AN INFORMATICS DRIVEN PROGRAM IN QUALITY AND PATIENT SAFETY TOWARD VALUE BASED HEALTHCARE

PETER L. ELKIN, MD, MACP, FACMI, FNYAM
PROFESSOR AND CHAIR
DEPARTMENT OF BIOMEDICAL INFORMATICS
PROFESSOR AND VICE-CHAIR OF QUALITY AND PATIENT SAFETY
DEPARTMENT OF MEDICINE
PROFESSOR OF PATHOLOGY
JACOBS SCHOOL OF MEDICINE AND BIOMEDICAL SCIENCES
UNIVERSITY AT BUFFALO
STATE UNIVERSITY OF NEW YORK
BIOMEDICAL INFORMATICS DEFINITION:

- The rapidly developing scientific field that deals with the storage, retrieval and optimal use of biomedical information, data, and knowledge for discovery, problem solving and decision making.
TOP TEN ACCOMPLISHMENTS IN
BIOMEDICAL INFORMATICS

10. Personalized Medicine
9. ePrescribing (including Drug-Drug Interaction Testing)
8. Evidence Based Medicine
7. Clinical Decision Support
6. Electronic Health Record Systems
TOP TEN ACCOMPLISHMENTS IN BIOMEDICAL INFORMATICS

5. Translational Research
4. Mapping the Human Genome
3. Systems that facilitate paying physicians for high quality care (eQuality)
2. Pubmed – Access and Cataloging of the Biomedical Literature
1. Systematizing the practice of medicine
UNIVERSITY AT BUFFALO’S DEPARTMENT OF BIOMEDICAL INFORMATICS

• Research
  • Academic Excellence and Innovation
  • Research Data Warehouse

• Practice
  • Service to other Departments, Institutes and the University
  • Service to the Clinical Enterprise (Great Lakes Health: ECMC, Kaleida; Roswell Park; UBMD Practice Plans)

• Education
  • Masters and PhD programs
  • Teaching in the IPE Program
  • Five year goal of starting a Bachelors Degree program in Biomedical Informatics
CLINICAL INFORMATICS

• Clinical Informatics Training Program
• Electronic Health Records
• Personal Health Records
• Electronic Prescribing Systems
• Computerized Physician (Clinician) Order Entry
• Electronic Quality Monitoring (eQuality)
• Educational Informatics
  • Case Based Teaching Tools
  • Evaluative Tools for evaluation of Learners
  • Web Based (remote) classroom teaching tools – Distance Learning
  • Virtual Learning Communities
  • Simulation
  • Educational Outcomes
• Expert Systems
• Models of Healthcare Workflow
• Systems Engineering
• Translational Informatics
• Ethical Issues in Health Informatics
• High Throughput Phenotyping
BIOINFORMATICS

• Protein Structure Prediction
• Docking Algorithms
• New Drug Discovery
• ReUse of existing Drugs
• Deep Sequencing
• Multiple Sequence Alignments
• GWAS Studies
• Galaxy
• Birdsuite to PLINK pipeline
• Formats for Gene Sequences (BSAM, GA4GH)
• Formats for Proteins (and Peptides)
• Semantic Cluster Analysis
• MicroArray
• High Throughput Studies (e.g. shRNA)
• Ontologies
• I2b2
• OMOP
• CANDO
• Translational Informatics
• Big Data Science
BIOMEDICAL ONTOLOGY

- Ontology Development
- Formal Languages
- Ontology Instantiation
- Ontology Usage in Research
- Ontology Usage in Clinical Practice
- Terminology / Ontology Services
- Natural Language Processing
- Semantic Web Technologies
Medical Ontology: Relationships between diseases, disorders, & systems, organs and tissues

- tissue
  - connective tissue
  - adipose tissue

- digestive system
  - liver
  - pancreas
    - islet cells

Adipose Tissue (Obesity)

Cardio vascular

Diabetes

Insulin

- islet cells impaired

- eye (Retinal exudates)

Pancreas

- cardiovascular system
  - blood vessel
  - retinal vessel
Biomedical Ontology: Neuronal interaction between diseases, systems, organs, substances, tissues, cells, proteins and genetics.
SOCIOTECHNICAL & HUMAN CENTERED DESIGN IN HEALTH INFORMATICS

- Health Systems
- Systems Engineering
- Cognitive Informatics
- Human Factors Engineering
- Human Centered Design
- Usability Testing
- Simulation
- Sociotechnical Issues in Health Informatics
- Management of Health Systems
- Systems Science
PUBLIC HEALTH INFORMATICS

- Population Health Informatics
- Mobile Computing
- Ethical Issues in Informatics
- Biosurveillance
  - NHSN
  - Biosense
  - Post-marketing Surveillance of Medications
- Ontology based Epidemiology
- Ontology based Payment for Health Services
- Public Health Data Standards
- Population based Research
- Health IT Policy
EDUCATIONAL GOALS

• Consistent Educational Outcomes
  • Given a diverse group of students both in interest and in their prior educational background
  • Methods to measure our success

• Integration of the program within our Research and Practice missions

• Utilization of the talents across our campuses

• Develop a pipeline of well trained graduate students to fill positions in our research laboratories
PROGRAM DIRECTORS

• Master’s Program
  • Gary Byrd, PhD and Peter L. Elkin, MD

• PhD Program
  • Werner Ceusters, MD and Peter L. Elkin, MD
UB Translational Research Pipeline

- Biomedical Informatics
  - Genomics
  - Structural Biology
  - Pathology
  - Structural Science Learning Center

---

Data
- Sequence
- Gene Expression
- Epigenetics
- Proteomics

Data Analysis

Hospital

Clinical & Genomic Data Warehouse

Biobank

Community Data
- Community Engagement

Out Patient Data
- EHR Data
- Imaging Data
- Drug Data
- Lab Data

---

Care for the Cure
- In vitro Simulation

Network Analysis
- Preclinical Trials
- Clinical Trials
- Phase 1, 2 & 3 Studies

Patient

---

Clinical Decision Support
- Personalized Medicine
- New Drug Development
- New Laboratory Test Development
- Regenerative Medicine
- Gene Therapy
- General Scientific Advances
- Reputation Health Impact

Knowledge Integration
- Identified Markers and Targets Screened Against Small Molecule Libraries
- Functional shRNA Development
FACULTY

• Eight Primary Appointees
  • Prof. Peter L. Elkin
  • Prof. Werner Ceusters
  • Associate Prof. Gary Byrd
  • Prof. Ram Samudrala
  • Associate Prof. Jos Aarts
  • Assistant Prof. Jaric Zola
  • Tbn Chief, Division of Clinical Informatics
  • Tbn, Chief, Division of Public Health Informatics

• 26 Adjunct Faculty
  • All faculty have agreed to teach in our program as a requirement of their appointment in the department.
LEAN / SIX SIGMA TIMELINE

1900

Ford Assembly Line

1930

Guinness Brewery

Shewhart Introduces SPC

1950

Deming

• PDSA

Gilbreth, Inc.

• Management Theory

• Industrial Engineering

Toyota Production System
Motorola Introduces Six Sigma

AlliedSignal GE Adapt LSS to Business Processes

Just – in–Time

Lean Mfg.

LEAN / SIX SIGMA TIMELINE

1980

1990

2000

LEAN / Six Sigma
QUALITY IMPROVEMENT

W. Edwards Deming

• American statistician, professor, author, lecturer, and consultant
• Improved production in the U.S. during World War II and in Japan after the war
• Pioneer – use of statistical analysis to achieve better industrial quality control – ‘quality movement’
Model for Improvement

What are we trying to accomplish? (AIM)

How will we know that changes are an improvement? (MEASURES)

What changes can we make that will result in an improvement? (IDEAS)

Act  Plan
Study  Do

TEST Ideas & Changes with Cycles for Learning and Improvement
PATIENT SAFETY ISSUES

• ‘Above all else, do no harm’
• Build systems with safety barriers
• So, why do adverse outcomes continue to happen?
The Swiss cheese model of how defenses, barriers, and safeguards may be penetrated by an accident trajectory.

No single barrier is foolproof!

Reason, J. BMJ 2000;320:768-770
WHEN THE SAFETY BARRIERS WORK

SUCCESSIVE LAYERS OF DEFENSES
PERFORMANCE MONITORING

• Goals
  • Best Practice
  • Staying one step ahead of those who measure us

• National Measures
  • Physician Quality Reporting System (PQRS)
  • Meaningful Use Measures (2 and 3)
  • Hedis Measures

• Our Practice Goals

• Local Measures by our healthcare payers
  • Shared Savings

• Goal: Monitoring every transaction in near real-time with on demand and push reporting
### HEDIS Measurement 2014 Updates

<table>
<thead>
<tr>
<th>Measure Name</th>
<th>Changes</th>
</tr>
</thead>
</table>
| **Guidelines for Physician Measurement** | - Changed all coding table references to value sets.  
- Clarified the Patient-reported Data section in the *Obtaining Medical Record Information Manually* guideline.  
- Revised the *Identifying Events/Diagnoses Using Laboratory Data* guideline under the Electronic Method section.  
- Renamed and revised the *Code Presentation* guideline to reflect the presentation of codes in the value sets.  
- Revised the *Uniform Bill Code Specificity* guideline to reflect how UB-TOB codes will be listed in the value sets. |

**Effectiveness of Preventive Care**

<table>
<thead>
<tr>
<th>Guidelines for Physician Effectiveness of Care</th>
<th>Revised the requirements for &quot;Which services count?&quot; when collecting data for the Effectiveness of Care measures.</th>
</tr>
</thead>
</table>
| **Adult BMI Assessment**                       | - Removed coding tables and replaced all coding table references with value set references.  
- Clarified in the Electronic Specification that patients 19 years of age and younger can meet criteria with a BMI percentile.  
- Clarified that ranges and thresholds do not meet numerator criteria for the Medical Record Specification. |
| **Weight Assessment and Counseling for Nutrition and Physical Activity for Children/Adolescents** | - Removed coding tables and replaced all coding table references with value set references.  
- Clarified in the Electronic Specification for BMI percentile that adolescents 16-17 years of age on the date of service can meet criteria with a BMI value.  
- Clarified that ranges and thresholds do not meet numerator criteria for BMI percentile in the Medical Record Specification.  
- Clarified that patients must receive educational materials during a face-to-face visit in order to meet criteria for the Hybrid Specification for the *Counseling for nutrition and Counseling for physical activity indicators*.  
- Added that weight or obesity counseling count as numerator compliant for they Hybrid Specification for both the *Counseling for nutrition* and *Counseling for physical activity indicators*.  
- Added a *Note* stating that a physical exam finding or observation alone is not compliant for *Counseling for nutrition*.  
- Clarified in the *Note* that services specific to an acute or chronic condition do not count toward the *Counseling for nutrition* and *Counseling for physical activity indicators*. |
| **Childhood Immunization Status**              | - Removed coding tables and replaced all coding table references with value set references. |
| **Immunizations for Adolescents**             | - Removed coding tables and replaced all coding table references with value set references. |
| **Human Papillomavirus Vaccine for Female Adolescents** | - Removed coding tables and replaced all coding table references with value set references. |
| **Lead Screening in Children**                | - Removed coding tables and replaced all coding table references with value set references. |
| **Colorectal Cancer Screening**               | - Removed coding tables and replaced all coding table references with value set references. |
| **Breast Cancer Screening**                   | - Removed coding tables and replaced all coding table references with value set references.  
- Revised the patient inclusion criteria.  
- Revised the age criterion to women 50–74 years of age.  
- Revised the numerator time frame. |
## 2012 Physician Quality Reporting System (Physician Quality Reporting) Measures List

The Physician Quality Reporting System (Physician Quality Reporting) measures were developed by various organizations for 2012. The following is a list of each measure, the measure developer, method of reporting available and contact information. Questions regarding the construct of a measure or its intent should be referred to the measure developer/contact as outlined in Appendix II (on page 33). Please note that gaps in measure numbering reflect retired 2007, 2008, 2009, 2010, and 2011 measures that are not included in 2012. This measure list is intended as a summary list to assist eligible professionals initially reviewing the measures and should not be used as a replacement for the measure specifications, which contain detailed reporting and coding instructions. A list of Physician Quality Reporting Measure Specifications and where they can be found on the CMS website is listed in Appendix I (on page 32).

<table>
<thead>
<tr>
<th>#</th>
<th>NQF #</th>
<th>Measure Title &amp; Description*</th>
<th>Measure Developer</th>
<th>Reporting Options/Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>GPDM-2</td>
<td>0059 Diabetes Mellitus: Hemoglobin A1c Poor Control in Diabetes Mellitus&lt;br&gt;Percentage of patients aged 18 through 75 years with diabetes mellitus who had most recent hemoglobin A1c greater than 9.0%</td>
<td>NCQA</td>
<td>Claims, Registry®, EHR®, DM Measures Group (C/R), GPRO®</td>
</tr>
<tr>
<td>2.</td>
<td>GPDM-5</td>
<td>0064 Diabetes Mellitus: Low Density Lipoprotein (LDL-C) Control in Diabetes Mellitus&lt;br&gt;Percentage of patients aged 18 through 75 years with diabetes mellitus who had most recent LDL-C level in control (less than 100 mg/dL)</td>
<td>NCQA</td>
<td>Claims, Registry®, EHR®, DM Measures Group (C/R), GPRO®, Cardiovascular Prevention Measures Group (C/R)</td>
</tr>
<tr>
<td>3.</td>
<td>GPDM-3</td>
<td>0061 Diabetes Mellitus: High Blood Pressure Control in Diabetes Mellitus&lt;br&gt;Percentage of patients aged 18 through 75 years with diabetes mellitus who had most recent blood pressure control (less than 140/90 mmHg)</td>
<td>NCQA</td>
<td>Claims, Registry®, EHR®, DM Measures Group (C/R), GPRO®</td>
</tr>
<tr>
<td>5.</td>
<td>GPRO HF-7</td>
<td>0081 Heart Failure: Angiotensin-Converting Enzyme (ACE) Inhibitor or Angiotensin Receptor Blocker (ARB) Therapy for Left Ventricular Systolic Dysfunction (LVSD)&lt;br&gt;Percentage of patients aged 18 years and older with a diagnosis of heart failure (HF) with a current or prior left ventricular ejection fraction (LVEF) &lt; 40% who were prescribed ACE inhibitor or ARB therapy either within a 12 month period when seen in the outpatient setting or at each hospital discharge</td>
<td>AMA-PCPI/ACCF/AHA</td>
<td>Registry®, EHR®, HF Measures Group (R), GPRO®</td>
</tr>
<tr>
<td>6.</td>
<td>GPRO CAD-1</td>
<td>0067 Coronary Artery Disease (CAD): Antiplatelet Therapy&lt;br&gt;Percentage of patients aged 18 years and older with a diagnosis of coronary artery disease seen within a 12 month period who were prescribed aspirin or clopidogrel</td>
<td>AMA-PCPI/ACCF/AHA</td>
<td>Claims, Registry®, EHR®, CAD Measures Group (R), GPRO®</td>
</tr>
<tr>
<td>7.</td>
<td>GPRO CAD-1</td>
<td>0070 Coronary Artery Disease (CAD): Beta-Blocker Therapy - Prior Myocardial Infarction (MI) or Left Ventricular Systolic Dysfunction (LVEF &lt; 40%)&lt;br&gt;Percentage of patients aged 18 years and older with a diagnosis of coronary artery disease seen within a 12 month period who also have prior MI OR a current or prior LVEF &lt; 40% who were prescribed beta-blocker therapy</td>
<td>AMA-PCPI/ACCF/AHA</td>
<td>Registry®, EHR®</td>
</tr>
</tbody>
</table>
Satisfactorily Reporting Scenarios
Measure #6: Coronary Artery Disease (CAD): Oral Antiplatelet Therapy Prescribed for Patients with CAD

Mrs. Jones, age 67, presents for office visit (99213) with Dr. Thomas

Mrs. Jones has diagnosis of CAD (414.00)

Scenario 1
Dr. Thomas prescribes oral antiplatelet therapy
4011F

Scenario 2
Dr. Thomas does not prescribe oral antiplatelet therapy due to medical reasons
4011F-1P

Scenario 3
Dr. Thomas does not prescribe oral antiplatelet therapy
4011F-8P
CLINICAL INTERVENTIONS

• Make changes where our measurements fall short of our goals
• Clinically Driven
• Our Quality and Patient Safety Committee (all divisions and practices are invited to participate)
• Goal: Improve our practice and to optimize our quality and safety as shown by longitudinal performance measurement results
• Optimize Clinical Workflows and Practice Efficiencies
• To align our processes with our hospital clinical partners where there exists a valid clinical use case
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.

3) **EHRs await federal action** (Oct 22, 2008) An expert predicts that federal standards for electronic quality monitoring will drive the market for intelligent EHRs.

4) **Health IT success: How cool is that?** (Nov 20, 2008) Energizing public-sector health care organizations should be near the top of Obama’s management agenda. Dr. Peter Elkin at the Mount Sinai School of Medicine is working on electronic health record technology that would automate clinical data gathering. Using so-called intelligent EHRs, clinicians would get swift feedback about the quality of the care their patients receive.

---

**ORIGINAL ARTICLE**

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

STEVEN H. BROWN, MS, MD, THEODORE SPRECHT, PhD, ELLIOT M. FELSTEIN, PhD, BRENT A. BAYER, MD; DENNIS L. WARNER-RIGHEL, MD, ROBERT GEVARY, PhD, AND PETER L. ELKIN, MD

OBJECTIVES: 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 spinal disability examinations that had previously undergone gold-standard quality review by human reviewers 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 100 examination reports. The initial data set was composed of all electronically available examination reports (N=135,976) utilized by the Veterans Health Administration between July and September 2001.

RESULTS: Sensitivity was 95% for the training set and 87% for the test set (P<0.05). Specificity was 74% for the training set and 71% for the test set (P<0.05). Human performance ranged from 4% to 6% higher (P<0.05) than the eQuality tool in sensitivity and 13% to 16% higher in specificity (P<0.05). Nonetheless, 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.


---

A single medical record needs to be reviewed in the case 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-readable format.

Three basic methods exist to electronically extract complete information from free text: Strong matching (downward matching) is a simple, often effective, approach to detect various medical terms. For example, simple keyword searches have used trigger words, such as complication, mental status, or rash, to identify adverse events with moderate success. However, string matching does not identify synonyms or closely related terms. For example, procedural infection and fever almost are syn-
• Value = Quality / Cost

• Quality is composed of:
  • Outcomes
  • Safety
  • Service
    • Reliability
“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”
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**.
## Basic Formal Ontology (BFO)

Defines the high-level structures common to all domains

Connects → Health – Basic Science – Finance & Engineering

<table>
<thead>
<tr>
<th>Domain Level</th>
<th>Information Artifact Ontology (IAO)</th>
<th>Ontology for Biomedical Investigations (OBI)</th>
<th>Spatial Ontology (BSFO)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toplevel</td>
<td>Anatomy Ontology (FMA*, CARO)</td>
<td>Infectious Disease Ontology (IDO*)</td>
<td>Biological Process Ontology (GO*)</td>
</tr>
<tr>
<td></td>
<td>Cell Ontology (CL)</td>
<td>Environment Ontology (ENVO)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cellular Component Ontology (FMA*, GO*)</td>
<td>Phenotypic Quality Ontology (PATO)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Subcellular Anatomy Ontology (SAC)</td>
<td>Sequence Ontology (SO*)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Protein Ontology (PRO*)</td>
<td>Molecular Function (GO*)</td>
<td></td>
</tr>
</tbody>
</table>

- Cell Ontology (NHGRI, NIAID)
- eagle-i and VIVO (NCATS)
- Environment Ontology (GSC)
- Gene Ontology (NHGRI)
- IDO Infectious Disease Ontology (NIAID)
- Nanoparticle Ontology (PNNL)
- Ontology for Risks Against Patient Safety (EU)
- Ontology for Pain, Mental Health and Quality Of Life (NIDCR)
- Plant Ontology (NSF)
- Protein Ontology (NIGMS)
- Translational Medicine Ontology (W3C)
- US Army Biometrics Ontology (DOD)
- Vaccine Ontology (NHBLI)

EHR architecture (Level 2 Ontology: Healthcare Specific)

Core Classes
- Patient
- Clinical State
- Episode of Care
- Documents
- Reports
- Non-Encounter Event
- Encounter
- Abstraction
- Quality Assurance
- Surveillance

Security management Information Base
- Authentication
- Authorization
- Confidentiality
- Integrity
- Non-reputability

Medications
- Allergic
- Non-allergic

Symptoms

Diagnosis

Procedure

Result

Privileged Clinician

Audit Log
- Best Practice Rules
- Temporal Model
- Clinical Reminders

Genomics/Proteomics

Adverse Reactions

Prescription

Order

Prescription

Security Policies

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…………..
Unstructured Text Converted to Indexed & Q.A.’d Electronic Health Record

1. Unstructured Medical Text
2. Parsed Electronic Health Record
3. Indexed Electronic Health Record
4. Q.A.’d Electronic Health Record
RECOMMENDED MEDICATIONS: 

- Hydrochlorothiazide 50 mg q.d.
- Digoxin 0.25 mg to 0.5 mg q.d.
- Spironolactone 100 mg q.d.
- Furosemide 40 mg q.d.

DOCTORS’ OFFICE VISIT: 

- Review current medications and adjust as needed.
- Check blood pressure and renal function.
-.Refer for possible referral to a specialist or further imaging studies.
Visit Purpose

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

History Section

Chief Complaint
Patient is a 57-year-old female with a 20-year history of back pain. She has a history of kidney stones that has been ongoing since her childhood. She has a history of diabetes mellitus, hypertension, and hypercholesterolemia, which has been under control with medication.

Past Medical History
- Diagnosed with diabetes mellitus at age 40. She has been on insulin since age 40.
- Hypertension and hypercholesterolemia, treated with medication.

Family History
- Father had a history of colon cancer in his 50s.
- Father had a history of renal failure.
- Mother had a history of diabetes mellitus.

Social History
- Drinks 2 ounces of alcohol daily. 
- Smokes 1 pack daily and has a 20-year smoking history. Lives with his wife and 2 children.

Review of Systems
- He has no complaints.
- He has a history of hypertension.
- He has a history of diabetes mellitus.
- He has a history of renal failure.
- He has had a history of kidney stones.
- He has a history of obesity.

Physical Examination
- Vital signs: Blood pressure 140/90, heart rate 80, respiratory rate 16, temperature 98.6.
- General appearance: Well-nourished, alert, oriented.

Diagnosis
- Hypertension
- Diabetes mellitus
- Obesity

Plan
- Continue with current medications.
- Refer to nephrologist for further evaluation.
- Refer to diabetologist for further evaluation.

Treatment
- Continue with lifestyle modifications.
- Medications: [list of medications]
FULLY ENCODED CLINICAL RECORD
Case One

Case Two

Multi-Center Data Sharing and Interchange
eStudies: The Semantic Biome: Diabetic patients who had an Acute Myocardial Infarction and did not have Chest Pain
Laboratory Name: Biomedical Informatics Research Group

Rule Engine Results Page

Found 43 matched records.

Processing Time = 00:023.033 Min:Sec

Return to Rule Engine Main Page
**General**


Encounter Diagnoses - Code Name Primary? - Qualifier - ? V70.9L Health Maintenance Examination
### “Five Minute” eStudy . . .

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>pneumonia 233604007 [P] [Explode] [A]</td>
</tr>
<tr>
<td>2</td>
<td>pneumovax 333598008 [P] [Explode] [W]</td>
</tr>
<tr>
<td>3</td>
<td>(1 AND 2)</td>
</tr>
<tr>
<td>4</td>
<td>influenza vaccine 46233009 [P] [Explode] [W]</td>
</tr>
<tr>
<td>5</td>
<td>(1 AND 4)</td>
</tr>
<tr>
<td>6</td>
<td>influenza 6142004 [P] [Explode] [W]</td>
</tr>
<tr>
<td>7</td>
<td>influenza 6142004 [P] [Explode] [A]</td>
</tr>
<tr>
<td>8</td>
<td>(1 AND 7)</td>
</tr>
<tr>
<td>9</td>
<td>(4 AND 8)</td>
</tr>
<tr>
<td>10</td>
<td>streptococcus pneumoniae 58800005 [P] [Explode] [W]</td>
</tr>
<tr>
<td>11</td>
<td>(1 AND 10)</td>
</tr>
<tr>
<td>12</td>
<td>(2 AND 11)</td>
</tr>
<tr>
<td>13</td>
<td>(3 AND 4)</td>
</tr>
</tbody>
</table>

**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 Pneumonae

**6**  
Pneumonia and Strep Pneumonae and Pvx

**8**  
Pneumonia and Influenza vaccine and Pvx

**Pneumonias and Smokers of 469 Pneumonias**

**Pneumonias and Smokers who were counseled to Quit smoking**

**Smokers**

**Smokers who were counseled to quit smoking**
# Automated Identification of Postoperative Complications within an Electronic Medical Record Using Natural Language Processing

**MURPH, ELKIN, ET AL. JAMA, AUGUST 24/31, 2011—VOL 306, NO. 8**

<table>
<thead>
<tr>
<th>Occurrence</th>
<th>Event Rate</th>
<th>Test Characteristic</th>
<th>Natural Language Processing</th>
<th>Patient Safety Indicator</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute renal failure</td>
<td>39/1924</td>
<td>Sensitivity</td>
<td>0.82 (0.67-0.91)</td>
<td>0.36 (0.25-0.54)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Specificity</td>
<td>0.84 (0.73-0.95)</td>
<td>1.00 (1.00-1.00)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Pulmonary embolism/ deep vein thrombosis</td>
<td>45/2327</td>
<td>Sensitivity</td>
<td>0.59 (0.44-0.74)</td>
<td>0.49 (0.32-0.60)</td>
<td>0.30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Specificity</td>
<td>0.81 (0.90-0.92)</td>
<td>0.98 (0.98-0.99)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Sepsis</td>
<td>61/888</td>
<td>Sensitivity</td>
<td>0.85 (0.78-0.94)</td>
<td>0.89 (0.74-0.95)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Specificity</td>
<td>0.94 (0.93-0.96)</td>
<td>0.99 (0.98-0.99)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>222/1406</td>
<td>Sensitivity</td>
<td>0.64 (0.58-0.71)</td>
<td>0.65 (0.59-0.70)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Specificity</td>
<td>0.65 (0.54-0.78)</td>
<td>0.69 (0.63-0.76)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Myocardial infarction</td>
<td>35/1822</td>
<td>Sensitivity</td>
<td>0.91 (0.78-0.97)</td>
<td>0.89 (0.74-0.95)</td>
<td>0.87</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Specificity</td>
<td>0.95 (0.94-0.96)</td>
<td>0.99 (0.98-0.99)</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>
Using DeLong’s method for comparing ROC area, the null hypothesis of equal areas is rejected ($p<0.001$). i.e., the “best” model based on all section symptoms yields a greater area under the ROC curve than that from the “best” model utilizing symptoms only from the Chief Complaint section.

*Comparison of natural language processing biosurveillance methods for identifying influenza from encounter notes.*

Elkin PL, Froehling DA, Wahner-Roedler DL, Brown SH, Bailey KR.

Internal Medicine Provider Report Cards for Target Patient Populations

Provider O

Patients with Diabetes 130

Diabetic Benchmarks

- Hba1c <7: Provider 56.9% vs. DENT 46.6%
- Hba1c 1 yr: Provider 80.0% vs. DENT 75.6%
- LDL <100: Provider 33.8% vs. DENT 35.4%
- LDL 1 yr: Provider 57.7% vs. DENT 58.7%
- MAIb <30: Provider 39.2% vs. DENT 37.5%
- MAIb 1yr: Provider 42.3% vs. DENT 40.9%
- MAIb or Neph: Provider 53.1% vs. DENT 51.8%
- Eye Exam: Provider 20.8% vs. DENT 22.8%

All benchmarks are within a one year period. Patient counts are on a provider level, unless otherwise noted.

Goals for benchmarks are 85% or higher for labs, vaccinations and exams. An 8% improvement from year to year is also considered meeting goals.

Patients with Coronary Artery Disease 65

CAD Benchmarks

- Myocardial Infarction: Provider 3 Pts vs. DENT 47 Pts
- Myo Inf on Beta: Provider 33.3% vs. DENT 21.3%
- LDL Done 1 yr: Provider 50.8% vs. DENT 59.5%
- LDL <100: Provider 35.4% vs. DENT 41.8%
- Diabetes or LVSD: Provider 22 Pts vs. DENT 219 Pts
- Diab/LVSD on Ace/Arb: Provider 77.3% vs. DENT 67.1%
Internal Medicine Provider Report Cards for Target Patient Populations

Provider O

<table>
<thead>
<tr>
<th>Patients Eligible for CRC Screening</th>
<th>Patients Eligible for Mammo Screening</th>
</tr>
</thead>
<tbody>
<tr>
<td>496</td>
<td>423</td>
</tr>
<tr>
<td>Patients Eligible for Cervical Screening</td>
<td>Patients Eligible for Chlamydia Screening</td>
</tr>
<tr>
<td>584</td>
<td>54</td>
</tr>
<tr>
<td>Patients Eligible for Flu Shot</td>
<td>Patients Eligible for Pneumo Shot</td>
</tr>
<tr>
<td>957</td>
<td>264</td>
</tr>
</tbody>
</table>

Preventative Benchmarks

- Colorectal Screening is colonoscopy in the last 10 yrs or FOBT in the last 2 yrs for patients between 50 and 80.
- Mammogram Screening is reporting on women ages 42 to 69.
- Chlamydia Screening is reporting on patients between 18 and 24.
- Cervical Screening is Pap Smear in the last 3 yrs. Flu shot is done with in the last yr and Pneumo is a Pneumococcal vaccination lifetime

<table>
<thead>
<tr>
<th>Preventative Test</th>
<th>Provider</th>
<th>Practice</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRC Screening</td>
<td>39.1%</td>
<td>39.0%</td>
</tr>
<tr>
<td>Mammo Screening</td>
<td>52.5%</td>
<td>56.0%</td>
</tr>
<tr>
<td>Chlamydia Screening</td>
<td>0.0%</td>
<td>2.9%</td>
</tr>
<tr>
<td>Cervical Cancer Screening</td>
<td>4.1%</td>
<td>5.4%</td>
</tr>
<tr>
<td>Flu shot 1yr</td>
<td>46.7%</td>
<td>35.0%</td>
</tr>
<tr>
<td>Pneumo</td>
<td>71.2%</td>
<td>74.0%</td>
</tr>
<tr>
<td>Dx Name</td>
<td>Impactable (1=yes)</td>
<td>Suggested Interventions</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Acute upper respiratory infections of unspecified site</td>
<td>0</td>
<td>Flu Shots, Prevnar Vaccine, Allergy Treatment, Asthma treatment</td>
</tr>
<tr>
<td>Abdominal pain, unspecified site</td>
<td>0</td>
<td>Possible serious diagnoses</td>
</tr>
<tr>
<td>Abdominal pain, unspecified site</td>
<td>0</td>
<td>Very Specialized</td>
</tr>
<tr>
<td>Urinary tract infection, site not specified</td>
<td>1</td>
<td>Prophylaxis, BS control in DM, Supression.</td>
</tr>
<tr>
<td>Abdominal pain, unspecified site</td>
<td>1</td>
<td>Identification of non-cardiac chest pain</td>
</tr>
<tr>
<td>Abdominal pain, unspecified site</td>
<td>1</td>
<td>Identification of non-cardiac chest pain</td>
</tr>
<tr>
<td>Abdominal pain, other specified site</td>
<td>1</td>
<td>Identification of non-cardiac chest pain</td>
</tr>
<tr>
<td>Unspecified otitis media</td>
<td>1</td>
<td>Identification of non-cardiac chest pain</td>
</tr>
<tr>
<td>Other chest pain</td>
<td>1</td>
<td>Identification of non-cardiac chest pain</td>
</tr>
<tr>
<td>Asthma, unspecified type, with (acute) exacerbation</td>
<td>1</td>
<td>Appropriate Asthma Rx, Allergy treatment, Ambulatory sensitive condition</td>
</tr>
<tr>
<td>Vomiting alone</td>
<td>1</td>
<td>Many ambulatory sensitive conditions, Hyperemesis Gravidarum, GERD, Ulcers, Food Allergies</td>
</tr>
<tr>
<td>Headache</td>
<td>1</td>
<td>Encouraging non-narcotic treatment</td>
</tr>
<tr>
<td>Threatened abortion, antepartum condition or complication</td>
<td>0</td>
<td>Urgent conditions</td>
</tr>
<tr>
<td>Unspecified viral infection</td>
<td>1</td>
<td>Ambulatory sensitive</td>
</tr>
<tr>
<td>Abdominal pain, other specified site</td>
<td>0</td>
<td>Although some may easily be treated as an outpatient some are very serious and any strategy may miss these cases</td>
</tr>
<tr>
<td>Acute pharyngitis</td>
<td>1</td>
<td>Ambulatory sensitive</td>
</tr>
<tr>
<td>Pneumonia, organism unspecified</td>
<td>1</td>
<td>CAP is mostly an outpatient disorder</td>
</tr>
<tr>
<td>Influenza with other respiratory manifestations</td>
<td>1</td>
<td>Ambulatory sensitive</td>
</tr>
<tr>
<td>Acute bronchitis due to other infectious organisms</td>
<td>1</td>
<td>Ambulatory sensitive</td>
</tr>
<tr>
<td>Acute appendicitis without mention of peritonitis</td>
<td>0</td>
<td>An emergent condition</td>
</tr>
<tr>
<td>Head injury, unspecified</td>
<td>1</td>
<td>Although you may think this not, for DD population any small fall where there is head contact may be in this category</td>
</tr>
<tr>
<td>Acute bronchitis</td>
<td>1</td>
<td>Ambulatory sensitive</td>
</tr>
<tr>
<td>Contusion of face, scalp, and neck except eye(s)</td>
<td>0</td>
<td>Could be emergent</td>
</tr>
<tr>
<td>Other convulsions</td>
<td>0</td>
<td>Seizures should be evaluated</td>
</tr>
<tr>
<td>Nausea with vomiting</td>
<td>1</td>
<td>Many causes of N&amp;V are not emergencies</td>
</tr>
<tr>
<td>Syncope and collapse</td>
<td>0</td>
<td>Even though these can be prevented in Diabetics for instance if you actually passout you need evaluation</td>
</tr>
<tr>
<td>Asthma, unspecified type, unspecified</td>
<td>1</td>
<td>Ambulatory sensitive</td>
</tr>
<tr>
<td>Croup</td>
<td>1</td>
<td>Ambulatory sensitive</td>
</tr>
<tr>
<td>Bronchitis, not specified as acute or chronic</td>
<td>1</td>
<td>Ambulatory sensitive</td>
</tr>
<tr>
<td>Strepococcal sore throat</td>
<td>1</td>
<td>Ambulatory sensitive</td>
</tr>
<tr>
<td>Acute bronchitis due to respiratory syncytial virus (RSV)</td>
<td>1</td>
<td>Ambulatory sensitive</td>
</tr>
<tr>
<td>Abdominal pain, right lower quadrant</td>
<td>1</td>
<td>Ambulatory sensitive</td>
</tr>
<tr>
<td>Abdominal pain, epigastric</td>
<td>0</td>
<td>Could be appendicitis</td>
</tr>
<tr>
<td>Diarrhea</td>
<td>1</td>
<td>Can be gastritis, or PUD which are both best initially treated as an outpatient</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Ambulatory sensitive and often self limited</td>
</tr>
</tbody>
</table>
Personal Care – Total - $1,436,086

- WILL CARE INC 00811069
- WESTERN NEW YORK INDEPENDENT LIVING 02407789
- PEOPLE SERVICES TO THE DD INC 01048017
- NIAGARA HOMEMAKER SERVICES 00887976
- INTERIM HLTH CARE/BUFFALO 00866726
- OTSEGO CNTY PUBLIC HLTH NUR 02689958
- DALE ASSOCIATION INC 01751028
- HEALTH ASSOC OF NIAGARA CO 00888000
- ANGELS IN YOUR HOME 03073883
- CENTER FOR DISABILITY RIGHTS 01945688
- RESOURCE CTR FOR INDEPENDENT LIVING 00974121
- INTERIM HEALTHCARE OF ROCHESTER INC 03157426

Home Health Agencies Total - $750,501

- VNA OF WESTERN NY INC 00321857
- MCAULEY-SETON HOME CARE CORP. 01080735
- HCR 01102432
- TLCHCS OF ERIE NIAGARA LLC 02640086
- CAH HERITAGE CHRISTIAN SERVIC 01940663
- MEDINA MEMORIAL HOSPITAL 03000855
- CAH ASPIRE OF WNY INC 02001449
Region 1 Costs per Service – Total Costs $1,496,889,494
Skilled Nursing Facility - Total Costs - $1,631,423

Medicaid Participants – 27,121

Medicaid Spending - Total $1,496,889,494

- Managed Care
- FHP
- FFS
Proportional Service Costs = $102,570,625
Managed Care Cost by OutPatient Encounter Type

Drug Costs by Drug Class

- 3439  INFANTILE CEREBRAL PALSY, UNSPECIFIED
- 33519 OTHER SPINAL MUSCULAR ATROPHY
- 33519 OTHER SPINAL MUSCULAR ATROPHY
- 78099 OTHER GENERAL SYMPTOMS
- 3432  CONGENITAL QUADRIPLEGIA
- 7999  OTHER UNKNOWN AND UNSPECIFIED CAUSE OF M
- 43491 CEREBRAL ARTERY OCCLUSION, UNSPECIFIED W
- 78039 OTHER CONVULSIONS
- 29900 AUTISTIC DISORDER, CURRENT OR ACTIVE STA
- 34830 ENCEPHALOPATHY, UNSPECIFIED

- ANTICONVULSANTS
- ATARACTICS-TRANQUILIZERS
- ANTIVIRALS
- DIABETIC THERAPY
- ANTAGSPASMOMICS,ANTICHOLINERGIC
- NASAL & OTIC PREPARATIONS,TOPI
- CNS STIMULANTS
- BRONCHIAL-DILATORS
- UNCLASSIFIED DRUG PRODUCTS
- PSYCHOSTIMULANTS-ANTIDEPRESSAN
- ANTI-UlCER PREPARATIONS
- GLUCOCORTICOIDS
- LAXATIVES
# SEMANTIC GENETIC CLUSTERING VS HCLUST

Clustered 17,180 of the 27,335 human genes vs. 5,553 genes (P< 0.001)

<table>
<thead>
<tr>
<th>Method</th>
<th>Clustered Genes</th>
<th>Unclustered Genes</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional</td>
<td>4,100 had Articles</td>
<td>4,178 had Articles</td>
<td>P=0.228</td>
</tr>
<tr>
<td>Semantic</td>
<td>38,820 had Articles</td>
<td>28,839 had Articles</td>
<td>P&lt;0.001</td>
</tr>
</tbody>
</table>

## Semantic Method

<table>
<thead>
<tr>
<th></th>
<th>True Cluster</th>
<th>Negative Cluster</th>
<th>Predictive Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clustered</td>
<td>1284</td>
<td>0</td>
<td>100%</td>
</tr>
<tr>
<td>Unclustered</td>
<td>6</td>
<td>734</td>
<td>99.2%</td>
</tr>
<tr>
<td></td>
<td>Sensitivity – 99.5%</td>
<td>Specificity – 100%</td>
<td></td>
</tr>
</tbody>
</table>

## Traditional Method

<table>
<thead>
<tr>
<th></th>
<th>True Cluster</th>
<th>Negative Cluster</th>
<th>Predictive Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clustered</td>
<td>861</td>
<td>0</td>
<td>100%</td>
</tr>
<tr>
<td>Unclustered</td>
<td>429</td>
<td>3325</td>
<td>88.6%</td>
</tr>
<tr>
<td></td>
<td>Sensitivity – 66.7%</td>
<td>Specificity – 100%</td>
<td></td>
</tr>
</tbody>
</table>
AIM: DEVELOP A CANCER SPECIFIC TRANSLATIONAL RESEARCH PIPELINE USING VA DATA CLINICAL, GENOMIC AND PROTEOMIC DATA

• Clinical

Functional: Cancer Metabolome

Structural: Proteome and Small Molecules

Structure and Function = Accurate Predictions => Bench Validations Toward a cure for Lung Cancer
CONCLUSIONS

• The Practice of Medicine is Changing to be driven by Quality
• Electronic Quality monitoring eQuality is essential to our success
• Informatics tools are driving the change of Health and Healthcare from a being a cottage industry to a systematized practice of care
• Mathematical and Computer Science skills can complement Medicine and Biology in this transformation
“...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.”

Nicolo Machiavelli c. 1505
“THE BEST WAY TO PREDICT THE FUTURE, IS TO CREATE IT.”
---- PETER DRUCKER
(HARVARD UNIVERSITY)