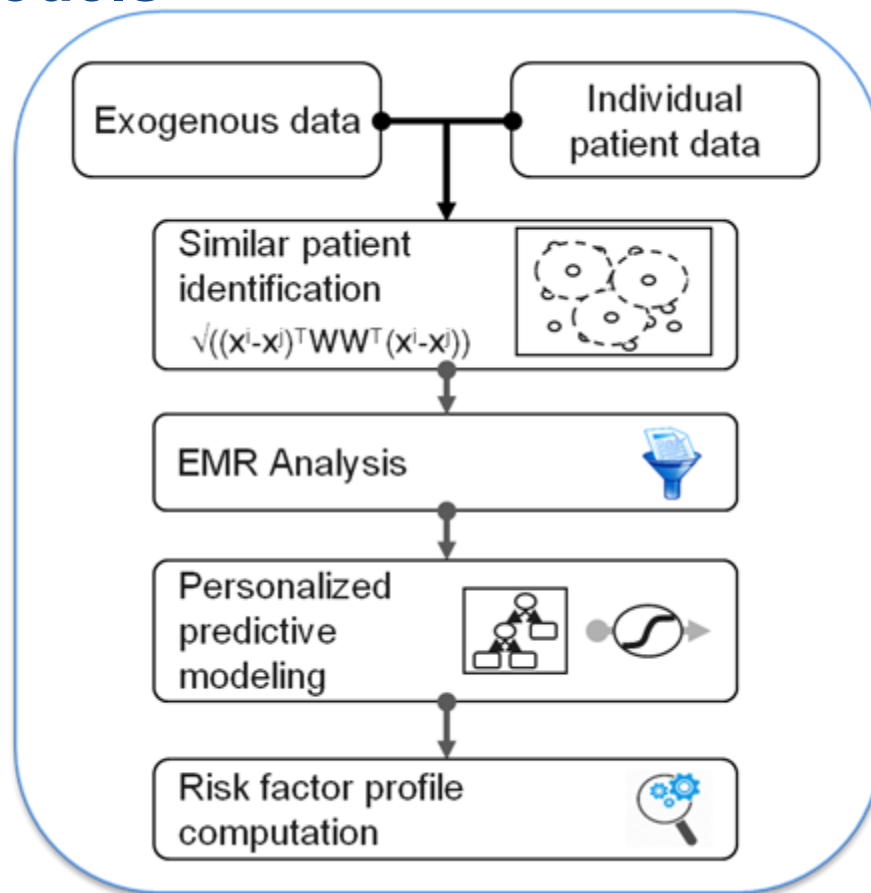
Potential to:

Predict

Personalize

Prevent

Promote



Humans + Cognitive = “AI” or Augmented Intelligence

People excel at:



Common sense



Dilemmas



Morals



Compassion



Imagination



Dreaming



Abstraction



Generalization

Cognitive systems excel at:



Natural Language



Pattern Identification



Locating Knowledge



Machine Learning



Eliminate
Bias

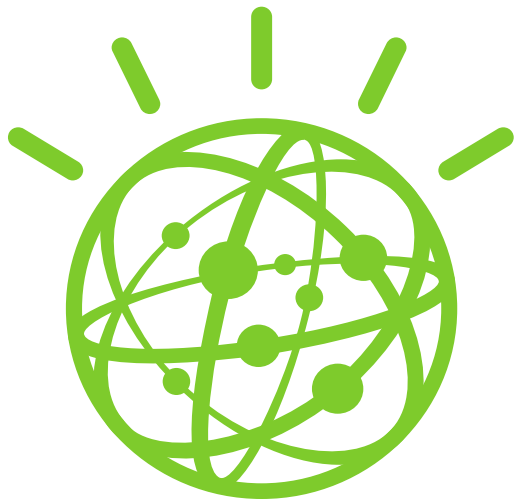


Endless
Capacity



This is one of Laennec's original
stethoscopes, and it was presented by him
to Dr Bègin a French Army Surgeon,
whose widow gave it to me in
1863.

Let's Work Together



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