

Clinical Decision Support: DeepQA



IBM WATSON



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Watson was built for *Jeopardy!*, but can be enhanced and paired with other solutions for future applications

Today

Watson's current capabilities were constrained for *Jeopardy!* requirements...

- English only
- A single questioner per system instance
- 3-second response time
- Static content
- Unstructured text
- Requires training data – history of questions and answers

Future

...but future Watson enhancements are possible with further development...

- Multiple, varied users
- More dynamic content updates
- More/varied training data
- Varied response times
- Additional languages

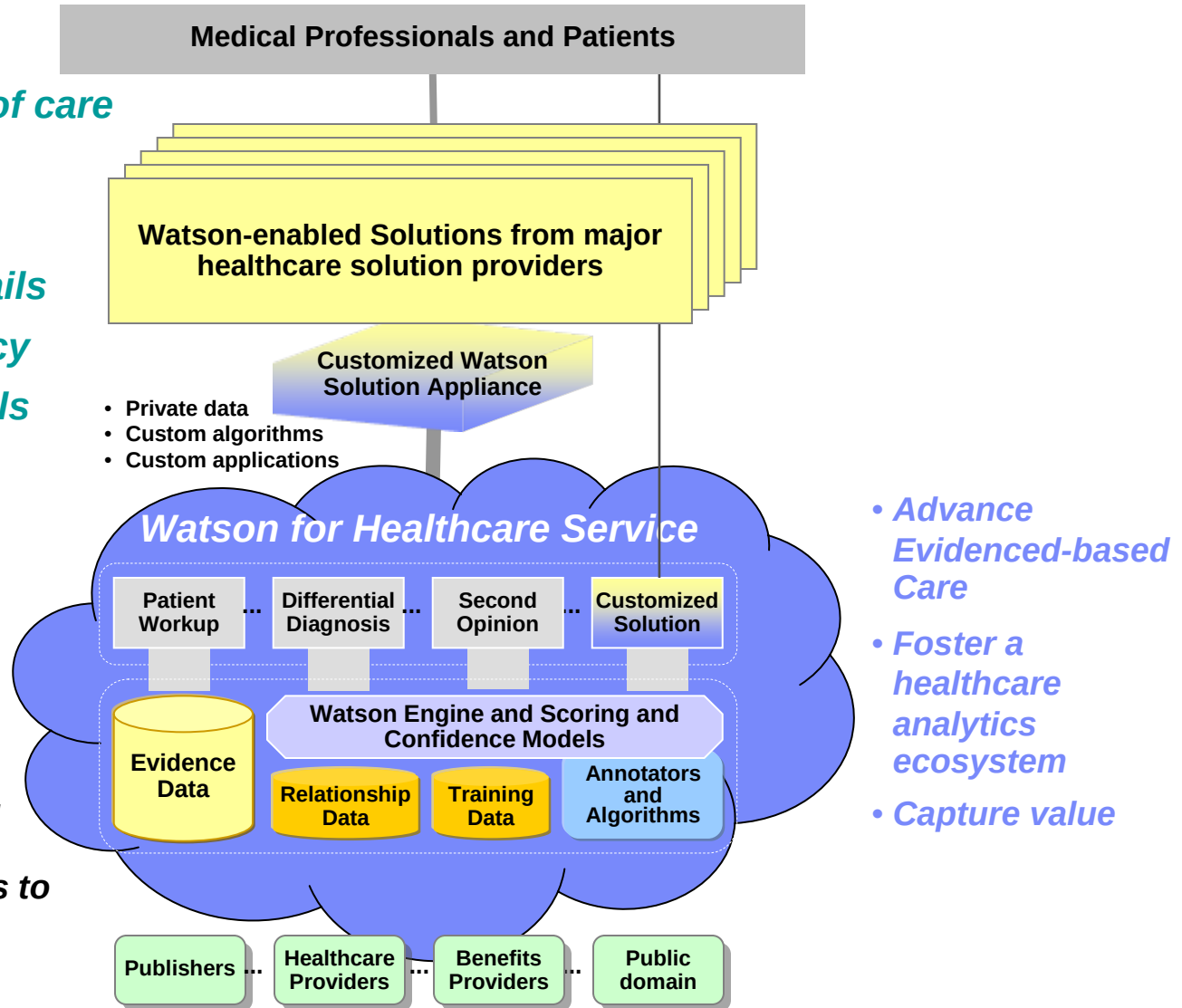
...and other solutions could ultimately compliment Watson capabilities

- Large amounts of structured data
 - Cognos, InfoSphere
- Predictive / statistical capabilities
 - SPSS
- Social media analysis
 - COBRA, Banter

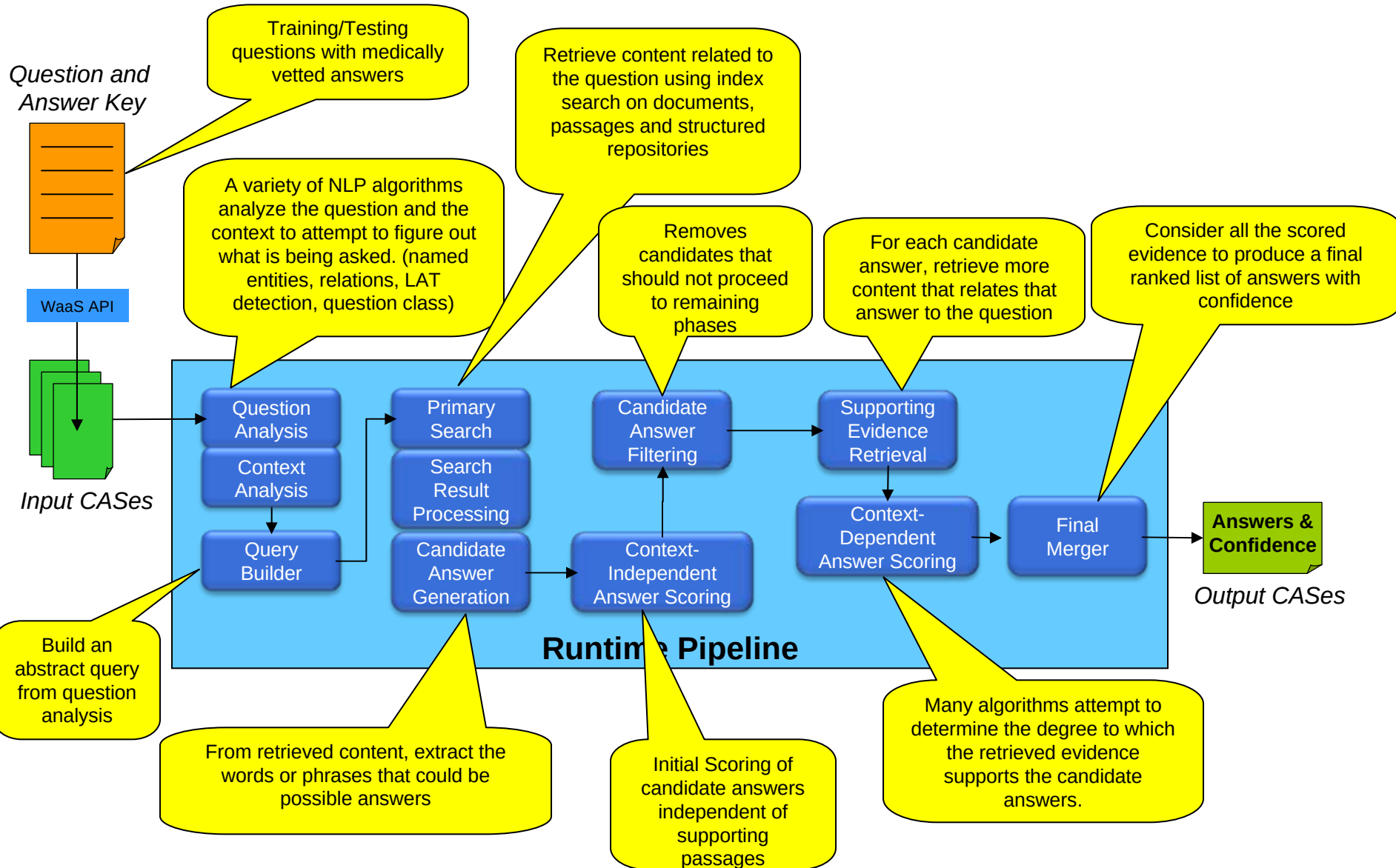
Watson for Healthcare

- *Improve quality of care*
- *Reduce errors*
- *Engage patients*
- *Improve audit trails*
- *Improve efficiency*
- *Better utilize skills*

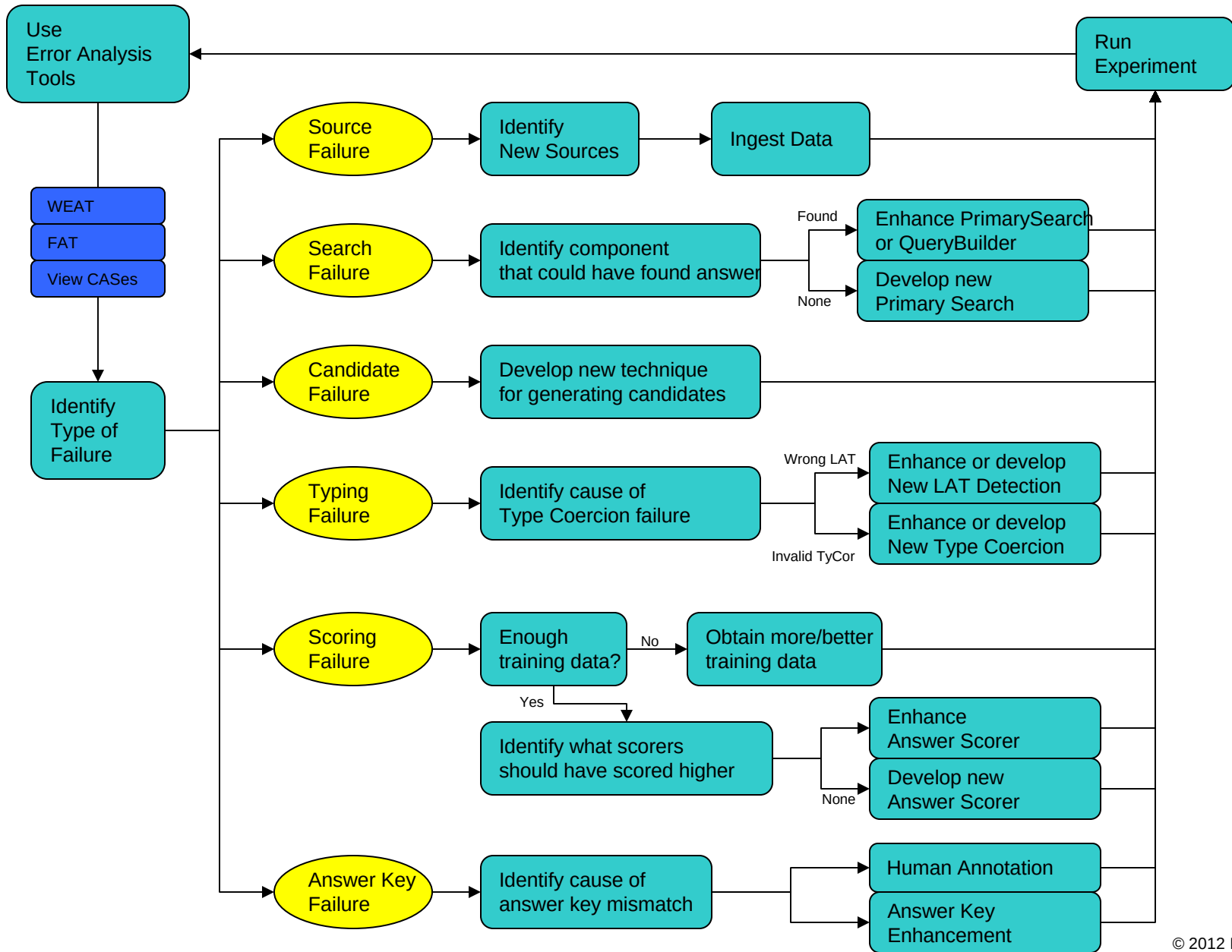
- *Right content, right time*
- *Best-practices to point of care*
- *Capture value*



Watson: How It Works

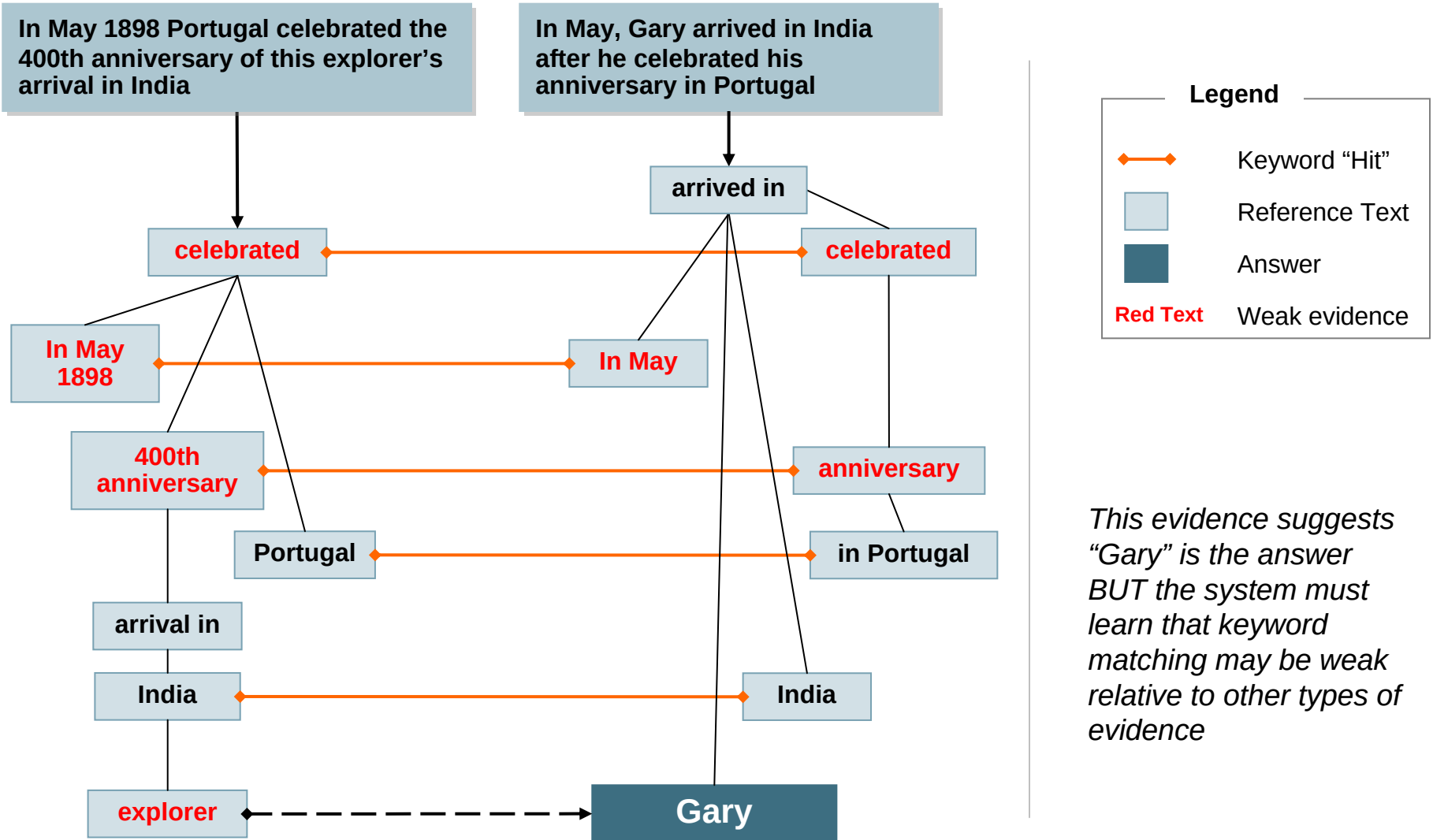


Watson Error Analysis Process



Why is Jeopardy! so difficult?

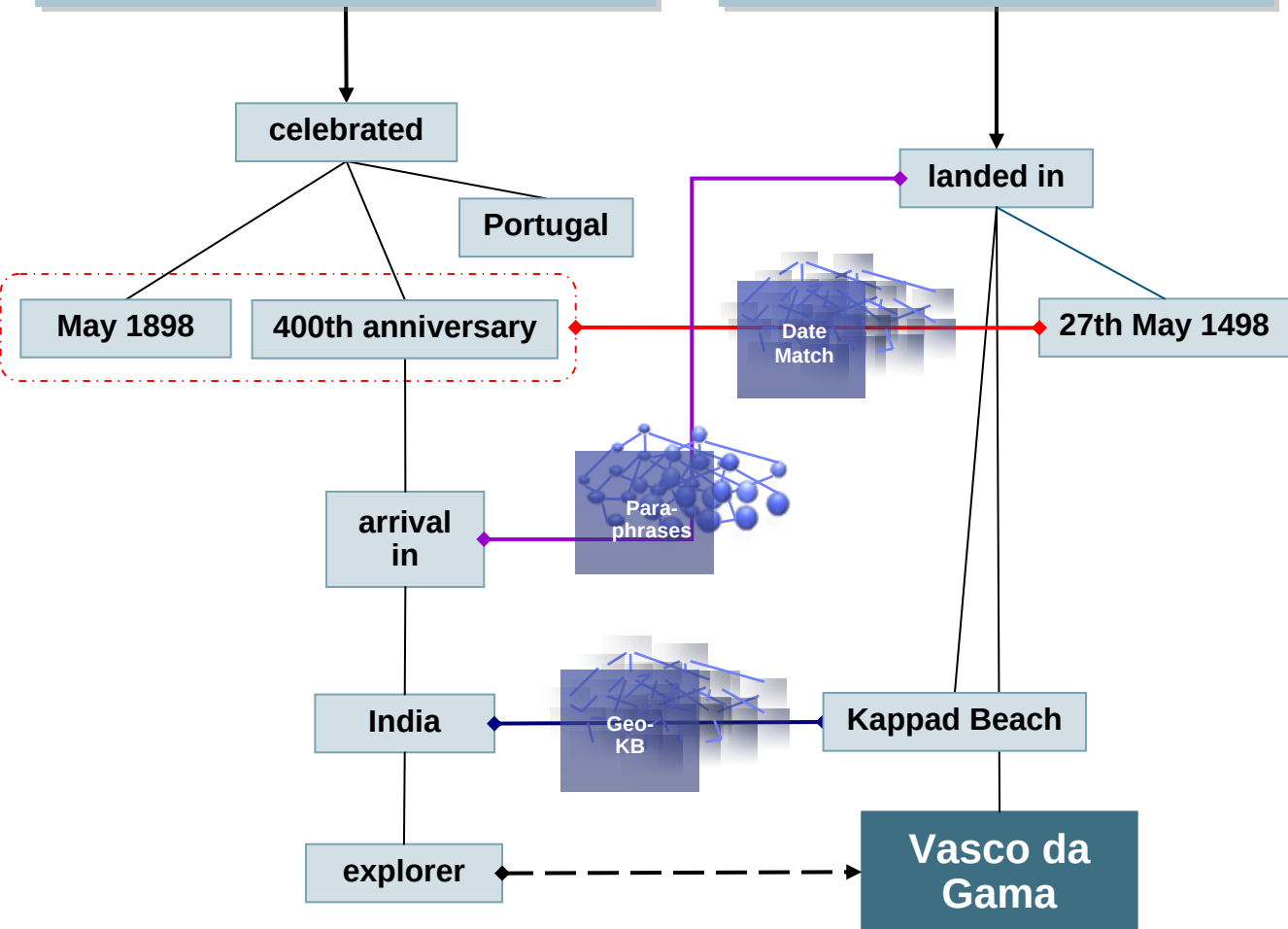
Answering complex natural language questions requires more than keyword evidence



Watson leverages multiple algorithms to gather deeper evidence

In May 1898 Portugal celebrated the 400th anniversary of this explorer's arrival in India.

On the 27th of May 1498, Vasco da Gama landed in Kappad Beach



Legend

- Temporal Reasoning
- Statistical Paraphrasing
- GeoSpatial Reasoning
- Reference Text
- Answer

Stronger evidence can be much harder to find and score...

- Search far and wide
- Explore many hypotheses
- Find judge evidence
- Many inference algorithms

...and the evidence is still not 100% certain

Evidence must be Evaluated for Different Forms

▪ Temporal Reasoning

- Developed for Jeopardy! Has application in Healthcare as sequence or timing of symptoms may be relevant

▪ Geospatial Reasoning

- Earth geography algorithms can be reworked for human body
(the Pain started in my fingertips and progressed up my left arm)

▪ Statistical Paraphrasing

- New Algorithms required to, for example, Map between medical terminology and lay terms.

TEMPORAL REASONING EXAMPLE

Typical influenza in adults is characterized by **sudden onset** of chills, fever, prostration, cough, and generalized aches and pains (especially in the back and legs). Headache is prominent, often with photophobia and retrobulbar aching. Respiratory **symptoms may be mild at first**, with scratchy sore throat, substernal burning, nonproductive cough, and **sometimes coryza**.

Later, lower respiratory tract illness **becomes dominant**; cough can be **persistent**, raspy, and productive. GI symptoms **may occur** and appear to be more common with the 2009 pandemic H1N1 strain. Children may have prominent nausea, vomiting, or abdominal pain, and infants may present with a sepsis-like syndrome.

After 2 to 3 days, acute symptoms rapidly **subside**, although fever may last up to 5 days. Cough, weakness, sweating, and fatigue may persist for **several days** or **occasionally for weeks**.

Why is Watson Technology ideal for Healthcare?

Interprets and understands natural language questions

Understands ambiguous and sophisticated natural language

What condition has red eye, pain, inflammation, blurred vision, floating spots and sensitivity to light?

Analyzes large volumes of unstructured data

Synthesizes broad domain knowledge from a variety of selected public

Physician Notes, Medical Journals, Pathology results, Clinical Trials, Wikipedia, etc/

Quantifies degrees of confidence in potential answers

Generates hypotheses and ranks them in a range of potential answers

Uveitis		91%
Iritis		48%
Keratitis		29%

Supports iterative dialogue to refine results

Internal iterative and interactive dialogue to refine and improve results

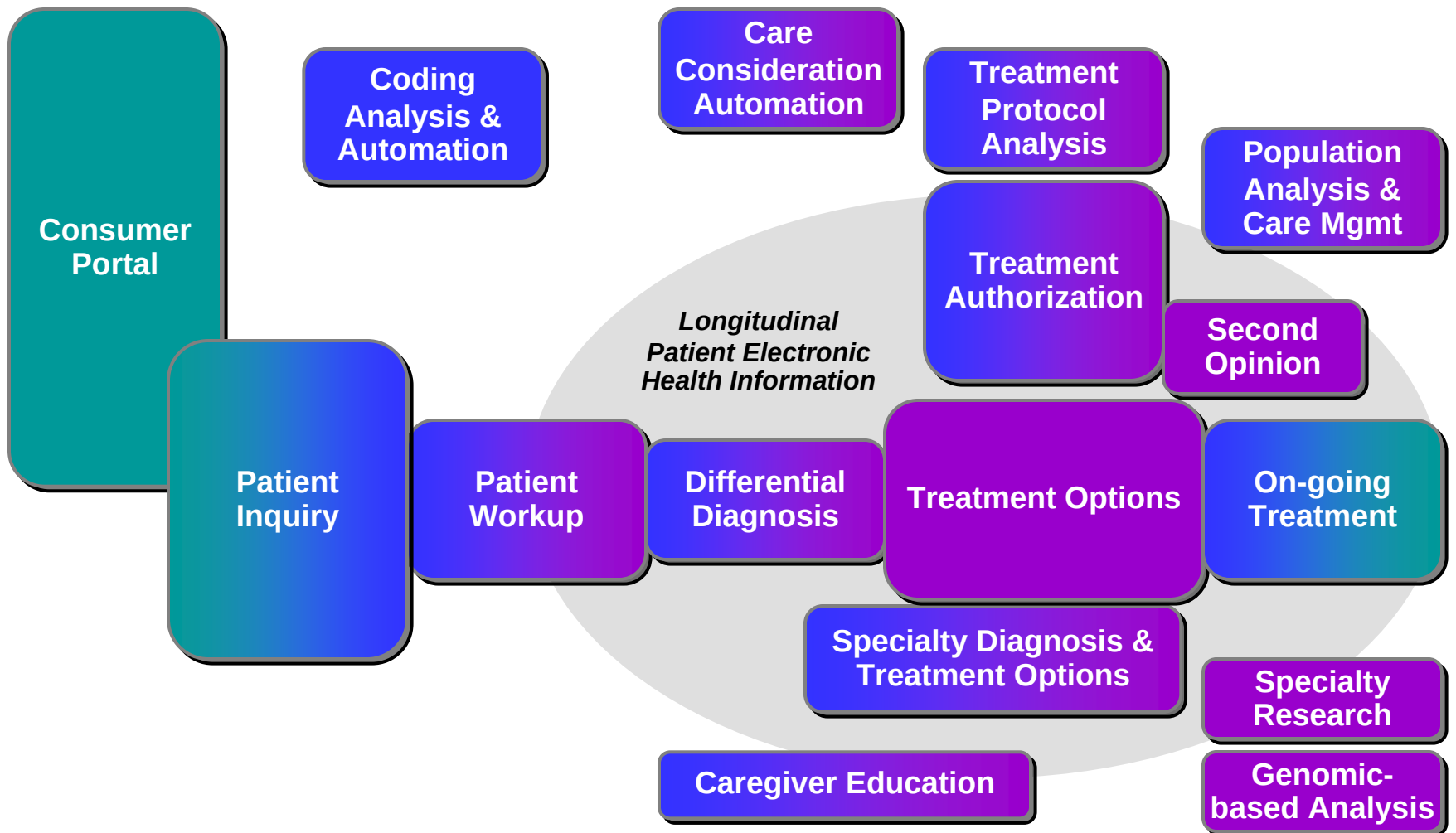
Family History, Physical Exam, Current Medications, etc.

Adapts and learns to improve results over time

Learns from additional evidence and mistakes to improve results

New Clinical Recommendations. New Drugs. Approved use of Drugs, etc.

A Range of Watson-enabled Healthcare Solutions



Patient

Caregiver...Nurse...Physician Assistant

Clinician

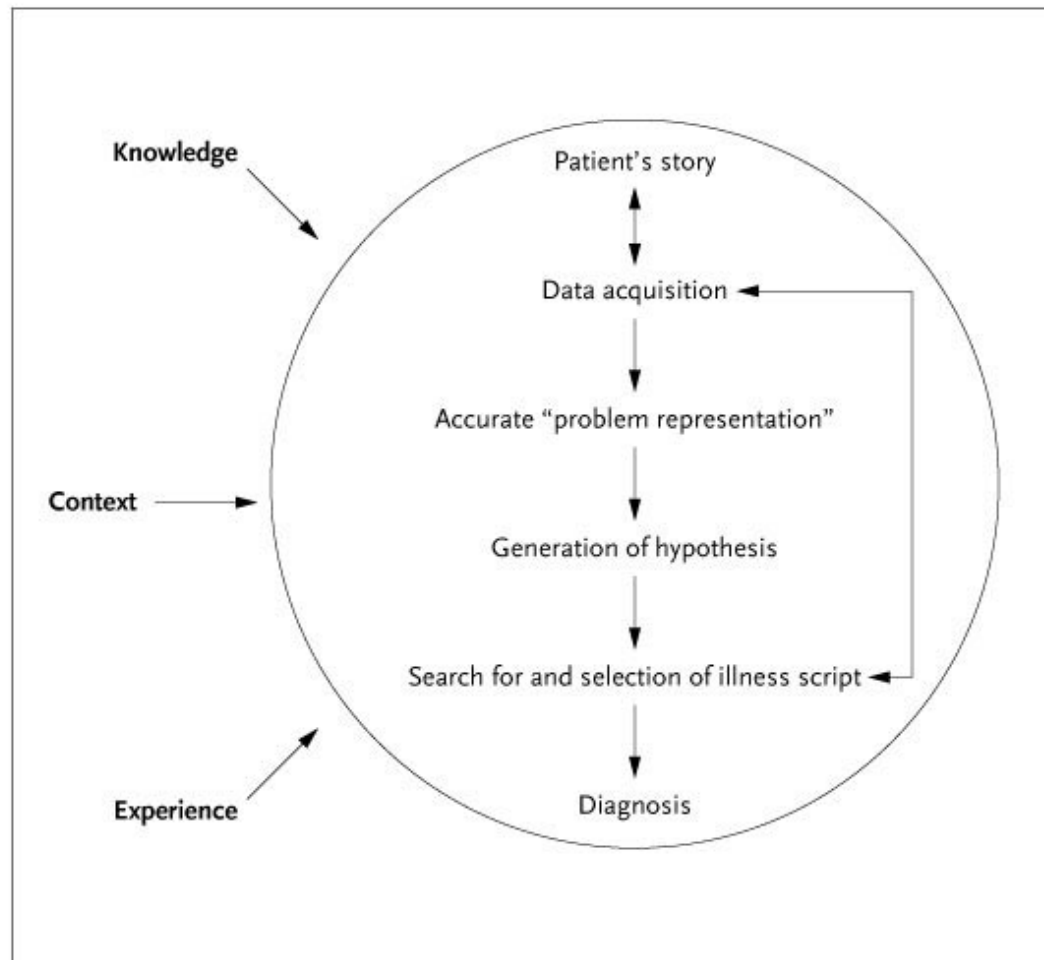
THE WALL STREET JOURNAL.

HEALTH INDUSTRY

SEPTEMBER 12, 2011

WellPoint's New Hire. What Is Watson?

Key Elements of the Clinical Diagnostic Reasoning Process



Bowen J. N Engl J Med 2006;355:2217-2225

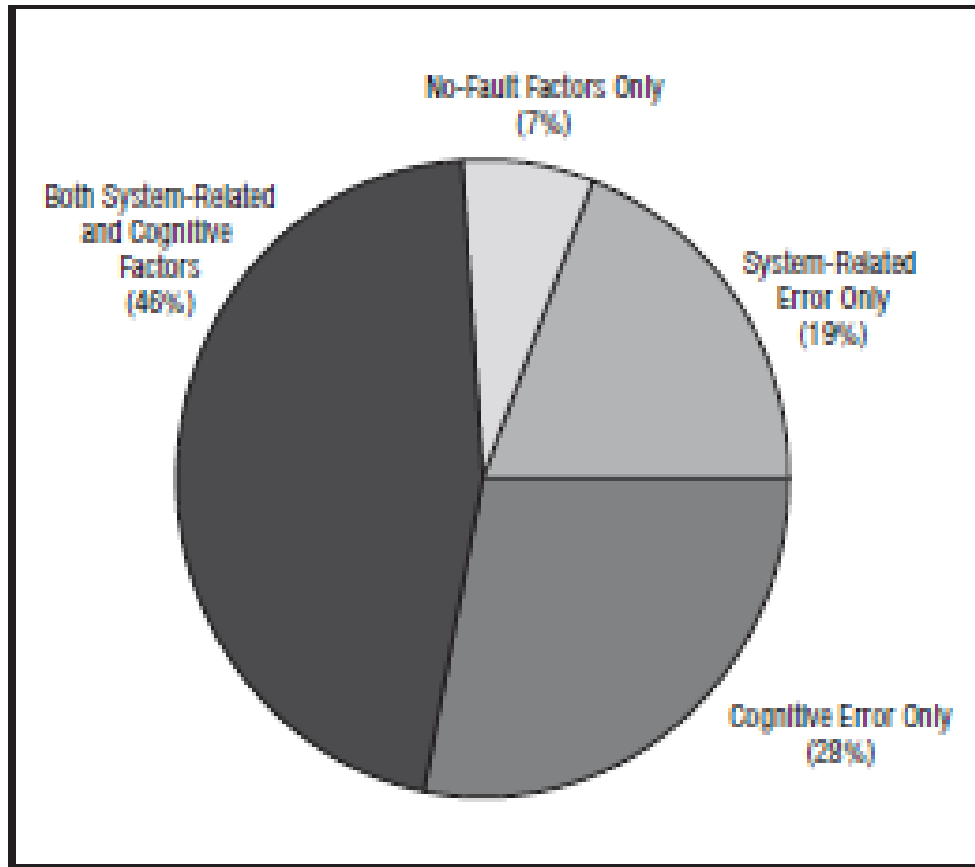


Figure. The categories of factors contributing to diagnostic error in 100 patients.

Graber, et al. Diagnostic Error in Internal Medicine, Arch Int Med 2005; 165:1493-1499

Role of Electronic Systems in Improving Diagnosis

- **Filtering, organizing, and providing access to information ... thoroughness in gathering the patient's history, findings from the physical examination, and other data. ... The problem of having too much information is now surpassing that of having too little, and it will become increasingly difficult to review all the patient information that is electronically available.**
- **Serving as a place where clinicians, together with patients, document succinct evaluations, craft thoughtful differential diagnoses, and note unanswered questions. Free-text narrative will often be superior to point-and-click boilerplate ...**

Role of Electronic Systems in Improving Diagnosis

- A better approach to managing problem lists is needed. The failure to effectively integrate the creation, updating, reorganization, and inactivation of items on problem lists into the clinician's workflow has been one of the great failures of clinical informatics. ...allowing specific providers (for instance, specialists or nonphysician staff members) to work selectively with a subset of problems are necessary features ...
- Electronic systems should incorporate checklist prompts to make sure that key questions are asked and relevant diagnoses considered. ... diagnostic checklists have so far been neither clinically helpful nor widely used. Yet, human memory alone cannot guarantee that key questions will be asked and important diagnoses considered and accurately weighed. Decision-support software and predictive models have also had limited use to date, but both could become important if their design were more practical and evidence-based — if, for example, they automatically generated differential diagnoses that facilitated both documentation and decision making.

Leveraging Electronic Clinical Documentation to Decrease Diagnostic Error Rates

Role for Electronic Documentation

- Providing access to information
- Recording and sharing assessments
- Providing prompts
- Providing access to information sources

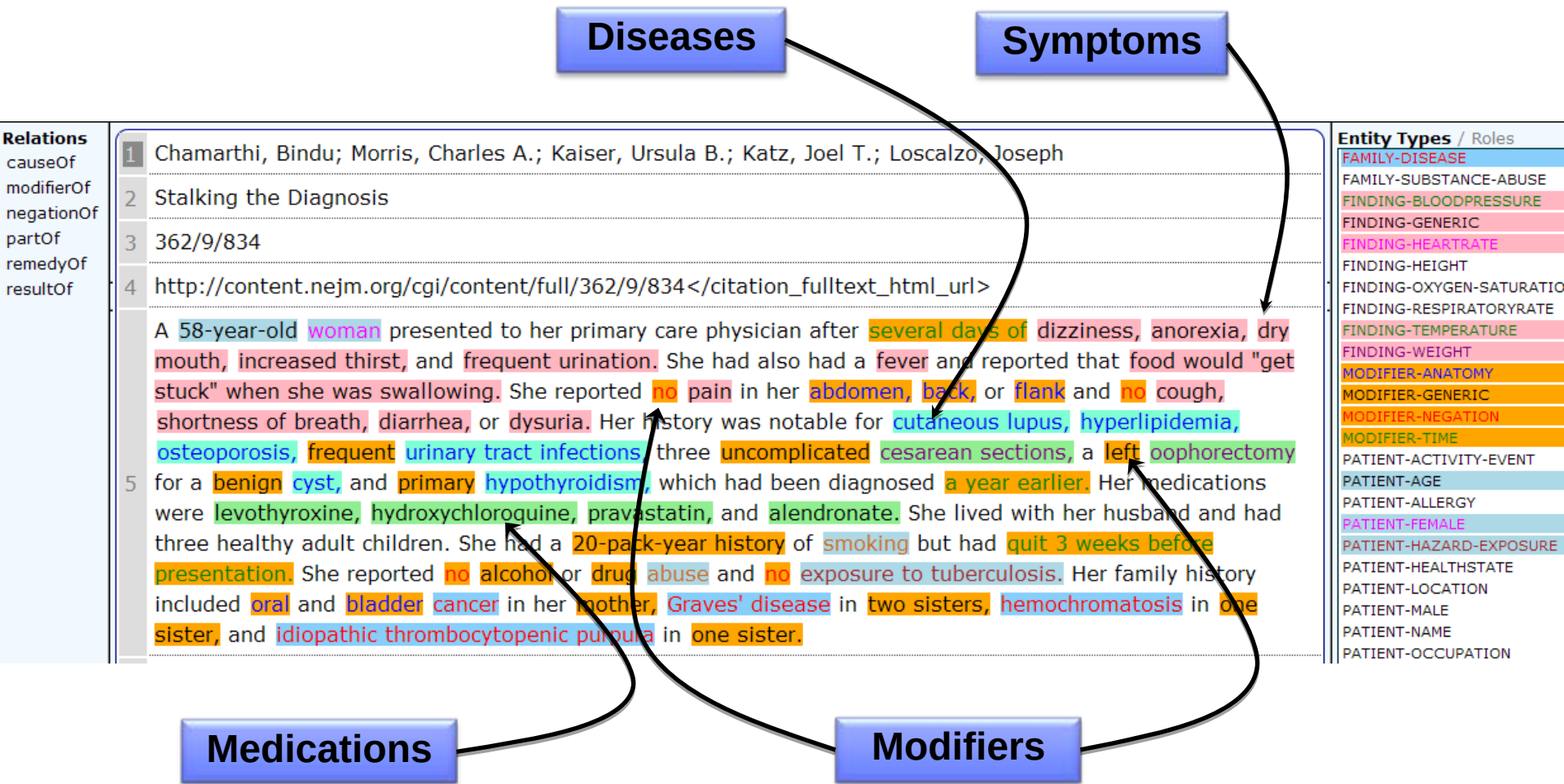
Goals and Features of Redesigned Systems

- Ensure ease, speed, and selectivity of information searches; aid cognition through aggregation, trending, contextual relevance, and minimizing of superfluous data
- Provide a space for recording thoughtful, succinct assessments, differential diagnoses, contingencies, and unanswered questions
- Provide checklists to minimize reliance on memory and directed questioning to aid in diagnostic thoroughness and problem solving
- Provide instant access to knowledge resources through context-specific “infobuttons” triggered by keywords in notes that link user to relevant textbooks and guidelines

Can Electronic Clinical Documentation Help Prevent Diagnostic Errors?

Gordon D. Schiff, M.D., and David W. Bates, M.D. N Engl J Med 2010; 362:1066-1069

NEJM Medical Concept Annotations



Matching Symptoms May Require Discovering Causal Chains

Observables: Patient Symptoms

Not directly explained by UTI

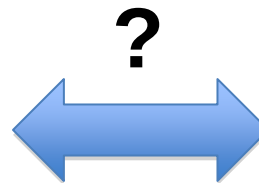
- Dysphagia (diff. swallowing)
- Xerostomia (dry mouth)
- Thirst
- Dizziness

(Others explained by UTI)

Hypothesis: UTI

UTI directly explains

- ...
- Fever
- Anorexia
- Frequent urination
- ...



To gain confidence in UTI as the diagnosis, we have to see if it is possible to match what UTI does explain to what is observed but not directly explained.

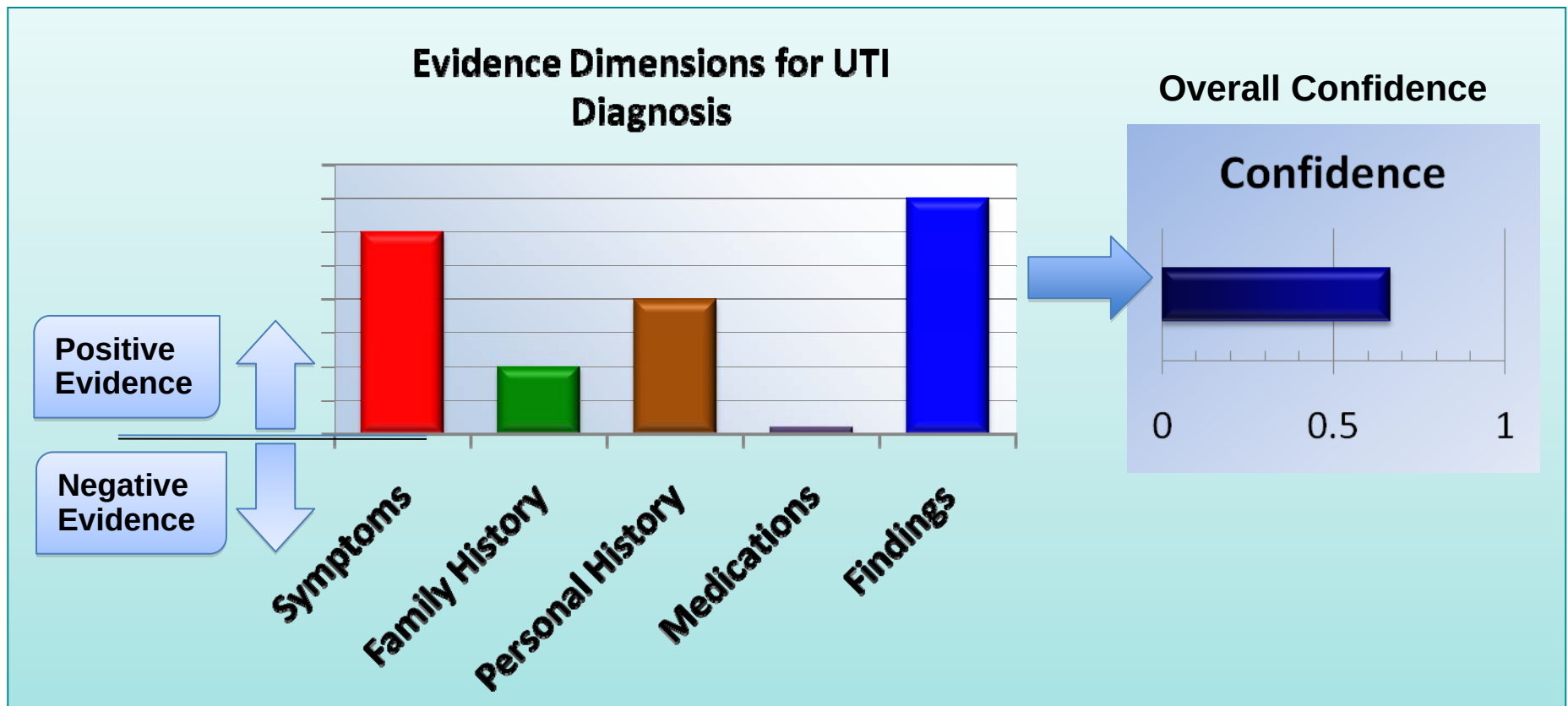
Are there “causal” or logical entailments that can be mined from text and knowledge bases that give some evidence that, for example,

fever can explain thirst and dry mouth?

difficulty swallowing can explain dry mouth?

DeepQA Collects and Combines Evidence in Evidence Profiles

- Each dimension contributes based on
 - Strength of evidence
 - Importance of dimension for diagnosis (learned from training data)
- Evidence dimensions are combined to produce an overall confidence



Bringing it Together ...

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**, **hydroxychloroquine**, **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 felt better when lying down. Her **supine blood pressure was 120/80 mm Hg**, and **her pulse was 88 beats per minute**; on standing, her **systolic blood pressure was 84 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 *Escherichiacoli***, which is sensitive to ciprofloxacin.

Symptoms

- difficulty swallowing
- fever
- dry mouth
- thirst
- anorexia
- frequent urination
- dizziness
- no abdominal pain
- no back pain
- no cough
- no diarrhea

Family History

- Oral cancer
- Bladder cancer
- Hemochromatosis
- Purpura
- Graves' Disease (Thyroid Autoimmune)

Patient History

- cutaneous lupus
- osteoporosis
- hyperlipidemia
- frequent UTI
- hypothyroidism

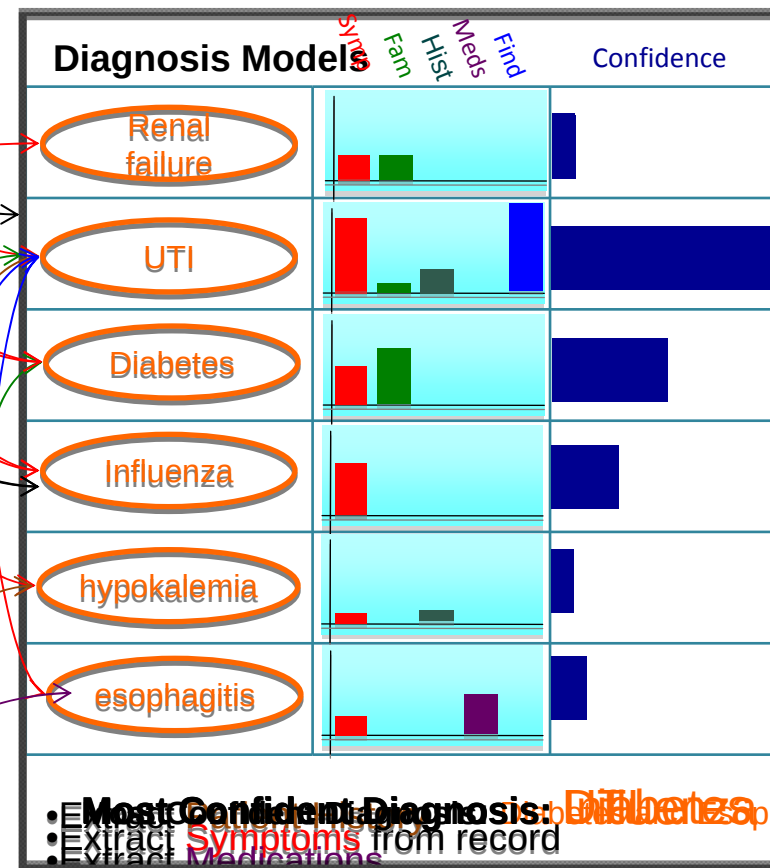
Medications

- alendronate
- pravastatin
- levothyroxine
- hydroxychloroquine

Findings

- urine dipstick: leukocyte esterase
- supine 120/80 mm HG
- heartrate: 88 bpm
- urine culture: E. Coli

Pervasive Probabilistic Framework



- Use database of drug side-effects
 - Together, multiple diagnoses may best explain symptoms
 - Extract **Findings**: Confirms that UTI was present
- present in each analysis based on evidence so far

Watson's Reasoning

- **“Shallower” reasoning over large volumes of data and presenting alternatives to clinicians for the final decisions**
- **Casts a wide net**
 - Considers a large amount of data
 - EMR
 - Literature
 - Unbiased
 - Learns
- **Not limited by a database structure**
- **Watson defers judgment until it has considered many possibilities**

Watson's Reasoning

- **Hits sweet spot of human judgment**
 - Problems with bias
 - Difficulty processing large arrays of evidence knows what additional case input information could have improved the confidence in the output analysis
- **Health Care is inherently "uncertain." Watson does not make a diagnosis. It provides evidence-based information to help the clinician make an informed decision.**
- **Identifies missing information**
- **Watson's interactive process helps clinician vector in on the appropriate decisions**

The words "Thank You" are rendered in a large, bold, 3D sans-serif font. The letters are a metallic silver color with a slight gradient and a soft shadow beneath them. Below the text, a faint, semi-transparent reflection of the letters is visible on the surface they appear to be standing on.

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