Opportunities for Collaboration Between Biomedical Informatics and Basic, Clinical, and Translational Sciences

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- What kinds of problems does informatics address?
- What types of scientific methods does informatics use?
- Who funds informatics science?
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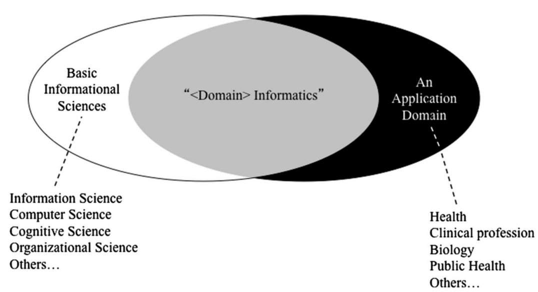
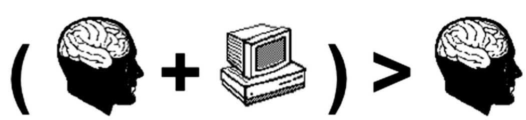
What is biomedical (and health) informatics?

- *Biomedical and health informatics* is the science of using data and information, often aided by technology, to improve individual health, health care, public health, and biomedical research (Hersh, 2009)
  - It is about information, not technology
- Practitioners of informatics are usually called *informaticians* (sometimes *informaticists*)

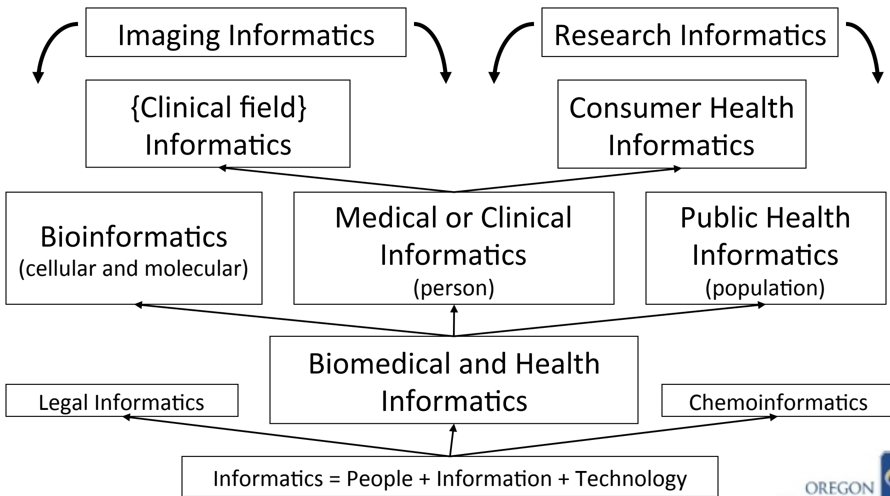
What informatics is and isn't (Friedman, 2012)

- Is
  - Cross-training
  - Making people better at what they do
- Is not
  - Analyzing large data sets per se
  - Employment in circumscribed information technology (IT) roles
  - Anything done using a computer





There are many flavors (sub-areas) of informatics (Hersh, 2009)



Sidebar: What is DMICE?

- The Department of Medical Informatics and Clinical Epidemiology, a department in the OHSU School of Medicine (SOM)
- Classified as a clinical department even though has no clinic and does have a graduate educational program
- Has a very basic science component: Division of Bioinformatics & Computational Biology
- Highly collaborative, not only in SOM
- Most years ranks about 4th-6th out of the 26 departments in external research funding

Questions addressed in this talk

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What kinds of problems does informatics address?

- Data
  - Entry and capture
  - Analysis
  - Standards and interoperability
- Information
  - Management
  - Access
  - Privacy and security
- Knowledge
  - Application
- Systems
  - Biological and medical
  - Information
- People
  - Usability
  - Workflow
  - Safety
- Organizations
  - Management
  - Outcomes and analytics

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A substantial amount of informatics is motivated by problems in healthcare

- Contextualized by recent IOM report (Smith, 2012)
  - $750B in waste (out of $2.5T system)
  - 75,000 premature deaths
- Sources of waste
  - Unnecessary services provided
  - Services inefficiently delivered
  - Prices too high relative to costs
  - Excess administrative costs
  - Missed opportunities for prevention
  - Fraud

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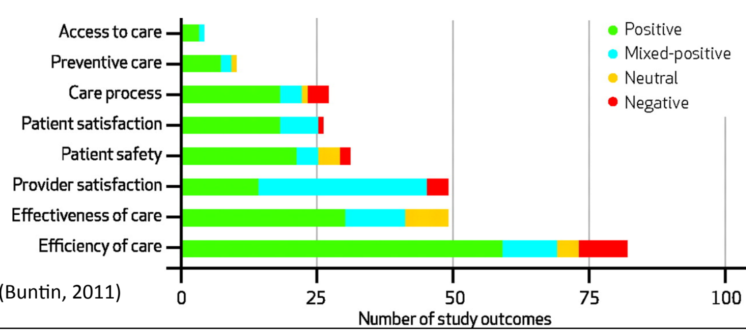
Growing evidence that information interventions are part of solution

- Systematic reviews (Chaudhry, 2006; Goldzweig, 2009; Buntin, 2011) have identified benefits in a variety of areas
  - Although 18-25% of studies come from a small number of 'health IT leader" institutions



(Buntin, 2011)

Informatics being enabled by recent federal investments

"To improve the quality of our health care while lowering its cost, we will make the immediate investments necessary to ensure that within five years, all of America's medical records are computerized … It just won't save billions of dollars and thousands of jobs – it will save lives by reducing the deadly but preventable medical errors that pervade our health care system."
January 5, 2009

Health Information Technology for Economic and Clinical Health (HITECH) Act of the American Recovery and Reinvestment Act (ARRA) (Blumenthal, 2011)

- Incentives for electronic health record (EHR) adoption by physicians and hospitals (up to $27B)
- Direct grants administered by federal agencies ($2B)

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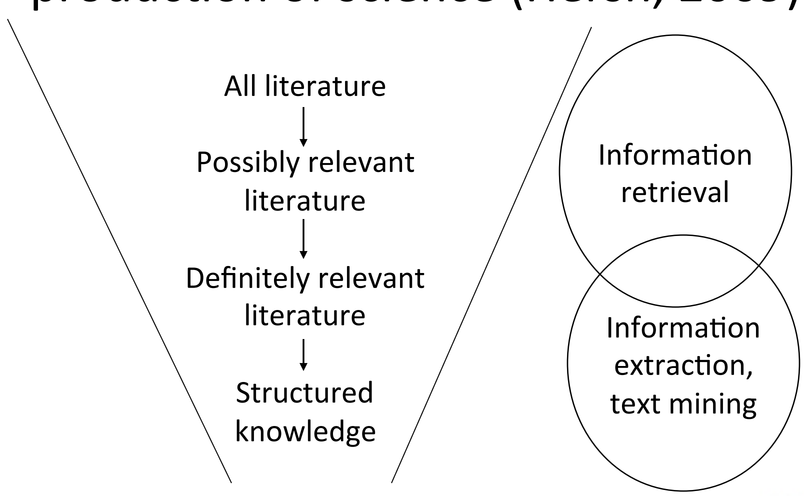
Informatics can also help the production of science (Hersh, 2009)



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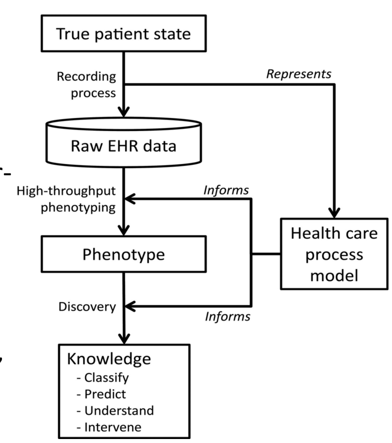
Growing focus on "secondary use" or re-use of clinical data

- Many "secondary uses" or re-uses of electronic health record (EHR) data, including (Safran, 2007; Geissbuhler, 2012)
  - Clinical and translational research – generating hypotheses and facilitating research
  - Public health surveillance for emerging threats
  - Healthcare quality measurement and improvement
- Enabled by growing development of research databases, e.g.,
  - HMO Research Network Virtual Data Warehouse (Hornbrook, 2005)
  - Clinical and Translational Research Award (CTSA) investments (MacKenzie, 2012; Anderson, 2012)
- Exemplified by demonstration of the phenotype in EHR being used with the genotype to replicate known genome-wide associations as well as identify new ones, e.g., eMERGE (Kho, 2011; Denny, 2010; Denny, 2010)

But there are challenges for secondary use of clinical data

- Data quality and accuracy is not a top priority for busy clinicians (deLusignan, 2005)
- Many data points, e.g., average pediatric ICU patient generates 1348 information items per 24 hours (Manor-Shulman, 2008)
- Little research, but problems identified
  - EHR data can be incorrect and incomplete, especially for longitudinal assessment (Berlin, 2011)
  - Much data is "locked" in text (Hripcsak, 2012)
  - Many steps in ICD-9 coding can lead to incorrectness or incompleteness (O'Malley, 2005)



(Hripcsak, 2012)

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There are many "idiosyncracies" of clinical data that undermine research

- (Weiner, 2011)
- "Left censoring": First instance of disease in record may not be when first manifested
- "Right censoring": Data source may not cover long enough time interval
- Data might not be captured from other clinical (other hospitals or health systems) or non-clinical (OTC drugs) settings
- Bias in testing or treatment
- Institutional or personal variation in practice or documentation styles
- Inconsistent use of coding or standards

Patients also get care at multiple sites

- Study of 3.7M patients in Massachusetts found 31% visited 2 or more hospitals over 5 years (57% of all visits) and 1% visited 5 or more hospitals (10% of all visits) (Bourgeois, 2010)
- Study of 2.8M emergency department (ED) patients in Indiana found 40% of patients had data at multiple institutions, with all 81 EDs sharing patients in a completely connected network (Finnell, 2011)
- Being addressed by growing development of health information exchange (HIE) (Kuperman, 2011)
  - "Data following the patient" – Carolyn Clancy, MD, Agency for Healthcare Research and Quality (AHRQ)

What kinds of methods does informatics use?

- Too numerous to fully enumerate in a talk like this, so will focus on one set of examples in areas of
  - Data mining (Bellazi, 2008)
  - Text mining – applying natural language processing (NLP) (Nadkarni, 2011; Rebholz-Schuhmann, 2012)
  - Information retrieval (IR) – also called "search" (Hersh, 2009)
- Methods usually involve application of these to specific biomedical problems, often assessed with test collections consisting of
  - Defined use case(s)
  - Realistic collection of data
  - Specific instances of tasks (e.g., queries)
  - Gold standard for outcome from task (using human judgments)

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Research often measured/driven by "challenge evaluations"

- Text Retrieval Conference (TREC, trec.nist.gov) – focus on IR, mostly non-biomedical, but has included
  - Retrieval of genomics literature (Hersh, 2009)
  - Retrieval of medical records (Voorhees, 2011-2012)
- Biocreative (www.biocreative.org) – focus on application of NLP to annotation of genes, proteins, pathways, etc. (Hirschman, 2005; Krallinger, 2007; Arighi, 2011)
- i2b2 (www.i2b2.org/NLP) – focus on NLP in medical records (Uzuner, 2007-2012)

TREC Medical Records Track

- Task – identify patients who are possible candidates for clinical studies/trials
- Documents from large-scale, de-identified data set developed by University of Pittsburgh Medical Center (UPMC)
- Topics derived from 100 top critical medical research priorities in comparative effectiveness research (IOM, 2009) and other information "needs"
- Relevance judgments by OHSU informatics students who were physicians on documents "pooled" from results of all participating research groups

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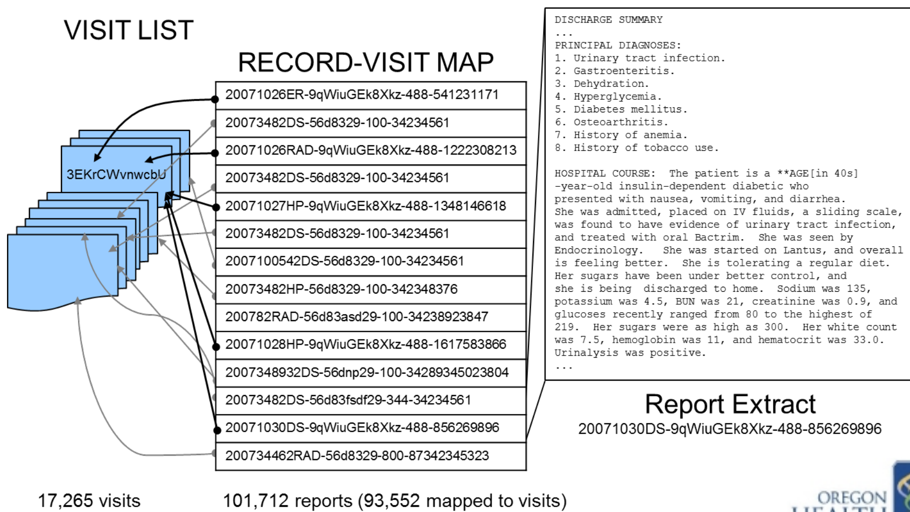
Test collection



(Courtesy, Ellen Voorhees, NIST)

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Some issues for test collection

- De-identified to remove protected health information (PHI), e.g., age number → range
- De-identification precludes linkage of same patient across different visits (encounters)
- UPMC only authorized use for TREC 2011 and TREC 2012 but nothing else, including any other research (unless approved by UPMC)

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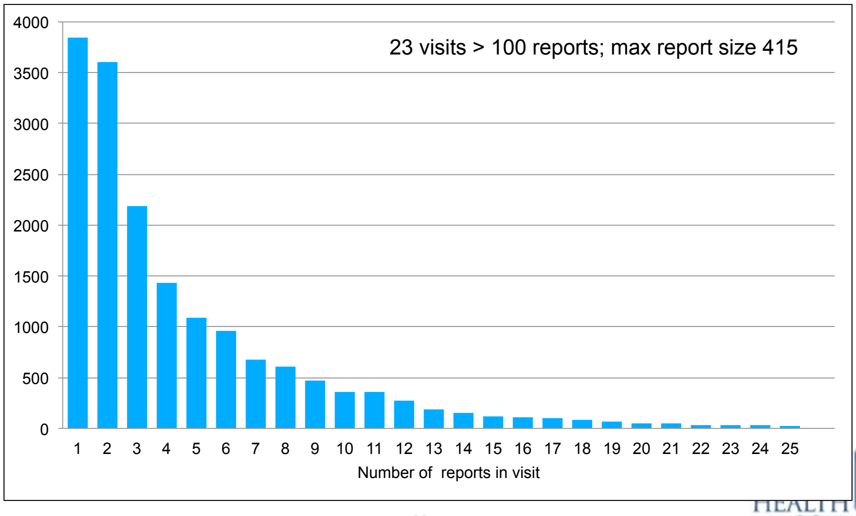
Number of documents per visit highly variable



(Courtesy, Ellen Voorhees, NIST)

What do we measure in IR?

- Recall (equivalent to sensitivity)

$$R = \frac{\#\,retrieved\ and\ relevant\ documents}{\#\,relevant\ documents\ in\ collection}$$

  - Usually use *relative recall* when not all relevant documents known, where denominator is number of known relevant documents in collection
- Precision (equivalent to positive predictive value)

$$P = \frac{\#\,retrieved\ and\ relevant\ documents}{\#\,retrieved\ documents}$$

- Aggregate measures combine both and adjust for non-judged documents
  - Mean average precision (MAP) (Harman, 2005)
  - Binary preference (bpref) (Buckley, 2004)
  - Normal discounted cumulative gain (NDCG) (Jarvelin, 2002)
  - Inferred measures (Yilmaz, 2008)
- All of above averaged over topics in test collection

Overview of track

- Participating groups perform and submit "runs," consisting of ranked list of up to 1000 visits per topic for each topic
- Runs classified as
  - Automatic – no human intervention from input of topic statement to output of ranked list
  - Manual – everything else
- Participation from
  - 29 groups in 2011
  - 24 groups in 2012
  - Including OHSU (Bedrick, 2011; Bedrick, 2012)

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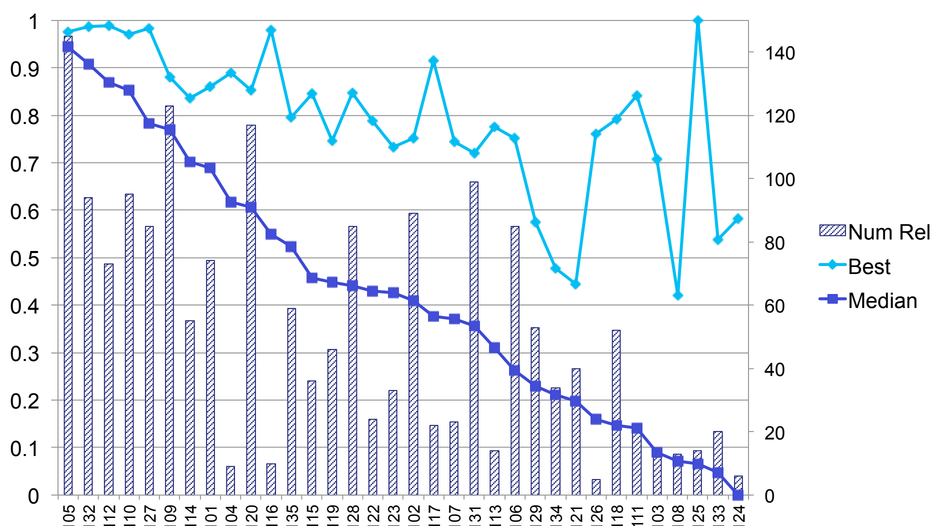
A common phenomenon: wide variation in results among topics



Easy and hard topics

- Easiest – best median bpref
  - 105: Patients with dementia
  - 132: Patients admitted for surgery of the cervical spine for fusion or discectomy
- Hardest – worst best bpref and worst median bpref
  - 108: Patients treated for vascular claudication surgically
  - 124: Patients who present to the hospital with episodes of acute loss of vision secondary to glaucoma
- Large differences between best and median bpref
  - 125: Patients co-infected with Hepatitis C and HIV
  - 103: Hospitalized patients treated for methicillin-resistant Staphylococcus aureus (MRSA) endocarditis
  - 111: Patients with chronic back pain who receive an intraspinal pain-medicine pump

Failure analysis for 2011 topics (Edinger, 2012)

Reasons for Incorrect Retrieval	Number of Visits	Number of Topics
Visits Judged Not Relevant		
Topic terms mentioned as future possibility	16	9
Topic symptom/condition/procedure done in the past	22	9
All topic criteria present but not in the time/sequence specified by the topic description	19	6
Most, but not all, required topic criteria present	17	8
Topic terms denied or ruled out	19	10
Notes contain very similar term confused with topic term	13	11
Non-relevant reference in record to topic terms	37	18
Topic terms not present—unclear why record was ranked highly	14	8
Topic present—record is relevant—disagree with expert judgment	25	11
Visits Judged Relevant		
Topic not present—record is not relevant—disagree with expert judgment	44	21
Topic present in record but overlooked in search	103	27
Visit notes used a synonym or lexical variant for topic terms	22	10
Topic terms not named in notes and must be inferred	3	2
Topic terms present in diagnosis list but not visit notes	5	5

Results and future directions

- Some generalizations from results
  - Many approaches that work in general IR did not work here
  - Expert-developed Boolean queries obtained best results
- Future directions
  - UPMC getting "cold feet" on widespread use of data; investigating other sources
  - A growing challenge in this type of research is getting access to realistic data; not helped by persistent security breaches in healthcare organizations

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Who funds informatics science?

- National Institutes of Health (NIH) – all institutes but "primary" institute is National Library of Medicine (NLM)
- Other agencies of Dept. of Health & Human Services (HHS) – especially Agency for Healthcare Research & Quality (AHRQ)
- Other governmental agencies – to extent "not medical," National Science Foundation (NSF)

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How does one get educated in BMHI?

- Educational programs at growing number of institutions
  - http://www.amia.org/informatics-academic-training-programs
- OHSU program one of largest and well-established (Hersh, 2007)
  - Graduate level programs at Certificate, Master's, and PhD levels
  - "Building block" approach allows courses to be carried forward to higher levels
- Education historically oriented to researchers, but increasing amount of professional education
  - Growing need for informatics professionals in a variety of settings (Hersh, 2010)
  - New subspecialty for physicians recently approved (Detmer, 2010)

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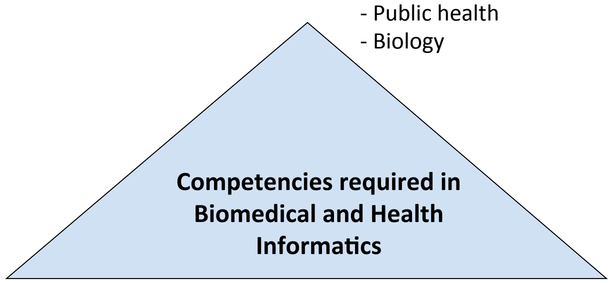
What competencies must informaticians have? (Hersh, 2009)

<u>Health and biological sciences</u>:
- Medicine, nursing, etc.
- Public health
- Biology



<u>Management and social sciences</u>:
- Business administration
- Human resources
- Organizational behavior

<u>Computational and mathematical sciences</u>:
- Computer science
- Information technology
- Statistics

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Overview of OHSU graduate programs

PhD
- Knowledge Base
- Advanced Research Methods
- Biostatistics
- Cognate
- Advanced Topics
- Doctoral Symposium
- Mentored Teaching
- Dissertation

Masters
- Tracks:
  - Clinical Informatics
  - Bioinformatics
- Thesis or Capstone

Graduate Certificate
- Tracks:
  - Clinical Informatics
  - Health Information Management

10x10
- Or introductory course

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Questions addressed in this talk

- What is biomedical informatics (and DMICE)?
- What kinds of problems does informatics address?
- What types of scientific methods does informatics use?
- Who funds informatics science?
- How does one get educated in informatics?
- Where are there opportunities for collaboration of informatics with basic, clinical, and translational research?

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Opportunities for collaboration

- Almost anywhere along the spectrum of basic, clinical, and translational science
- My view is that opportunities are in areas that advance human health, e.g.,
  - Personalized medicine – how do we help clinicians and patients make decisions that involved increasing amounts of data and complexity?
  - How do we take advantage of the growing quantity of data in operational clinical systems?
  - How do we improve the quality of that data?
  - How do we incorporate new technologies into clinical care, e.g., mobile devices, patient sensoring, ubiquitous networks, etc.?
  - How do we leverage this data for informatics research?
- Your view?

For more information

- Bill Hersh
  - http://www.billhersh.info
- Informatics Professor blog
  - http://informaticsprofessor.blogspot.com
- OHSU Department of Medical Informatics & Clinical Epidemiology (DMICE)
  - http://www.ohsu.edu/informatics
  - http://www.youtube.com/watch?v=T-74duDDvwU
  - http://oninformatics.com
- What is Biomedical and Health Informatics?
  - http://www.billhersh.info/whatis
- Office of the National Coordinator for Health IT (ONC)
  - http://healthit.gov
- American Medical Informatics Association (AMIA)
  - http://www.amia.org
- National Library of Medicine (NLM)
  - http://www.nlm.nih.gov