Biomedical and Health Informatics: Improving Health, Healthcare, and Biomedical Research with Information and Technology

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References

Angrisano, C, Farrell, D, et al. (2007). Accounting for the Cost of Health Care in the United States. Washington, DC, McKinsey & Company. http://www.mckinsey.com/mgi/rp/healthcare/accounting_cost_healthcare.asp

Anonymous (2010). The State of Health Care Quality: 2010. Washington, DC, National Committee for Quality Assurance. http://www.ncqa.org/tabid/836/Default.aspx

Anonymous (2011). Health at a Glance 2011. Paris, France, Organisation for Economic Co-operation and Development (OECD). http://www.oecd.org/health/healthataglance

Berwick, DM and Hackbarth, AD (2012). Eliminating waste in US health care. *Journal of the American Medical Association*. 307: 1513-1516.

Berwick, DM, Nolan, TW, et al. (2008). The triple aim: care, health, and cost. *Health Affairs*. 27: 759-769.

Blumenthal, D (2010). Launching HITECH. *New England Journal of Medicine*. 362: 382-385.

Blumenthal, D (2011). Implementation of the federal health information technology initiative. *New England Journal of Medicine*. 365: 2426-2431.

Blumenthal, D (2011). Wiring the health system--origins and provisions of a new federal program. *New England Journal of Medicine*. 365: 2323-2329.

Blumenthal, D and Tavenner, M (2010). The "meaningful use" regulation for electronic health records. *New England Journal of Medicine*. 363: 501-504.

Bourgeois, FC, Olson, KL, et al. (2010). Patients treated at multiple acute health care facilities: quantifying information fragmentation. *Archives of Internal Medicine*. 170: 1989-1995.

Buntin, MB, Burke, MF, et al. (2011). The benefits of health information technology: a review of the recent literature shows predominantly positive results. *Health Affairs*. 30: 464-471.

Butler, D (2013). When Google got flu wrong. *Nature*. 494: 155-156.

Chapman, WW, Christensen, LM, et al. (2004). Classifying free-text triage chief complaints into syndromic categories with natural language processing. *Artificial Intelligence in Medicine*. 33: 31-40.

Chaudhry, B, Wang, J, et al. (2006). Systematic review: impact of health information technology on quality, efficiency, and costs of medical care. *Annals of Internal Medicine*. 144: 742-752.

Classen, DC, Resar, R, et al. (2011). 'Global trigger tool' shows that adverse events in hospitals may be ten times greater than previously measured. *Health Affairs*. 30: 4581-4589.
deLusignan, S and vanWeel, C (2005). The use of routinely collected computer data for research in primary care: opportunities and challenges. *Family Practice*. 23: 253-263.
Denny, JC, Ritchie, MD, et al. (2010). PheWAS: Demonstrating the feasibility of a phenome-wide scan to discover gene-disease associations. *Bioinformatics*. 26: 1205-1210.
Finnell, JT, Overhage, JM, et al. (2011). All health care is not local: an evaluation of the distribution of emergency department care delivered in Indiana. *AMIA Annual Symposium Proceedings*, Washington, DC. 409-416.
Fleurence, RL, Curtis, LH, et al. (2014). Launching PCORnet, a national patient-centered clinical research network. *Journal of the American Medical Informatics Association*: Epub ahead of print.
Gerbier, S, Yarovaya, O, et al. (2011). Evaluation of natural language processing from emergency department computerized medical records for intra-hospital syndromic surveillance. *BMC Medical Informatics & Decision Making*. 11: 50. http://www.biomedcentral.com/1472-6947/11/50
Ginsberg, J, Mohebbi, MH, et al. (2009). Detecting influenza epidemics using search engine query data. *Nature*. 457: 1012-1014.
Goldzweig, CL, Towfigh, A, et al. (2009). Costs and benefits of health information technology: new trends from the literature. *Health Affairs*. 28: w282-w293.
Greiner, AC and Knebel, E, Eds. (2003). Health Professions Education: A Bridge to Quality. Washington, DC, National Academies Press.
Henning, KJ (2004). What is syndromic surveillance? *Morbidity and Mortality Weekly Report*. 53(Suppl): 5-11. http://www.cdc.gov/mmwr/preview/mmwrhtml/su5301a3.htm
Hersh, W (2004). Health care information technology: progress and barriers. *Journal of the American Medical Association*. 292: 2273-2274.
Hersh, W (2009). A stimulus to define informatics and health information technology. *BMC Medical Informatics & Decision Making*. 9: 24. http://www.biomedcentral.com/1472-6947/9/24/
Hersh, W (2010). The health information technology workforce: estimations of demands and a framework for requirements. *Applied Clinical Informatics*. 1: 197-212.
Hersh, WR (2007). The full spectrum of biomedical informatics education at Oregon Health & Science University. *Methods of Information in Medicine*. 46: 80-83.
Hersh, WR, Gorman, PN, et al. (2014). Beyond information retrieval and EHR use: competencies in clinical informatics for medical education. *Advances in Medical Education and Practice*: in press.
Hersh, WR, Weiner, MG, et al. (2013). Caveats for the use of operational electronic health record data in comparative effectiveness research. *Medical Care*. 51(Suppl 3): S30-S37.
Hoyt, RE and Yoshihashi, A, Eds. (2014). Health Informatics: Practical Guide for Healthcare and Information Technology Professionals, Sixth Edition. Pensacola, FL, Lulu.com.
Hripcsak, G and Albers, DJ (2012). Next-generation phenotyping of electronic health records. *Journal of the American Medical Informatics Association*. 20: 117-121.
Hsiao, CJ and Hing, E (2014). Use and Characteristics of Electronic Health Record Systems Among Office-based Physician Practices: United States, 2001–2013. Hyattsville, MD,

National Center for Health Statistics.
http://www.cdc.gov/nchs/data/databriefs/db143.htm
James, JT (2013). A new, evidence-based estimate of patient harms associated with hospital care. *Journal of Patient Safety*. 13: 122-128.
Jones, SS, Rudin, RS, et al. (2014). Health information technology: an updated systematic review with a focus on meaningful use. *Annals of Internal Medicine*. 160: 48-54.
Kann, M and Lewitter, F, Eds. (2013). Translational Bioinformatics. San Francisco, CA, Public Library of Science.
Kellermann, AL and Jones, SS (2013). What will it take to achieve the as-yet-unfulfilled promises of health information technology? *Health Affairs*. 32: 63-68.
Kho, AN, Pacheco, JA, et al. (2011). Electronic medical records for genetic research: results of the eMERGE Consortium. *Science Translational Medicine*. 3: 79re71.
http://stm.sciencemag.org/content/3/79/79re1.short
Klompas, M, McVetta, J, et al. (2012). Integrating clinical practice and public health surveillance using electronic medical record systems. *American Journal of Preventive Medicine*. 42(6S2): S154-S162.
Kohn, LT, Corrigan, JM, et al., Eds. (2000). To Err Is Human: Building a Safer Health System. Washington, DC, National Academies Press.
Kuperman, GJ (2011). Health-information exchange: why are we doing it, and what are we doing? *Journal of the American Medical Informatics Association*. 18: 678-682.
Lazer, D, Kennedy, R, et al. (2014). Big data. The parable of Google Flu: traps in big data analysis. *Science*. 343: 1203-1205.
Manor-Shulman, O, Beyene, J, et al. (2008). Quantifying the volume of documented clinical information in critical illness. *Journal of Critical Care*. 23: 245-250.
McGlynn, EA, Asch, SM, et al. (2003). The quality of health care delivered to adults in the United States. *New England Journal of Medicine*. 348: 2635-2645.
Richesson, RL and Andrews, JE, Eds. (2012). Clinical Research Informatics. New York, NY, Springer.
Safran, C, Bloomrosen, M, et al. (2007). Toward a national framework for the secondary use of health data: an American Medical Informatics Association white paper. *Journal of the American Medical Informatics Association*. 14: 1-9.
Schoen, C, Osborn, R, et al. (2009). A survey of primary care physicians in eleven countries, 2009: perspectives on care, costs, and experiences. *Health Affairs*. 28: w1171-1183.
Selby, JV, Beal, AC, et al. (2012). The Patient-Centered Outcomes Research Institute (PCORI) national priorities for research and initial research agenda. *Journal of the American Medical Association*. 307: 1583-1584.
Shortliffe, EH (2011). President's column: subspecialty certification in clinical informatics. *Journal of the American Medical Informatics Association*. 18: 890-891.
Shortliffe, EH and Cimino, JJ, Eds. (2014). Biomedical Informatics: Computer Applications in Health Care and Biomedicine (Fourth Edition). London, England, Springer.
Smith, M, Saunders, R, et al. (2012). Best Care at Lower Cost: The Path to Continuously Learning Health Care in America. Washington, DC, National Academies Press.
Smith, PC, Araya-Guerra, R, et al. (2005). Missing clinical information during primary care visits. *Journal of the American Medical Association*. 293: 565-571.
Tannen, RL, Weiner, MG, et al. (2008). Replicated studies of two randomized trials of angiotensin-converting enzyme inhibitors: further empiric validation of the 'prior event

rate ratio' to adjust for unmeasured confounding by indication. *Pharmacoepidemiology and Drug Safety*. 17: 671-685.
Tannen, RL, Weiner, MG, et al. (2009). Use of primary care electronic medical record database in drug efficacy research on cardiovascular outcomes: comparison of database and randomised controlled trial findings. *British Medical Journal*. 338: b81. http://www.bmj.com/cgi/content/full/338/jan27_1/b81
Tannen, RL, Weiner, MG, et al. (2007). A simulation using data from a primary care practice database closely replicated the Women's Health Initiative trial. *Journal of Clinical Epidemiology*. 60: 686-695.

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Outline

- Problems in our healthcare system and a vision for fixing them
- Biomedical and health informatics is part of the solution
- Opportunities and challenges for informatics
- Informatics at OHSU

Some problems in healthcare have information-related solutions

- Quality – not as good as it could be (McGlynn, 2003; Schoen, 2009; NCQA, 2010)
- Safety – errors cause morbidity and mortality; many preventable (Kohn, 2000; Classen, 2011; James, 2013)
- Cost – rising costs not sustainable; US spends more but gets less (Angrisano, 2007; OECD, 2011)
- Inaccessible information – missing information frequent in primary care (Smith, 2005)

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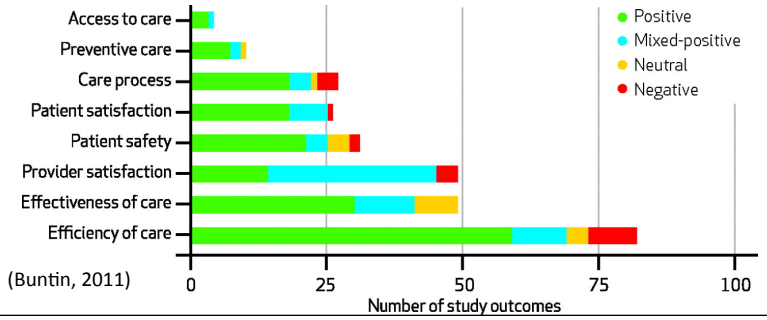
There is evidence that information interventions are part of solution

- Systematic reviews (Chaudhry, 2006; Goldzweig, 2009; Buntin, 2011; Jones, 2014) 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)

Some visions for solving healthcare problems

- Action must be taken to address (Smith, 2012)
  - $750B in waste (out of $2.5T system)
  - 75,000 premature deaths
- Sources of waste – from Berwick (2012)
  - Unnecessary services provided
  - Services inefficiently delivered
  - Prices too high relative to costs
  - Excess administrative costs
  - Missed opportunities for prevention
  - Fraud
- One vision for repair is the IOM's "learning healthcare system" (Smith, 2012)

http://www.iom.edu/Reports/2012/Best-Care-at-Lower-Cost-The-Path-to-Continuously-Learning-Health-Care-in-America.aspx

Triple aim (Berwick, 2008)
- Better care
- Better health
- Lower cost

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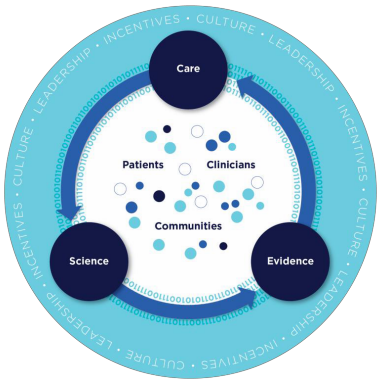
We need to go from:

(Smith, 2012)

To:



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Features of a "continuously learning healthcare system" (Smith, 2012)

- Records immediately updated and available for use by patients
- Care delivered the has been proven "reliable at the core and tailored at the margins"
- Patient and family needs and preferences are a central part of the decision process
- All healthcare team members are fully informed about each other's activities in real time
- Prices and total costs are fully transparent to all participants in the care process
- Incentives for payment are structured to "reward outcomes and value, not volume"
- Errors are promptly identified and corrected
- Outcomes are routinely captured and used for continuous improvement

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What is role of biomedical and health informatics?

- *Biomedical and health informatics* (BMHI) 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 are BMHI are usually called *informaticians* (sometimes *informaticists*)
- Overview textbooks: Shortliffe, 2014; Hoyt, 2014

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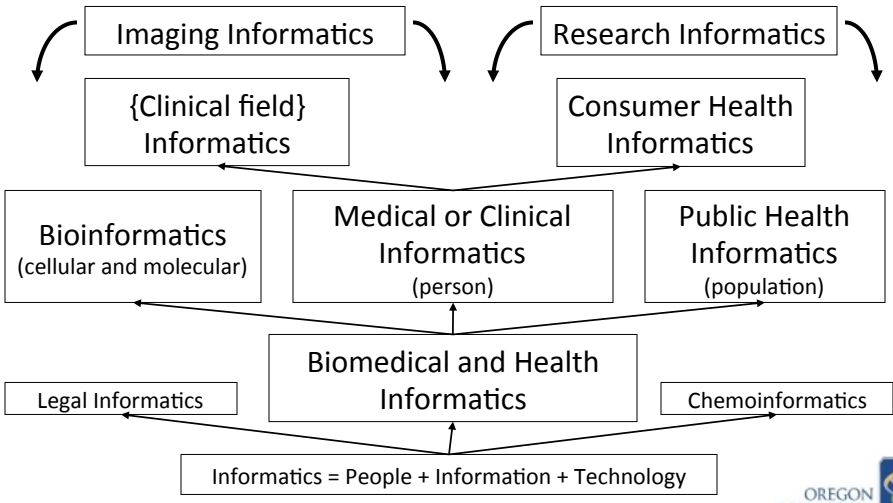
Areas within BMHI



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Why are we not there? (Hersh, 2004)

Health Care Information Technology
Progress and Barriers

William Hersh, MD

IN THE 3 DECADES SINCE THE TERM "MEDICAL INFORMATICS" was first used, individuals working at the intersection of information technology (IT) and medicine have developed and evaluated computer applications aim-

- Cost
- Technical challenges
- Interoperability
- Privacy and confidentiality
- Workforce

in this issue of JAMA, Slack demonstrates the value that patient-physician e-mail can have in improving patient care, and also catalogs the incomplete but encouraging underlying evidence.[11] As with many applications of IT, the technology can improve the existing situation but also empower clinicians and patients to think more fundamentally about how innovation can lead to changes in the way medicine is practiced

care IT.[8,9] It is no exaggeration to declare that the years ahead portend the "decade of health information technology."[10]

Informatics is poised to have a major impact in patient-clinician communication. In the Clinical Crossroads article

ment. The rest goes to those who typically do not pay for

See also p 2255.

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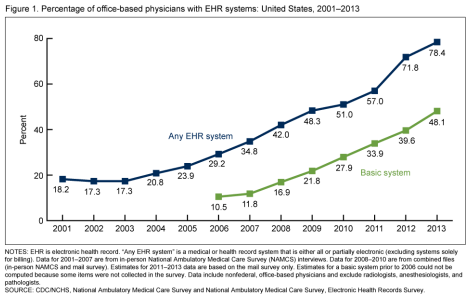
Need to overcome barriers led to HITECH Act (aka, "meaningful use")

RECOVERY.GOV

HealthIT.gov

(Blumenthal, various)



(Hsaio, 2014)

Opportunities and challenges for BMHI going forward

- Optimizing the electronic health record (EHR)
  - Analytics of EHR and other clinical data for increasing quality, efficiency, and coordination of healthcare
  - Standards, interoperability, and health information exchange (HIE)
  - Will expand to "big data" when we add in data from genomics, imaging, personal health devices, etc.
- Patient engagement
  - Use of personal health record (PHR) for engaging consumers and patients in their health and healthcare
- Precision/personalized medicine
  - Based in part on bioinformatics and computational biology, with potential to revolutionize diagnosis and treatment of disease

Important for research too

- Clinical & Translational Science Award (CTSA) Program
  - Has galvanized related area of clinical research informatics (Richesson, 2012)
- Patient-Centered Outcomes Research Institute (PCORI)
  - Comparative effectiveness research (Selby, 2012)
  - Clinical Data Research Networks (Fleurence, 2014) – www.pcornet.org
- NIH Big Data to Knowledge (BD2K; http://bd2k.nih.gov)
  - Training the next generation of scientists in data and related techniques

Major opportunity: "secondary use" or "re-use" of clinical data

- Many secondary uses or re-uses of EHR and other clinical data (Safran, 2007); these include
  - Health information exchange
  - Personal health records
  - Using data to improve care delivery and coordination
  - Quality measurement and improvement
  - Clinical and translational research
  - Public health surveillance

Health information exchange (HIE)

- Patients are "mobile" in many ways – data bears this out
  - In Massachusetts, of 3.69M patients visiting acute care facilities, 31% visited more than one, accounting for 56% of all visits, and 1% visited five or more (Bourgeois, 2010)
  - In Indiana, 40% of patients visiting EDs had data at more than one hospital, with network analysis showed all EDs sharing patients (Finnell, 2011)
- "Data following the patient"
  - Dr. Carolyn Clancy, Director, AHRQ, 2007
- Requires that information be interoperable and flow seamlessly across business boundaries (Kuperman, 2011)
- Part of HITECH investment: $564 for state-based HIE

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EHR data use for clinical research

- Not only benefit conventional research but allows new approaches (Richesson, 2012), e.g.,
  - Replication of randomized controlled trial (RCT) outcomes using EHR data and statistical corrections (Tannen, 2007; Tannen, 2008; Tannen, 2009)
  - Associating "phenotype" with genotype to replicate known associations as well as identify new ones in eMERGE (Kho, 2011; Denny, 2010)
  - Promise of genomics and bioinformatics yielding other successes as well (Kann, 2013)

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Public health

- Improving interface between healthcare and public health systems (Klompas, 2012)
- "Syndromic surveillance" – uses data sources for early detection of public health threats, from bioterrorism to emergent diseases
  - Interest increased after 9/11 attacks (Henning, 2004; Chapman, 2004; Gerbier, 2011)
  - One notable effort is Google Flu Trends – http://www.google.org/flutrends/
    - Search terms entered into Google predict flu activity, but not enough to allow intervention (Ginsberg, 2009)
    - Less accuracy more recently (Butler, 2013)
    - Need to avoid "big data hubris" (Lazer, 2014)

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Some challenges for secondary use of clinical data

- Data quality and accuracy is not a top priority for busy clinicians (de Lusignan, 2005)
- Patients get care at different places (Bourgeois, 2010; Finnell, 2011)
- Average pediatric ICU patient generates 1348 information items per 24 hours (Manor-Shulman, 2008)
- Much data is "locked" in text (Hripcsak, 2012)
- Standards and interoperability – mature approaches but lack of widespread adoption (Kellermann, 2013)
- EHR data can be incorrect and incomplete, especially for longitudinal assessment (Hersh, 2013)

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Challenges (cont.)

- Many data "idiosyncrasies" (Hersh, 2013)
  - "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

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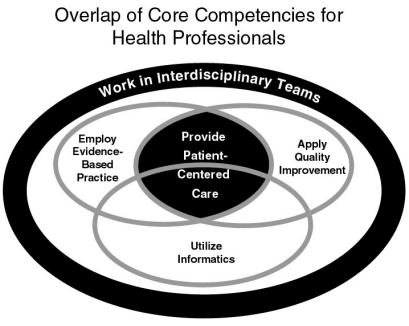
Another need is for skilled clinicians and informaticians

- Knowledge of informatics essential for data-rich, information-driven future – both for clinicians as well informatics professionals (Greiner, 2003; Hersh, 2010)
- 21st century physicians need skills, not only in using EHRs and knowledge sources, but the full range of vision in the IOM *Best Care, Lower Cost* report (Hersh, 2014)
- For informatics professionals, this may be aided by coming certification, starting with physicians (Shortliffe, 2011)



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Informatics at OHSU: DMICE
http://www.ohsu.edu/informatics

- Department of
  - One of 26 departments in OHSU School of Medicine
- Medical Informatics and
  - Focus on improving health and healthcare with information and associated technologies
- Clinical Epidemiology
  - Generating and applying best evidence to support clinical practice and decision-making

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Sampling of DMICE research

- Re-use of clinical data
  - Predictive analytics, care coordination – Dorr
  - Data and text mining – Cohen
- Information retrieval (search) – Hersh
- Data terminology and quality – Logan
- Patient shared decision-making – Eden
- People and organizational issues – Ash
- EHR simulation for safety – Mohan
- Systematic reviews methodology – Chou, McDonagh
- Bioinformatics – McWeeney, Zheng, Sonmez
- Functional imaging – Boudreau

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Another major activity of DMICE informatics is education (Hersh, 2007)

BMI Current Enrollment (Active & LOA) by Degree & Track					
	BCB	CI	HIM	Total	%
BCRT	0	85	26	111	53%
MBI	3	55	7	65	31%
MS	11	6	0	17	8%
PHD	6	10	0	16	8%
	20	156	33	209	100%

BMI Graduates to Date by Degree & Track					
	BCB	CI	HIM	Total	%
BCRT	0	279	32	311	60%
MBI	4	119	0	123	24%
MS	6	65	0	71	14%
PHD	4	8	0	12	2%
	14	471	32	517	100%

- Educating the next generation of informatics researchers and practitioners
- Also a number of international collaborations – Singapore, Argentina, others
- http://www.ohsu.edu/informatics-education

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Also involved in development of new clinical informatics subspecialty

- Approved by ABMS in 2011
  - Administrative home is ABPM
  - First board exam October, 2013
- Subspecialty of any primary specialty
- "Grandfathering" of training requirements for five years
  - ACGME-accredited fellowships thereafter
    - Developing at OHSU

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Another important activity is academia-industry collaboration

- Collaboration beyond usual federal grants
- http://www.ohsu.edu/idl

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Summary

- There are problems in our healthcare system but also a vision for fixing them
- Biomedical and health informatics is part of the solution
- There are many opportunities and challenges for informatics
- Including at OHSU

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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://www.healthit.gov
- American Medical Informatics Association (AMIA)
  - http://www.amia.org
- National Library of Medicine (NLM)
  - http://www.nlm.nih.gov