

# SOA Enabled eQuality Solutions: Enabling Safe and Effective Medical Practice while Decreasing Costs

Peter L. Elkin, MD, FACP, FACMI

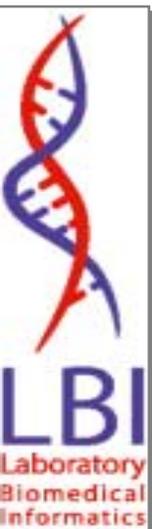
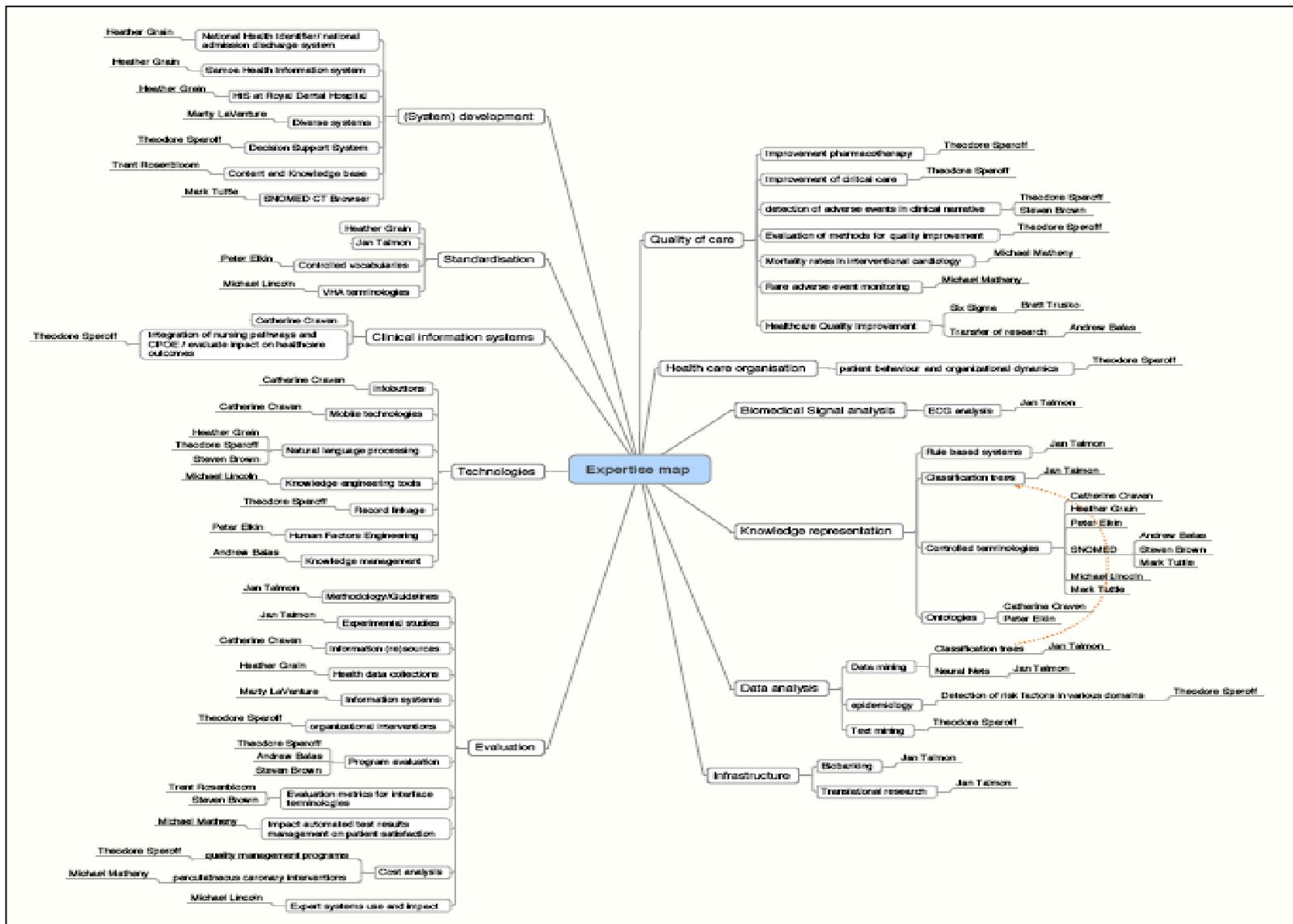
Professor of Medicine

Mayo Clinic College of Medicine

Biomedical Informatics Research Collaborative



## The Qualifications of the Laboratory: Biomedical Informatics Research Collaborative



# Our Investment in Healthcare Quality

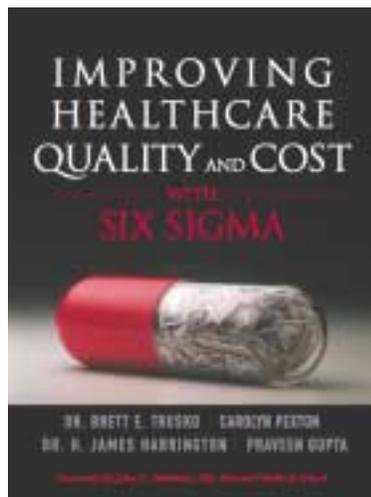
## Government Health IT

1) **The ultimate health care record** -  
(Sep 10 2007)

Mayo Clinic researchers are working on ways to make electronic health care records more intelligent. But can they get too smart for everyday providers?

2) **Editor's Letter: To the edge and back** -  
(Sep 10 2007)

The United States is no doubt one of the most innovative countries in its use of health IT.



### ORIGINAL ARTICLE

#### eQuality: Electronic Quality Assessment From Narrative Clinical Reports

STEVEN H. BROWN, MS, MD; THEODORE SPEROFF, PhD; ELLIOT M. FIELSTEIN, PhD; BRENT A. BAUER, MD; DIETLIND L. WAHNER-ROEDLER, MD; ROBERT GREEVY, PhD; AND PETER L. ELKIN, MD

**OBJECTIVE:** To evaluate an electronic quality (eQuality) assessment tool for dictated disability examination records.

**METHODS:** We applied automated concept-based indexing techniques to automated quality screening of Department of Veterans Affairs spine disability examinations that had previously undergone gold standard quality review by human experts using established quality indicators. We developed automated quality screening rules and refined them iteratively on a training set of disability examination reports. We applied the resulting rules to a novel test set of spine disability examination reports. The initial data set was composed of all electronically available examination reports (N=325,576) finalized by the Veterans Health Administration between July and September 2001.

**RESULTS:** Sensitivity was 91% for the training set and 87% for the test set (P=.02). Specificity was 74% for the training set and 71% for the test set (P=.44). Human performance ranged from 4% to 6% higher (P<.001) than the eQuality tool in sensitivity and 13% to 18% higher in specificity (P<.001). In addition, the eQuality tool was equivalent or higher in sensitivity for 5 of 9 individual quality indicators.

**CONCLUSION:** The results demonstrate that a properly authored computer-based expert systems approach can perform quality measurement as well as human reviewers for many quality indicators. Although automation will likely always rely on expert guidance to be accurate and meaningful, eQuality is an important new method to assist clinicians in their efforts to practice safe and effective medicine.

Mayo Clin Proc. 2006;81(11):1472-1481

a single medical record needs to be reviewed in the care of an individual patient, sentences and paragraphs of prose are resources not obstacles. However, when hundreds or thousands of medical records must be reviewed in search of specific facts (eg, for research, population-based care, or quality improvement), manual data abstraction from volumes of free text becomes a time-consuming chore. The costs of manual data abstraction include reviewer time, record logistics (eg, availability, handling, and storage), data identification errors, data transcription errors, data representation errors, sample size reductions, and study design impacts. Electronic health record systems that store free text begin to address the logistical problems but otherwise do little to make data available in a computer-usable form.

Three basic methods exist to automatically extract computer-usable information from free text. String matching (keyword searching) is a simple, often effective, approach to detect various medical terms.<sup>6,6</sup> For example, simple keyword searches have used trigger words, such as *complication*, *mental status*, or *rank*, to identify adverse events with moderate success.<sup>10</sup> However, string matching does not identify synonyms or closely related terms. For example, *myocardial infarction* and *heart attack* are syn-

## Case Study

- Bill Kneivel is a 49 w male on vacation with his family in Florida. Driving conditions are wet and slippery and after being cut off his car impacts an embankment. Unconscious he is taken to FGH ED. He routinely gets his care at St. Elsewhere in Boston MA. Records are requested by FGH and text records are sent which show Mr. K to have a PMHx of hypertension and Type II DM. He is currently taking Lisinopril, HCTZ, Metformin, and ASA.

## Case Study

- In ED he is found to have an MI with a Troponin-T of 0.42, his CBC was wnl, he had a creatinine of 2.7, normal electrolytes and a glucose of 187, Beta-Hydroxybuterate was not elevated, and his Bicarb was 24. He was found to have ketones in his urine.

## Case Study: As Is Model

- Mr. K is continued on his present medication. A beta-blocker is started. However, two days later his serum  $K^+$  was 7.2 and pts Bicarbonate was 14. Mr. Kneivel's rhythm degenerates into ventricular tachycardia, followed by a cardiac arrest and in spite of an aggressive resuscitation attempt he passes away.

## Case Study: To be Model

- Data from St. Elsewhere was transmitted to FGH in a standards-based codified interoperable format. The Dr. Overworked (admitting physician) uses an order entry system that provides decision support and incorporates into its logic engine the data transferred from St. Elsewhere. The system alerts the admitting physician that “*with a creatinine of 2.7 (>2.0) the metformin should be discontinued due to the risk of a serious metabolic acidosis.*” Dr. O d/cs the Metformin and orders a SS Insulin regimen.

## Case Study: To be Model

- Two days later Mr. K's  $K^+$  is 4.7 and his bicarbonate is 24, his creatinine is 1.7 and trending toward his baseline of 1.3. On the fourth hospital day he is discharged in good condition and his family decides to plan a repeat trip to Disney World next year when dad feels a little better.
- For Mr. K, Informatics standards and FGH's clinical decision support system made an immeasurable difference for him and his family.

## Case Study: To be Model

- Michael, Mr K's son, is inconsolable. His pediatric records from St. Elsewhere shows that he is considered healthy, but due to his behavior and separation from his parents, he is visited by child psychiatry. It is determined that Michael is suffering from an acute stress reaction and they wish to prescribe a selective serotonin reuptake inhibitor, namely escitalopram (Lexapro). However, Michael's St. Elsewhere records show his DNA sequence data to have a polymorphism associated with nonfunctioning CYP3A4 enzyme indicating that Michael would likely be a poor metabolizer of escitalopram. Therefore, he is placed on sertraline (Zoloft) which is metabolized by the p450 CYP2D6 and CYP2C19 pathways where he is known to have a \*1/\*1 phenotype. This medication decision avoids subjecting Michael to potentially serious medication side-effects that may have occurred through inadvertent overdosing of escitalopram.

## AHIC – Quality Use Case

The Institute of Medicine defines Quality as “the degree to which health services for individuals and populations increase the likelihood of desired outcomes and are consistent with current professional knowledge.”

## AHIC – Quality Use Case

- 1) Provide the data needed for the development of quality measures,
- 2) Automate the measurement, feedback and reporting of a comprehensive and future set of quality measures,
- 3) Accelerate the use of clinical decision support to improve performance on these quality measures, and
- 4) How performance measures should align with the capabilities and limitations for HIT.

## Healthcare Value

- **Value = Quality / Cost**
- **Quality** is composed of:
  - Outcomes
  - Safety
  - Service
  - Reliability
- **Only what gets measured can be effectively managed!!!**



# Measuring Strategic Performance

***“You can’t manage what you can’t measure. You can’t measure what you can’t describe”***

***Robert Kaplan and David Norton***  
**Authors of “The Balanced Scorecard”**

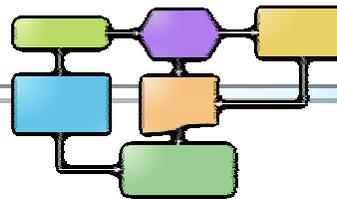


# Business Process Excellence

A Framework that **aligns the entire organization** to what is **important to the customer**, allowing the organization to **excel at the critical activities** and **reduce time spent** on the **things that don't matter**



People



Process



Technology

## Transformation to iEHRs

Depends on “whether the systems installed are designed to produce the information required to make possible the quality and cost reforms that are sought.” by the Federal Government and by Healthcare Practitioners and Healthcare Organizations

Information Technology Comes to Medicine;

Blumenthal D, Glaser JP, N Eng J Med 356;24 June 14, 2007

## Barriers to iEHR Adoption

- Disruptions to the Practice of Medicine
- Change in Practice Style
- Cost of Systems Purchase and Implementation
- Payment for Clinician's time spent on Web-based Consultation
- Lack of Interoperability
- Lack of Decision Support

Information Technology Comes to Medicine;

Blumenthal D, Glaser JP, N Eng J Med 356;24 June 14, 2007

## Minimally Invasive Informatics (MII)

- Minimize the need for Change in the Practice
- Maximize the ROI for Investing in HIT
  - Providing eQuality Monitoring
  - Clinical Decision Support Systems
  - Multiple pathways for clinical communication
  - Ubiquitous and Interoperable Availability of Clinical Records for Care Purposes
  - Knowledge based Care Delivery Empowered by Informatics (e.g. Care Coordination and Continuous Learning Environments)

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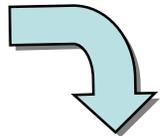
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Apr 17, 2006 ... Microsoft **service oriented architecture (SOA) in healthcare**: Enabling effective care at lower cost.  
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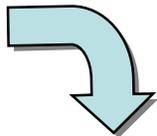
**SERVICE ORIENTED ARCHITECTURE (SOA) HEALTHCARE EXECUTIVE BRIEF**

# iEHR Overall Goal

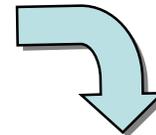
Data



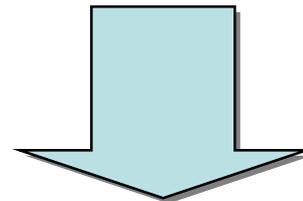
Information



Knowledge



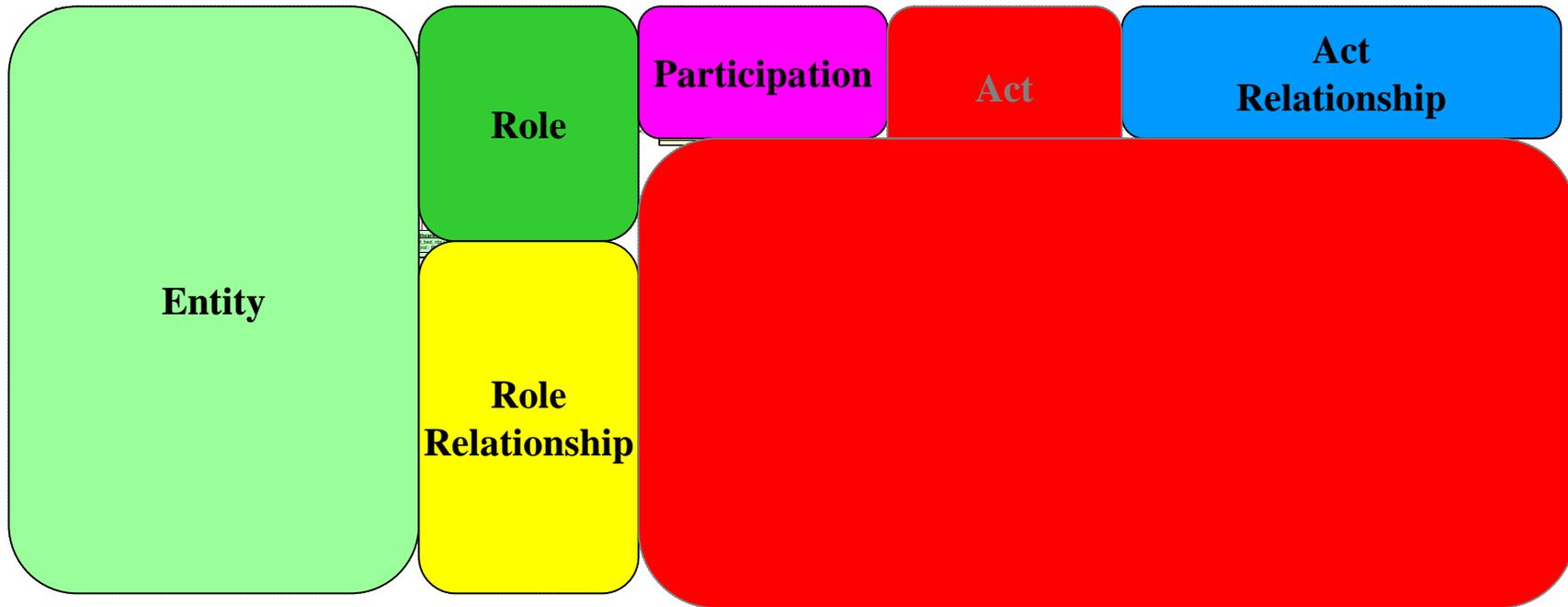
**INTELLIGENCE**

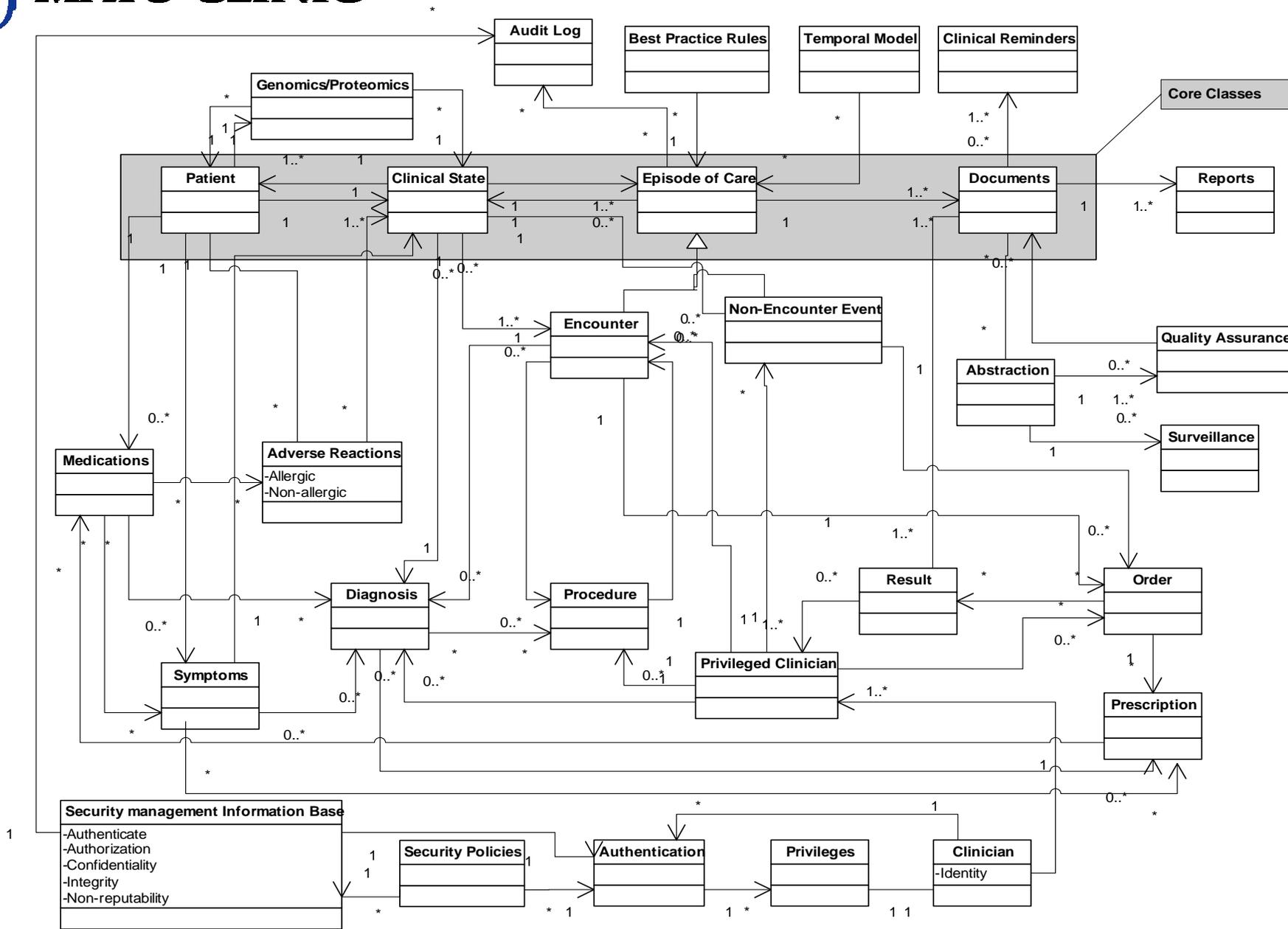


**Clinical Outcomes**

# Level One Ontology

HEALTH LEVEL 7  
REFERENCE INFORMATION MODEL  
RIM\_0100





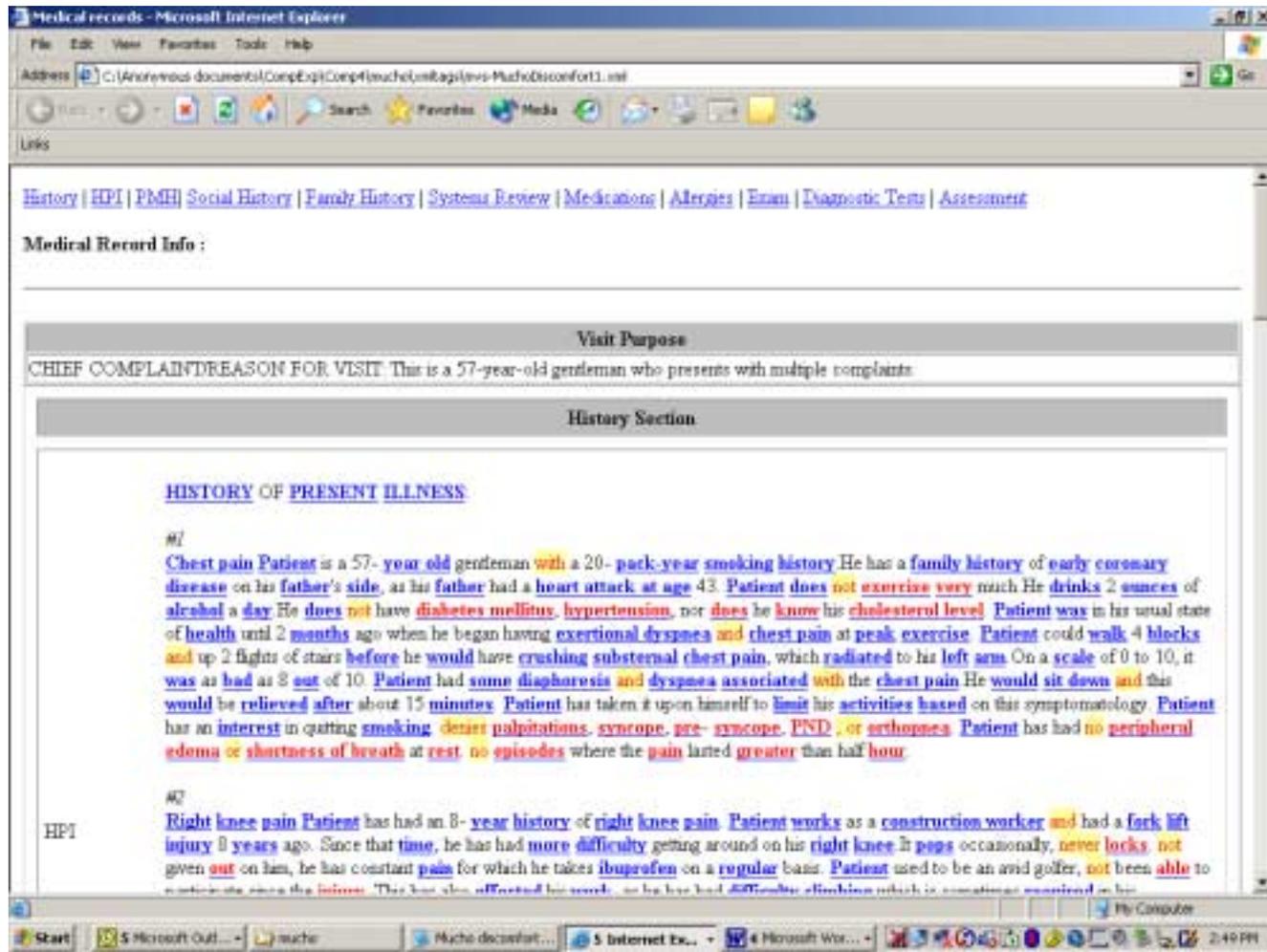
# Level Two Ontology

# Level Three Ontology

- Fully Encoded Health Record
- Consistent with the Level One and Two Ontologies for Health
- Compositional Expressions are assigned Automagically
- Information is gathered through the usual documentation of patient care.
- Example.....



# Parsed



Medical records - Microsoft Internet Explorer

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Links

[History](#) | [HPI](#) | [PMH](#) | [Social History](#) | [Family History](#) | [Systems Review](#) | [Medications](#) | [Allergies](#) | [Exam](#) | [Diagnostic Tests](#) | [Assessment](#)

Medical Record Info :

Visit Purpose

CHIEF COMPLAINT/REASON FOR VISIT: This is a 57-year-old gentleman who presents with multiple complaints.

History Section

HISTORY OF PRESENT ILLNESS

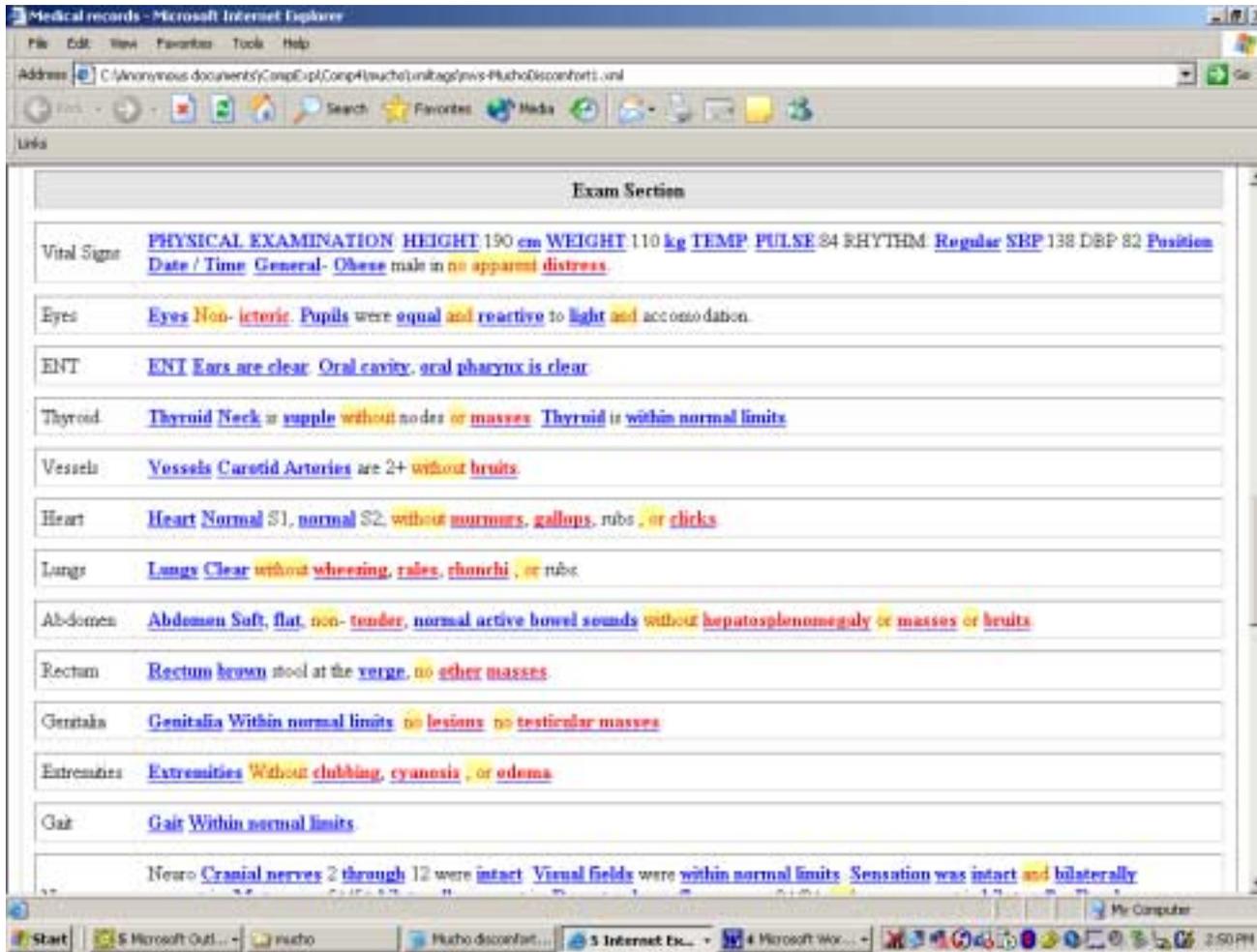
#1  
Chest pain Patient is a 57- year old gentleman with a 20- pack-year smoking history. He has a family history of early coronary disease on his father's side, as his father had a heart attack at age 43. Patient does not exercise very much. He drinks 2 ounces of alcohol a day. He does not have diabetes mellitus, hypertension, nor does he know his cholesterol level. Patient was in his usual state of health until 2 months ago when he began having exertional dyspnea and chest pain at peak exercise. Patient could walk 4 blocks and up 2 flights of stairs before he would have crushing substernal chest pain, which radiated to his left arm. On a scale of 0 to 10, it was as bad as 8 out of 10. Patient had some diaphoresis and dyspnea associated with the chest pain. He would sit down and this would be relieved after about 15 minutes. Patient has taken it upon himself to limit his activities based on this symptomatology. Patient has an interest in quitting smoking. denies palpitations, syncope, pre-syncope, PND, or arthralgia. Patient has had no peripheral edema or shortness of breath at rest, no episodes where the pain lasted greater than half hour.

#2  
HPI Right knee pain Patient has had an 8- year history of right knee pain. Patient works as a construction worker and had a fork lift injury 8 years ago. Since that time, he has had more difficulty getting around on his right knee. It pings occasionally, never locks, not given out on him, he has constant pain for which he takes ibuprofen on a regular basis. Patient used to be an avid golfer, not been able to participate since the injury. This has also affected his work, so he has had 3000 hours of sick time which is sometimes excused as he

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## Parsed



Medical records - Microsoft Internet Explorer

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### Exam Section

**Vital Signs** [PHYSICAL EXAMINATION](#) [HEIGHT](#) 190 [cm](#) [WEIGHT](#) 110 [kg](#) [TEMP](#) [PULSE](#) 84 [RHYTHM](#) [Regular](#) [SRP](#) 138 [DBP](#) 82 [Position](#)  
[Date / Time](#) [General](#)- [Obese](#) male in [no](#) [apparent](#) [distress](#).

**Eyes** [Eyes](#) [Non-icteric](#). [Pupils](#) were [equal](#) and [reactive](#) to [light](#) and [accommodation](#).

**ENT** [ENT](#) [Ears](#) are [clear](#). [Oral cavity](#), [oral pharynx](#) is [clear](#).

**Thyroid** [Thyroid](#) [Neck](#) is [supple](#) [without](#) [nodes](#) or [masses](#). [Thyroid](#) is [within normal limits](#).

**Vessels** [Vessels](#) [Carotid Arteries](#) are 2+ [without](#) [bruits](#).

**Heart** [Heart](#) [Normal](#) [S1](#), [normal](#) [S2](#), [without](#) [murmurs](#), [gallops](#), [rubs](#), or [clicks](#).

**Lungs** [Lungs](#) [Clear](#) [without](#) [wheezing](#), [rales](#), [rhonchi](#), or [rubs](#).

**Abdomen** [Abdomen](#) [Soft](#), [flat](#), [non-tender](#), [normal](#) [active](#) [bowel](#) [sounds](#) [without](#) [hepatosplenomegaly](#) or [masses](#) or [bruits](#).

**Rectum** [Rectum](#) [brown](#) [stool](#) at the [verge](#), [no](#) [other](#) [masses](#).

**Genitalia** [Genitalia](#) [Within normal limits](#) [no](#) [lesions](#) [no](#) [testicular](#) [masses](#).

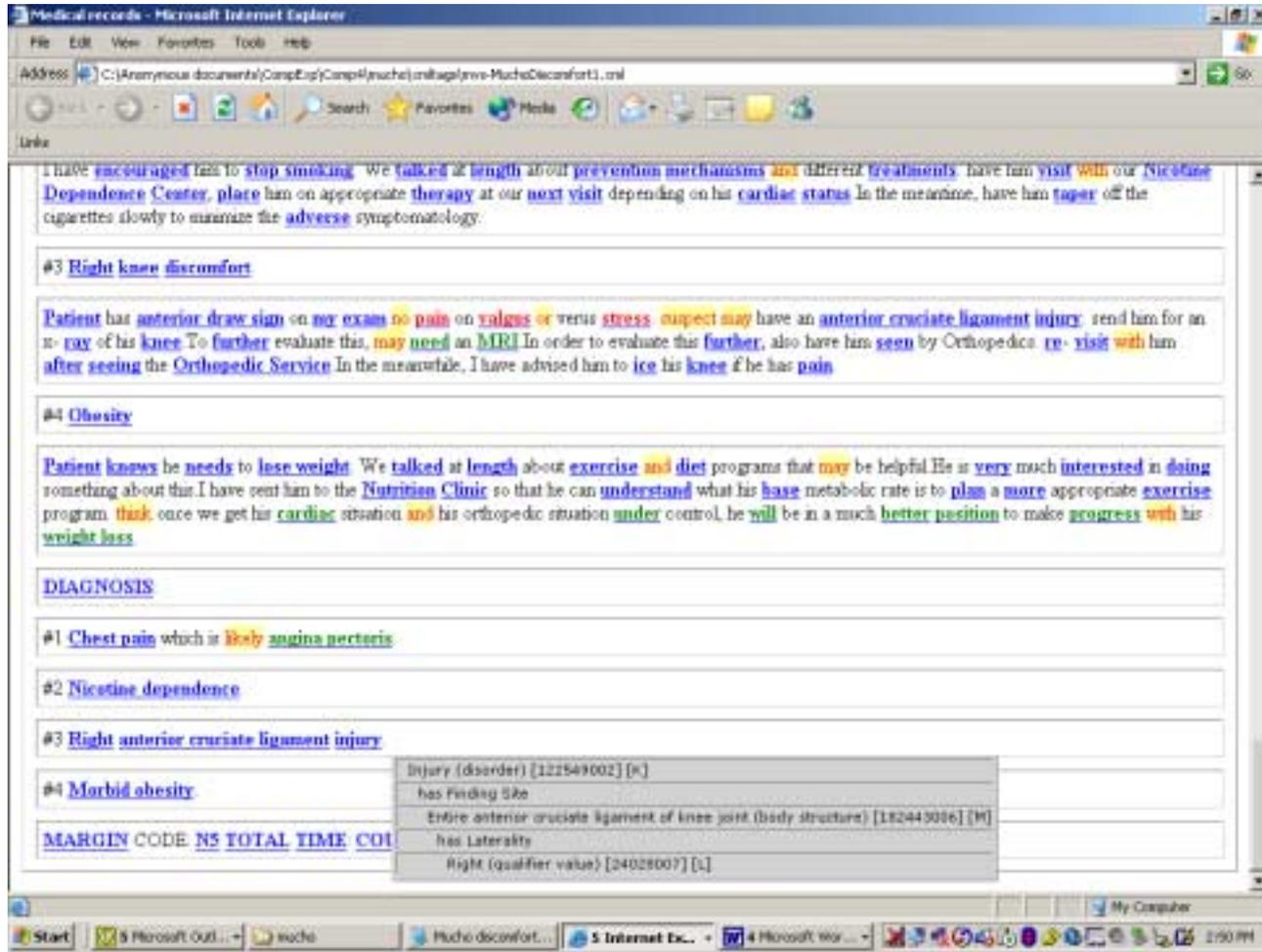
**Extremities** [Extremities](#) [Without](#) [clubbing](#), [cyanosis](#), or [edema](#).

**Gait** [Gait](#) [Within normal limits](#).

**Neuro** [Cranial nerves](#) 2 through 12 were [intact](#). [Visual fields](#) were [within normal limits](#). [Sensation](#) was [intact](#) and [bilaterally](#).

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## Parsed



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Links

I have encouraged him to stop smoking. We talked at length about prevention mechanisms and different treatments. Have him visit with our Nicotine Dependence Center, place him on appropriate therapy at our next visit depending on his cardiac status. In the meantime, have him taper off the cigarettes slowly to minimize the adverse symptomatology.

#3 Right knee discomfort

Patient has anterior draw sign on per exam, no pain on valgus or varus stress, suspect may have an anterior cruciate ligament injury. Send him for an x-ray of his knee. To further evaluate this, may need an MRI. In order to evaluate this further, also have him seen by Orthopedics. re-visit with him after seeing the Orthopedic Service. In the meantime, I have advised him to ice his knee if he has pain.

#4 Obesity

Patient knows he needs to lose weight. We talked at length about exercise and diet programs that may be helpful. He is very much interested in doing something about this. I have sent him to the Nutrition Clinic so that he can understand what his base metabolic rate is to plan a more appropriate exercise program. Think once we get his cardiac situation and his orthopedic situation under control, he will be in a much better position to make progress with his weight loss.

DIAGNOSIS

#1 Chest pain which is likely angina pectoris

#2 Nicotine dependence

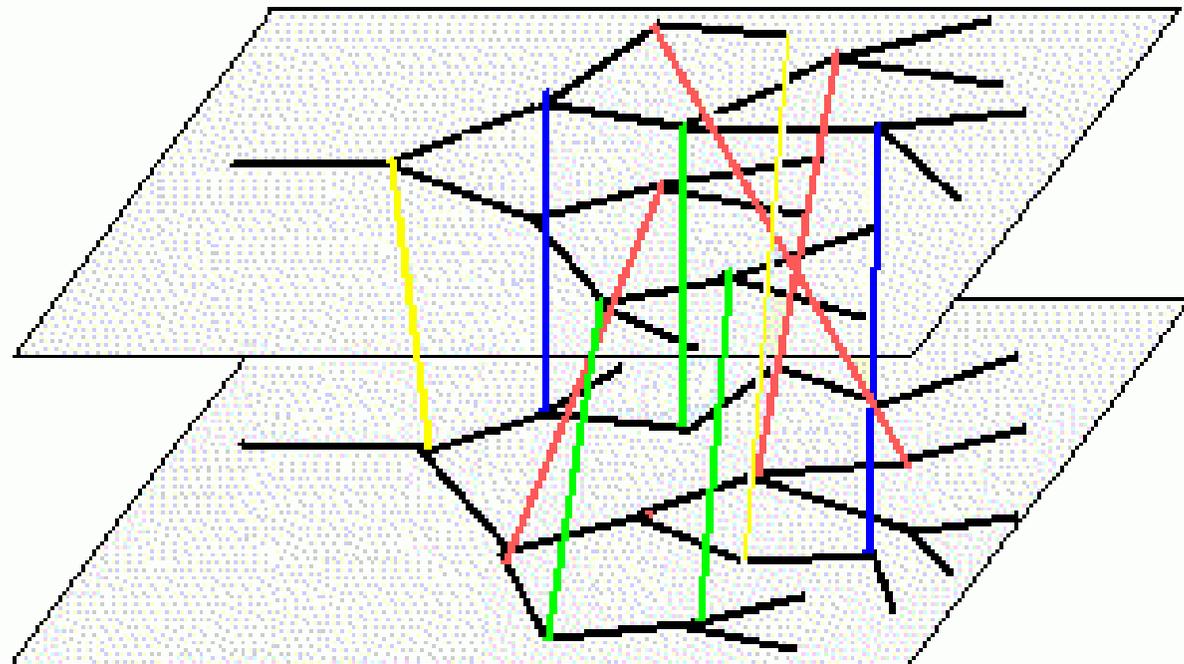
#3 Right anterior cruciate ligament injury

#4 Morbid obesity

MARGIN CODE N5 TOTAL TIME COI

Injury (disorder) [122549002] [D]
has Finding Site
Entire anterior cruciate ligament of knee joint (body structure) [182449006] [M]
has Laterality
Right (qualifier value) [24028007] [L]

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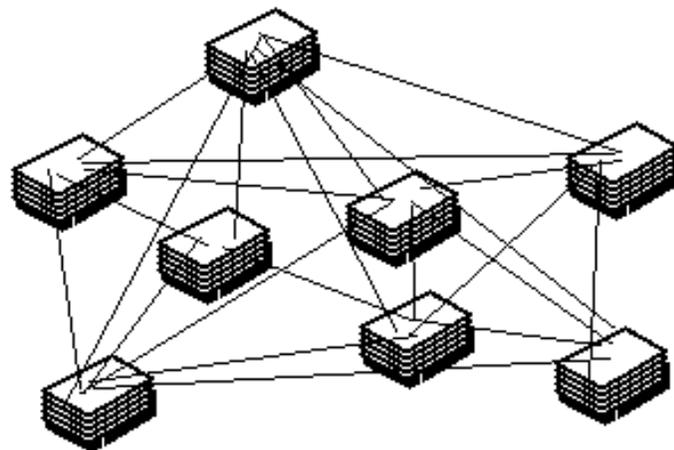


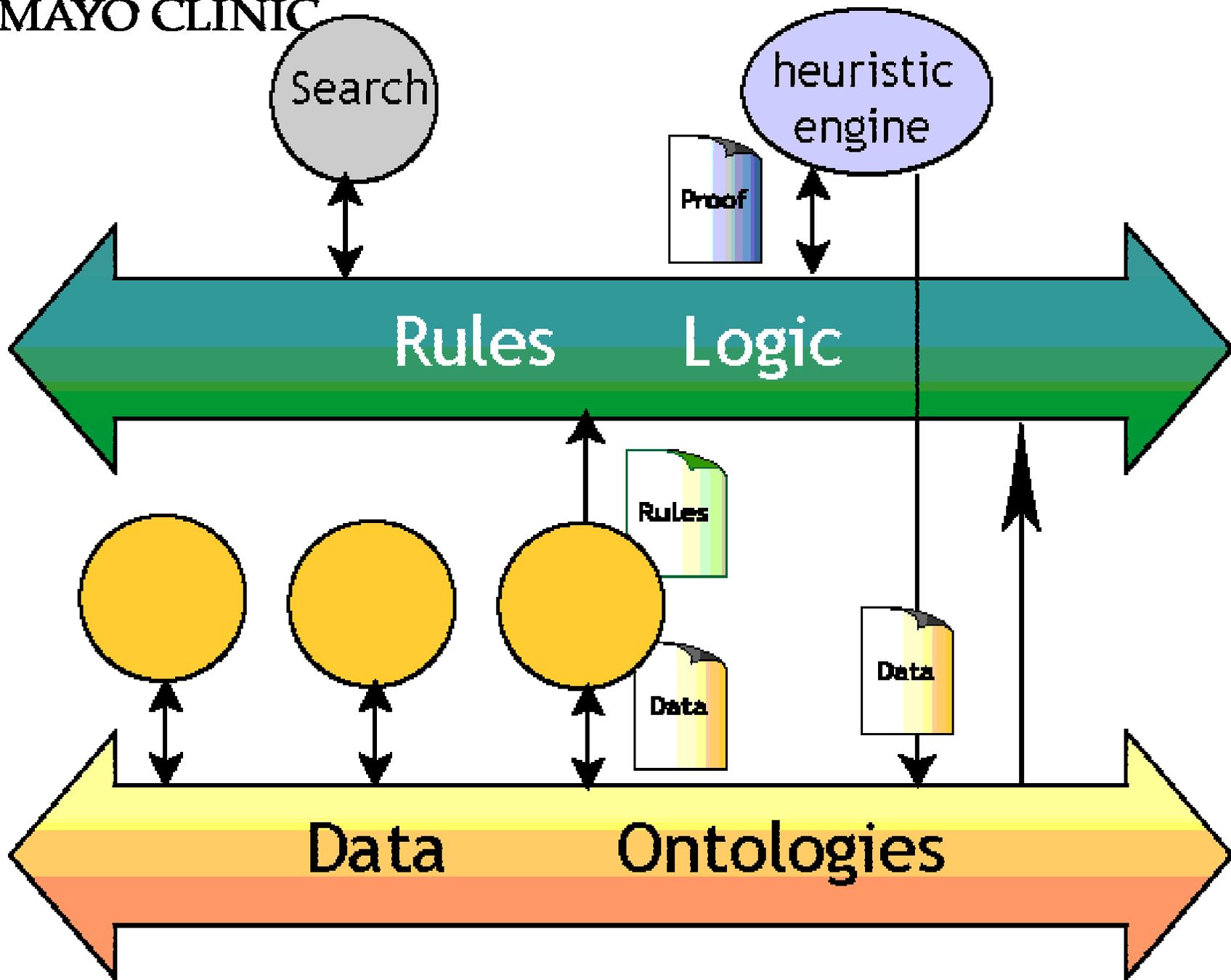
**Case One**

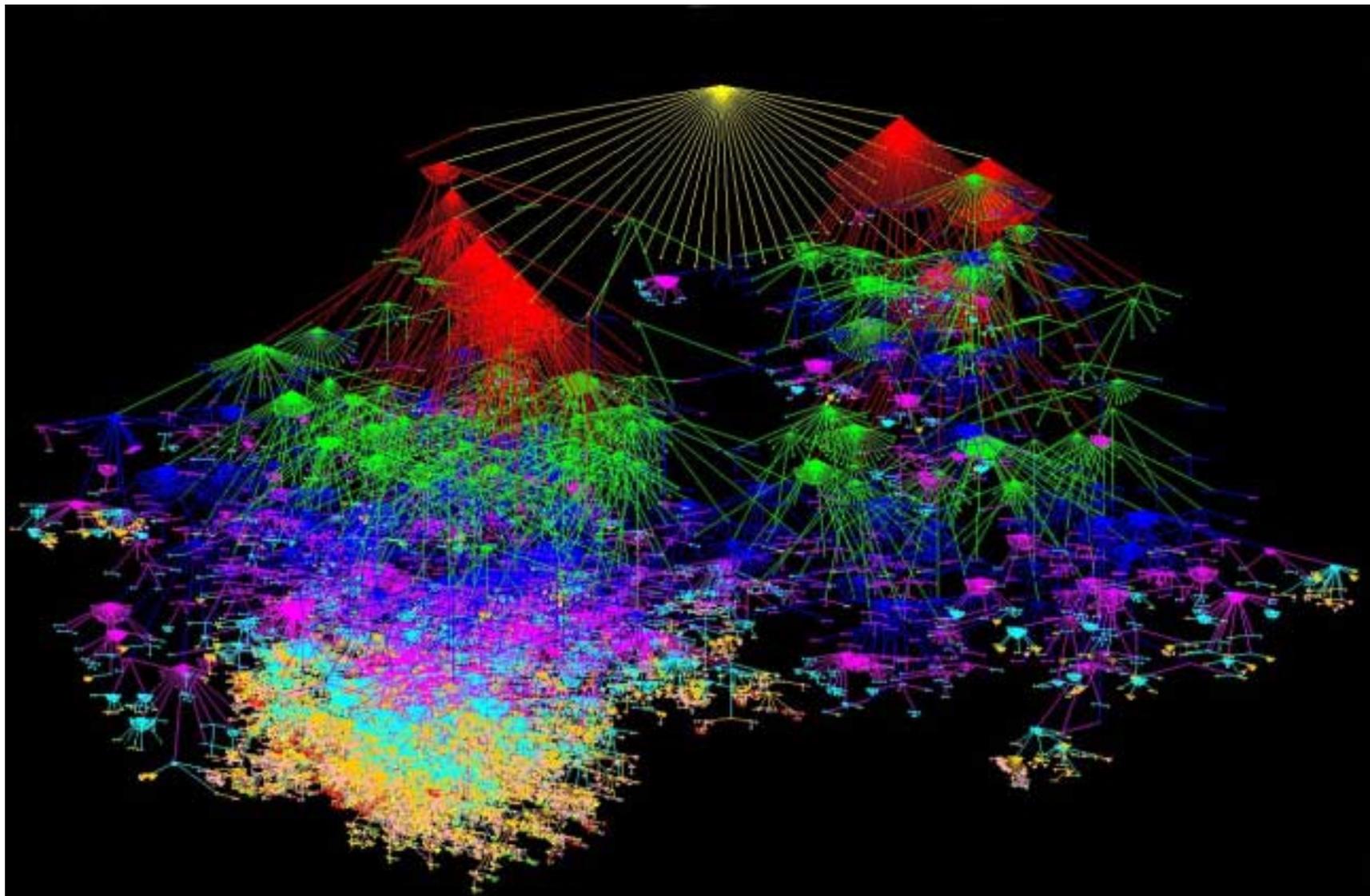
**Case Two**

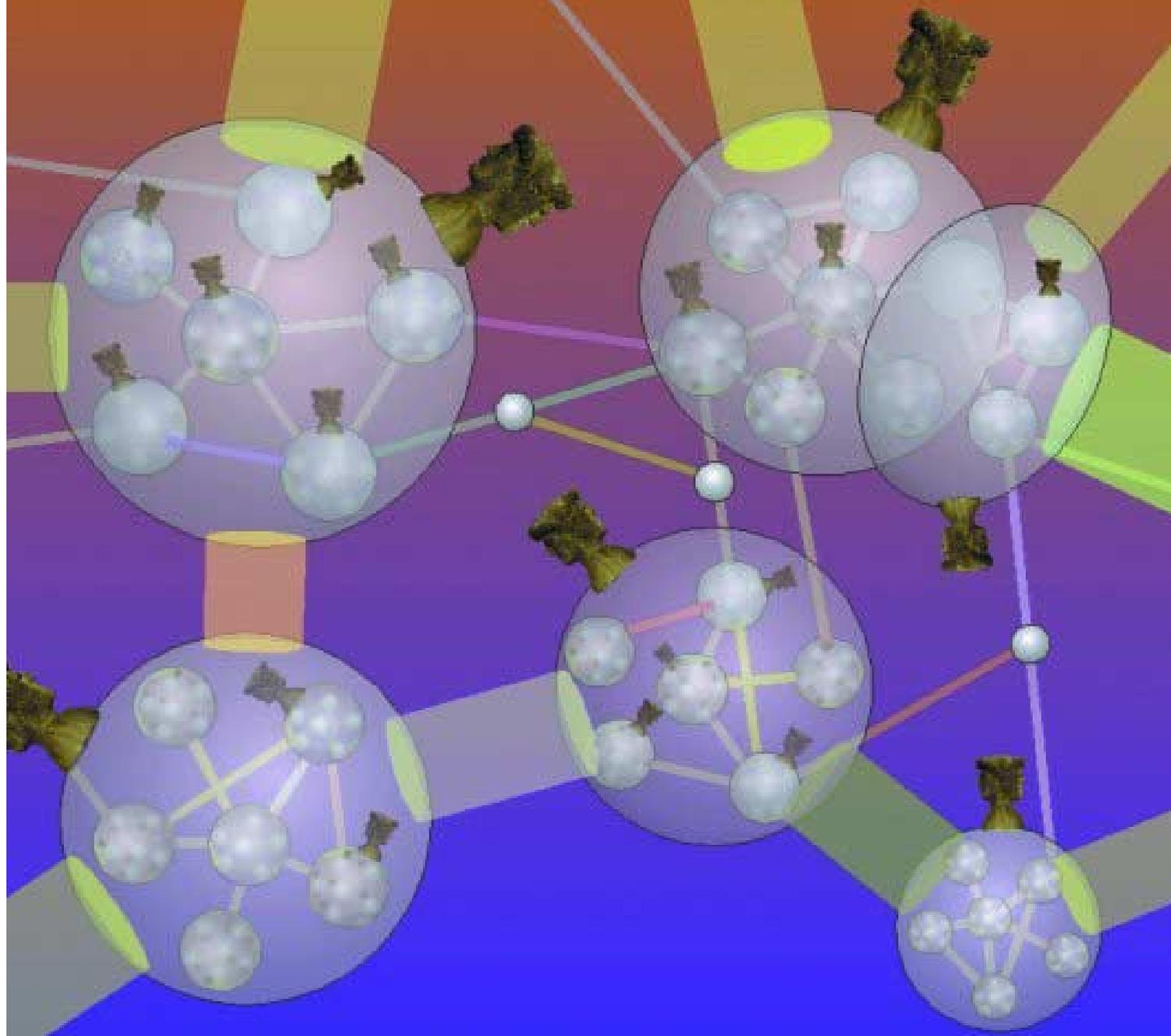
**Semantic Network**

**Multi-Center Data  
Sharing and  
Interchange**



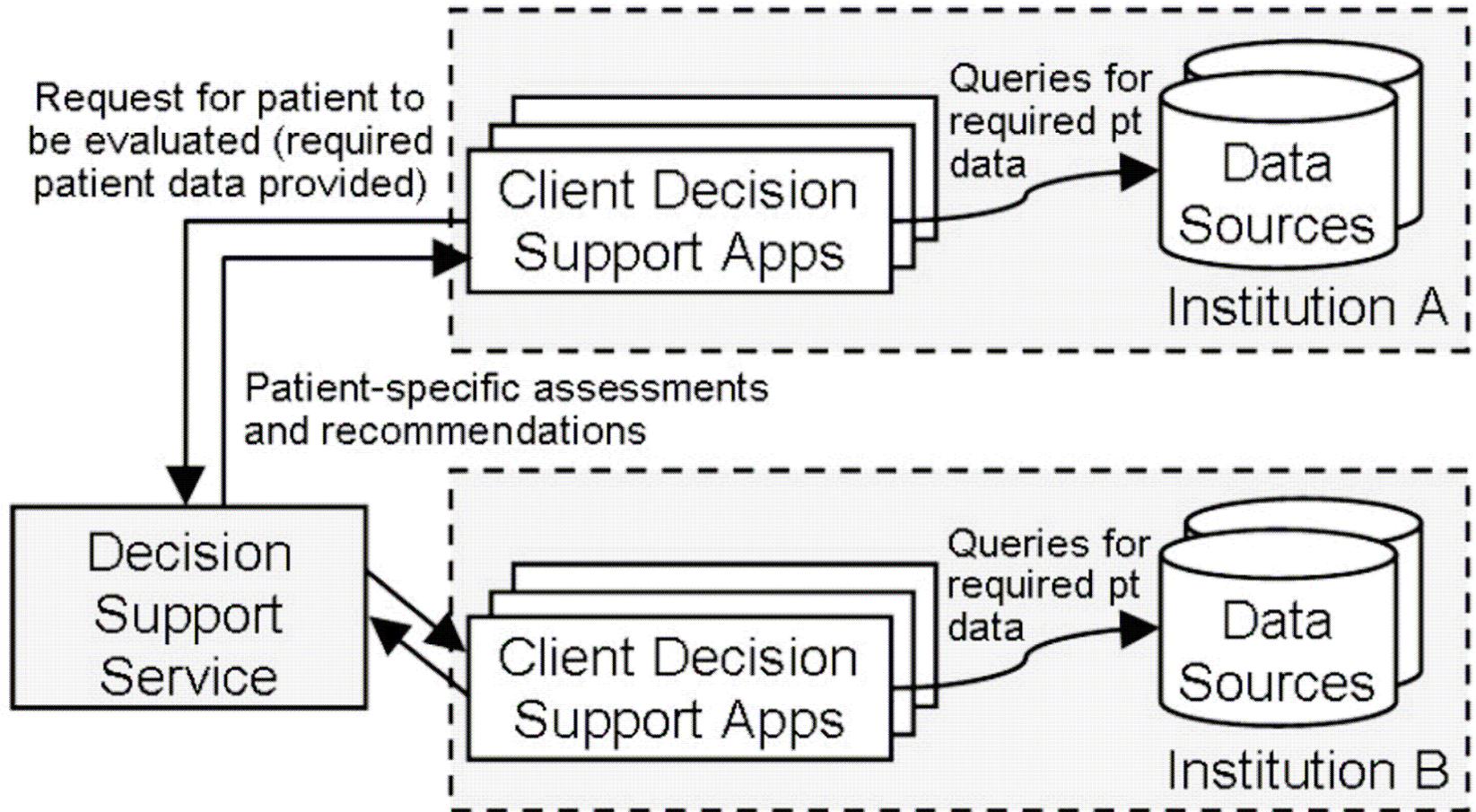


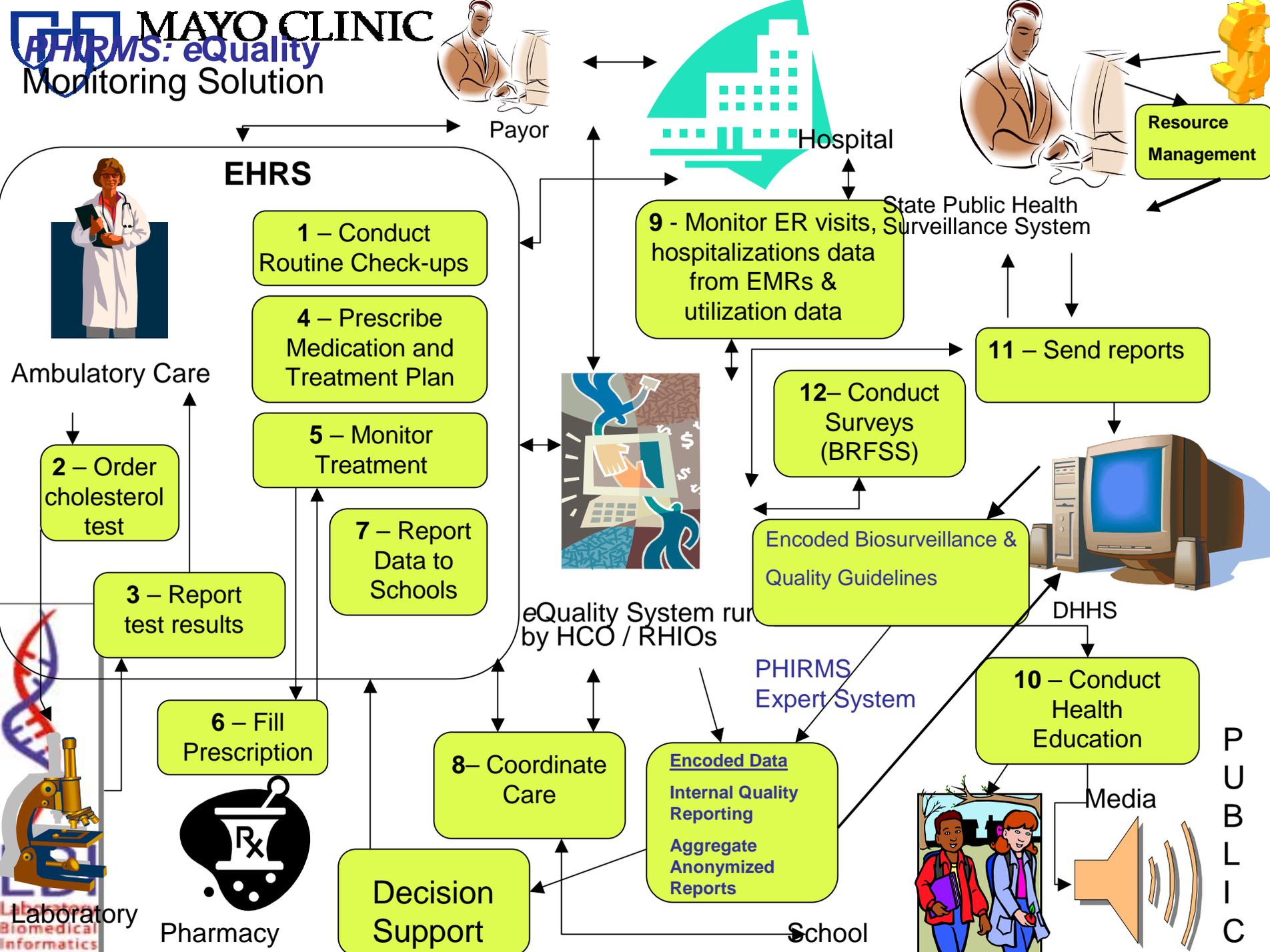




# Intelligent Agents

## Healthcare Services Specification Project Goal

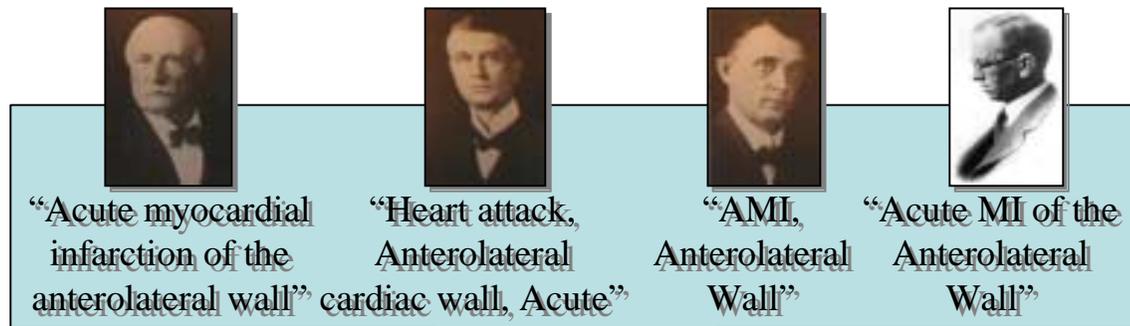




# Bird Flu

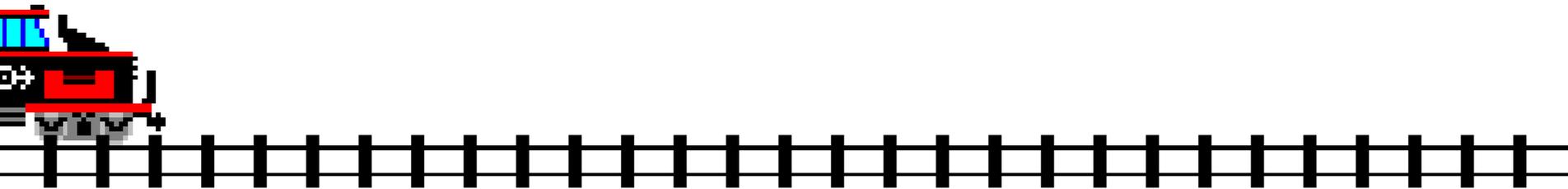


# Its all about Meaning.....



- Myocardial infarction (disorder) [22298006]  
 - [has Finding Site] .  
Entire myocardium of anterolateral region (body structure) [190762001]  
 - [is Modified By] .  
Acute (qualifier value) [53737009]

# Compositional Systems

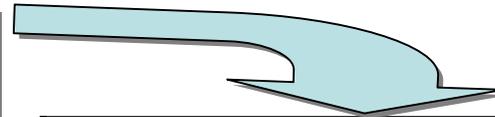


# Experimental Design

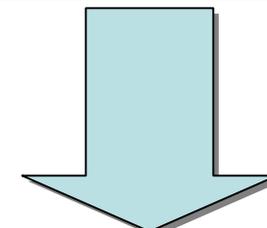
- VA Disability Exams
  - Reviewed by two reviewers
  - Disagreements adjudicated by a Super reviewer
- Rules for what constitutes a good exam are translated into computable rules (HAL-42)
- *eQuality* System reviewed the quality criteria against each record
- The *eQuality* System Review was compared with the human review.

# “Five Minutes” in the MCVS’s HAL-42. . . .

1	pneumonia 233604007 [P] [Explode] [A]
2	pneumovax 333598008 [P] [Explode] [W]
3	(1 AND 2)
4	influenza vaccine 46233009 [P] [Explode] [W]
5	(1 AND 4)
6	influenza 6142004 [P] [Explode] [W]
7	influenza 6142004 [P] [Explode] [A]
8	(1 AND 7)
9	(4 AND 8)
10	streptococcus pneumoniae 58800005 [P] [Explode] [W]
11	(1 AND 10)
12	(2 AND 11)
13	(3 AND 4)



469	Pneumonia Records
167	Pneumonia and Pvx
24	Pneumonia and Influenza Vaccine
77	Pneumonia and Influenza
3	Pneumonia and Influenza and Influenza Vaccine
37	Pneumonia and Strep Pneumoniae
6	Pneumonia and Strep Pneumoniae and Pvx
8	Pneumonia and Influenza vaccine and Pvx



44	Pneumonias and Smokers of 469 Pneumonias
3	Pneumonias and Smokers who were counseled to Quit smoking
319	Smokers
202	Smokers who were counseled to quit smoking

## Conclusions

- Technology and standards have progressed to the point where NLP is a viable solution
- MCVS
  - Recall (Sensitivity) of 99.7%
  - Precision (PPV) of 99.8%.
- NLP can support electronic quality monitoring (eQuality) and clinical decision support, information retrieval for research and digital image education libraries.

Peter L. Elkin, MD<sup>1</sup>, Steven H. Brown, MD, Casey Husser, MD, Brent A. Bauer, MD, Dietlind Wahner-Roedler, MD, S. Trent Rosenbloom, MD, Ted Speroff, PhD; “An Evaluation of the Content Coverage of SNOMED-CT for Clinical Problem Lists”, Mayo Clin Proc. 2006 Jun;81(6):741-8.

## What have we learned from our case?

- That our patients deserve the highest quality, safest care that we can provide.
  - Requires the use of all of the patient's relevant data.
  - Utilizing that data in the context of best practice.
  - Our hypothetical Mr. Kneivel and his son Michael are representative of people who have put their trust in us to provide for them the very best care. This requires systems engineering that can help us to integrate and analyze patient data in order to provide clinicians with just-in-time point-of-care best practice advice, in support of their medical practice.

## Conclusions: SOA Enabled **eQuality**

- **SOA Enabled Intelligent Electronic Systems (iEHR) can facilitate data capture in support of eQuality Monitoring**
- Quality Rules can be encoded and compared with iEHR data
- This data can inform and monitor Quality Improvement Projects
- eQuality data can be fed back to clinicians in real time to improve decision making
- **Biomedical Informatics** => *Moving toward the iEHR fueling eQuality solutions in support of the best practice of health and healthcare*

***“...there is nothing more difficult to take in hand, more perilous to conduct, or more uncertain in its success, than to take the lead in the introduction of a new order of things. Because the innovator has for enemies all those who have done well under the old conditions, and lukewarm defenders in those who may do well under the new. “***

***Niccolo Machiavelli c. 1505***

“The best way to predict the future,  
is to create it.”

---- Peter Drucker (Harvard University)