What is Biomedical Informatics?

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Outline

- Terms and definitions
- Recent growth and change – HITECH and meaningful use
- People
- Resources
- Education and training

What is biomedical and health informatics?

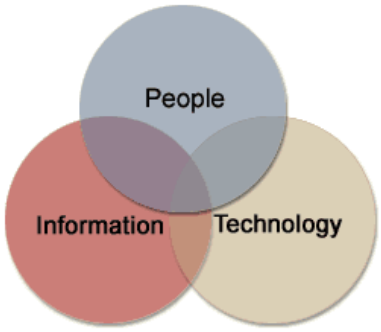
- I get asked this so often that I keep a Web site
  - http://www.billhersh.info/whatis/
- And a blog
  - http://informaticsprofessor.blogspot.com
- I have also written articles about it
  - Medical informatics: improving healthcare through information (Hersh, 2002)
  - But there are barriers (Hersh, 2004)
  - Characterization of and changes in the profession (Hersh, 2006)
  - Many career opportunities as well (Hersh, 2008)
  - Reconciling definitions of terms (Hersh, 2009)
  - The informatics professional workforce (Hersh, 2010)
  - Clinical informatics in the context of health systems science (Hersh, 2017)

Other views

- Early definition: "storage, acquisition, and use of information" (Greenes, 1990)
- Other (US) perspectives
  - "The science of information applied to biomedicine … data plus meaning." (Bernstam, 2010)
  - Paradigm shift in biomedicine from "individual brains to systems of brains" (Stead, 2011)
  - AMIA: "The interdisciplinary field that studies and pursues the effective uses of biomedical data, information, and knowledge for scientific inquiry, problem solving, decision making, motivated by efforts to improve human health" (Kulikowski, 2012)
- European and global perspectives (Haux, 2010; Hasman, 2011; Geissbuhler, 2011)

Let us start by defining "informatics"

- The discipline focused on the acquisition, storage, and use of information in a specific setting or domain (Hersh, 2009)
  - Is more about information than technology
- Sometimes defined as activity at the intersection of people, information, and technology
- The science of "sociotechnical systems" (Coiera, 2007)



(SUNY Buffalo)

5

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

- Is
  - Cross-training where basic informational sciences meet a biomedical application domain
  - Relentless pursuit of assisting people
  - Tower of achievement
    - Model formulation
    - System development
    - System implementation
    - Study of effects
- Isn't
  - Scientists or clinicians tinkering with computers
  - Analysis of large data sets per se
  - Circumscribed roles related to deployment of electronic health records (*point of disagreement)
  - Profession of health information management
  - Anything done using a computer

6

It has a "fundamental theorem" and a "golden rule"

Fundamental Theorem (Friedman, 2009) – based on "relentless pursuit of assisting people"

Goal of informatics is

Goal is not

Golden Rule (Kuperman, personal communication, 2013):

"Never implement unto others that which you would not implement unto yourself"

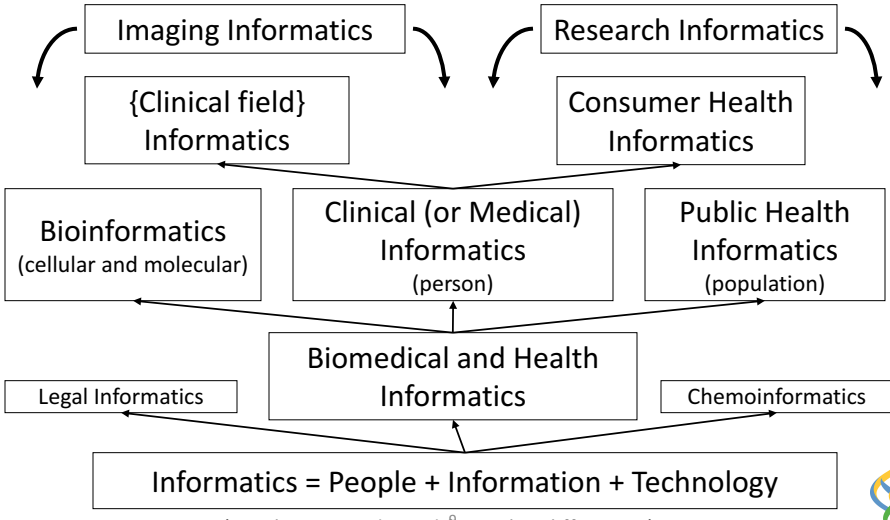
7

My current preferred terminology

- *Biomedical and health informatics* (BMHI) is the field concerned with the optimal use of information, often aided by technology, to improve individual health, healthcare, public health, and biomedical research
  - Informatics applied in a more focused domain is {X} informatics, e.g., nursing, dental, pathology, primary care, etc.
  - Can be classified by "level" of domain but also has some overarching areas, e.g., imaging and research
- Practitioners of BMHI are usually called *informaticians* (sometimes *informaticists*)

8

Informatics also has an "adjective problem"

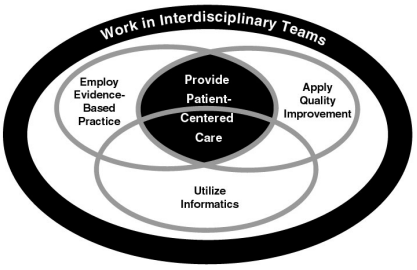


(Hersh, 2009; adapted from Shortliffe, 2006)

Informatics now viewed as a core competency for health professionals

- According to Institute of Medicine report, the modern healthcare professional must have competency in informatics as part of larger goal to provide patient-centered care (Greiner, 2003)
- Informatics competency is not just computer literacy!
  - The "Google generation" does not necessarily have good information skills (CIBER, 2008)
- Informatics is a core component of the "learning health system" (Friedman, 2010; Smith, 2012)

Overlap of Core Competencies for Health Professionals



Some historical perspective on informatics

- Origin of term attributed to Dreyfus in 1962 (Fourman, 2002)
- Achieved widespread use in France (*informatique*), Russia, and later rest of Europe in 1960s to denote computing issues related to information use
- "Medical informatics" first used in 1974 (Collen, 1994)
  - More European history from Moehr (2004)
  - History of field documented by Collen (1995, 2015)
- At present, most significant use is in biomedical arena, but it is used by other domains, such as law, chemistry, social sciences, etc.

11

How is informatics distinguished from related terms?

- *Information technology* (IT) – computer and related technology
- *Computer science* is academic discipline that underlies IT (and other technologies)
- *Management information systems* is another field underlying IT (usually in business schools)
- *Health information technology* (HIT or *health IT*) – health-related application of IT

12

Other related terms

- *Health information management* (HIM) – discipline historically focused on management of (paper) medical records (changing in current environment), with three main levels of practice
  - *Registered Health Information Administrator* (RHIA) – highest level, baccalaureate degree
  - *Registered Health Information Technologist* (RHIT) – associate degree
  - *Certified Coding Specialist* (CCS) – usually less then associate degree

Other related terms

- *Information and communications technology* (ICT) – same as IT with added emphasis on telecommunications
- *eHealth* – use of ICT for health
- *Telemedicine* – provision of healthcare when participants separated by time and/or distance
- *Telehealth* – pursuit of health when separated by time and/or distance
- *mHealth* – use of mobile devices for health

Other related terms

- *Evidence-based medicine* (EBM) – the application of the best scientific evidence in the medical decision-making process
- *Evidence-based practice* (EBP) – the application of EBM in clinical practice
- *Comparative effectiveness research* (CER) – research that compares one or more diagnostic or treatment options to evaluate effectiveness, safety or outcomes (also called *patient-centered outcomes research*)
- *Information retrieval* (also known as *search*, part of larger *knowledge management*) – the field devoted to searching (mostly text, mostly knowledge-based information)

15

Terms related to medical/clinical records

- *Electronic health record* (EHR) – patient's health record in digital form
  - Has mostly supplanted electronic medical record (EMR)
- *Meaningful use* – program of incentives for EHR adoption in US requiring that they be used in ways that achieve healthcare goals
- *Personal health record* (PHR) – personally controlled health record
- *Health information exchange* (HIE) – exchange of health information across traditional business and other boundaries (a verb)
  - Organization managing HIE used to be called a *Regional Health Information Organization* (RHIO), now called an HIE (a noun)

16

Key aspects of the EHR

- The record and its data
- *Standards* and *interoperability*
- *Meaningful use* through *clinical decision support* (CDS) and *computerized physician/provider order entry* (CPOE)
- Implementation and evaluation
- *Privacy*, *security*, and *confidentiality*
- *Re-use* (or *secondary use*), including analytics, of data

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Many are extolling the virtues of BMHI in healthcare and related areas

- Most prominent discussion has focused on improving healthcare through improved quality, safety, and efficiency
- However, there are many challenges
  - Mixing IT with clinical workflow has been difficult
  - Some HIT has been deleterious
  - Financial benefits of IT do not always accrue to those who pay
  - Larger problems in healthcare organization and financing make any type of change difficult

18

Informatics is also essential for modern biomedical research

- Embodied in the National Institutes of Health (NIH) Roadmap to accelerate biomedical research discovery (http://commonfund.nih.gov)
  - *Today's biomedical researcher routinely generates … billions of bytes of data. … What researchers need are computer programs and other tools to evaluate, combine, and visualize these data. In some cases, these tools will greatly benefit from the awesome strength of supercomputers or the combined power of many smaller machines in a coordinated way but, in other cases, these tools will be used on modern personal computers and workstations.*
- Also permeates priorities of NIH Director (Collins, 2010)
  - High-throughput technologies
  - Translational research
  - Supporting healthcare reform
  - Global health
  - Empowering the research community

Informatics terms for biomedical research

- *Translational research* – classically, the translation of basic research into clinical applicability ("bench to bedside"), but also from controlled settings to community and population (Woolf, 2008)
  - Increasing recognition that research findings must "translate" into clinical care more quickly and efficiently, leading to US government investment in *clinical and translational research* through the NIH Clinical & Translational Science Award (CTSA) program (Leshner, 2013)
  - *Translational bioinformatics* – bioinformatics applied to health-related problems (Kann, 2013)
- *Precision medicine* (IOM, 2011; Collins, 2015) – clinical care tailored to an individual's characteristics, including their genome
  - Sometimes called *personalized medicine* (Schleidgen, 2013)
- *Clinical research informatics* (CRI) is area of informatics applied to clinical research (Richesson, 2012)
  - Difference between information technology (IT) and informatics very evident in this domain (Bernstam, 2009)

We cannot ignore the essential role of the consumer/patient/citizen

- Original Strategic Framework of the Office of the National Coordinator for Health IT (ONC) called for IT to facilitate "consumer-centric, information-rich" healthcare (Brailer, 2004)
- Some advocate that the PHR be at the center of the discussion concerning health records (Krist, 2011)
  - Many issues related to flow of information and responsibility for it
- *e-Patients* – Internet-enabled patients
  - Originated with self-help leader, Dr. Tom Ferguson (2007)
  - Best known is e-Patient Dave, who found a great deal of incorrect information in his medical record in Boston teaching hospital and publicized it widely (Wangsness, 2009)

21

A final perspective of informatics

- Data ➔ Information ➔ Knowledge
  - Used in many fields but introduced in informatics by Blum (1984)
- Data are the raw material collected and stored
- Information gives meaning and organization to the data
- Knowledge provides understanding and applicability to new situations
- Some add wisdom, as knowing how to apply knowledge (Rowley, 2007)

22

Informatics is increasingly becoming a "data science"

- EHR (and probably all informatics) work changing from "implementation" to "analytics" (Hersh, 2012)
- Data science is the "sexiest job of the 21st century?" (Davenport, 2012)
- Growing importance of role for *analytics* in healthcare (Adams, 2011; O'Reilly, 2012; Hersh, 2014)
  - But we must use caution to make sure that clinical data is complete, correct, and otherwise sound (the role of informatics?) (Hersh, 2013)

We have entered the era of "Big Data"

- Four "V's" of Big Data: volume, velocity, variety, and veracity (Zikopoulos, 2011)
- Leading to a new paradigm of science (Hey, 2009)?
  - Making the scientific method obsolete, i.e., no need for experimentation any more? (Anderson, 2007)
  - Not really; many caveats for research use of clinical data (Hersh, 2013)
- Other concerns about data science and Big Data
  - "Provocations" to studying data (Boyd, 2011)
    - Bigger is not necessarily better
    - We study what we can answer
    - Not all data is available or accessible
  - Haven't many fields been doing this already, e.g., statistics (Donoho, 2015)?

Is medicine/health really an information science?

- Time studies of hospital (Ammenwerth, 2009; Tipping, 2010; Kim, 2010; Tipping, 2010; Yousefi, 2011; Victores, 2014) and emergency (Chisholm, 2011) physicians show physicians spend about
  - 15-38% of their time in direct patient care
  - 50-67% of their time in indirect patient care, divided between reviewing results, performing documentation, and engaging in communication
- Studies of outpatient physicians find
  - 14-39% of work takes place outside the exam room (Gilchrist, 2005; Gottschalk, 2005)
  - Work related to patient when he/she not present consumes 15-23% of physician work day (Gottschalk, 2005; Farber, 2007; Chen, 2010)

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Even more work with data and information more recently

- Studies in era of widespread EHR adoption
  - Interns in light of duty hours restrictions found to spend less time in direct patient care and more in talking with other physicians and documenting, with about 40% of time spent interacting with computers (Block, 2013)
  - About 60% of internists reported "loss" of around 48 minutes per day due to EHR usage (McDonald, 2014)
  - Residents in an academic teaching hospital found to spend 50% of time with computers vs. 10% time directly with patients (Mamykina, 2016)
  - Physicians found to spend two hours of time doing EHR and desk time for every hour of direct patient time, plus an additional 1-2 hours per night (Sinsky, 2016)
- These studies don't answer what is the right amount of time (Hersh, 2013)

26

Pause

- Turn to your neighbor and discuss one of the following
  - Describe activity in your work that
    - Is informatics
    - Is not informatics
  - Does healthcare system now spend too much time with computers?
- I will ask for a few to volunteer answers to one of the two questions

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Informatics has gone from "dot-com" to "dot-gov"(Kleinke, 2007)

- Bush Administration
  - Recognized value of health information technology (HIT)
  - Actions: Office of the National Coordinator for Health IT (ONC), American Health Information Community (AHIC), etc.
- Obama Administration
  - The American Recovery & Reinvestment Act (ARRA) of 2009 provided incentives for "meaningful use" of electronic health records (EHRs) and the infrastructure to achieve it through provisions of the Health Information Technology for Economic and Clinical Health (HITECH) Act (Blumenthal, 2011; Blumenthal, 2011)

28

The Bush Administration started promotion of the field

- President Bush State of the Union – mentioned every year from 2004 to 2008
  - January, 2004 – "Computerizing health records [can] reduce costs, improve care, and lower the risk of medical mistakes."
  - January, 2007 – "We need to reduce costs and medical errors with better information technology."
- Bush also set goal of electronic health records (EHRs) for half of all Americans by 2014 (White House, 2005)

29

The Obama Administration upped the ante

"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."

January, 2009

Other US government agencies and entities involved in health IT

- National Library of Medicine (NLM, www.nlm.nih.gov) and other institutes of the National Institutes of Health (NIH)
  - NLM leader in funding research and training in informatics
  - Reaffirmed with appointment of new leader and incorporation of NIH data science activities (Brennan, 2016; Brennan, 2016)
- Agency for Healthcare Research & Quality (AHRQ, www.ahrq.gov)
  - Funds research and policy development, produces health IT information resources
- Centers for Medicare and Medicaid Services (CMS, www.cms.hhs.gov)
  - Payor for Medicare and Medicaid, including HITECH incentives
- National Committee for Vital & Health Statistics (NCVHS, www.ncvhs.hhs.gov)
  - Government advisory board, including issues related to health IT

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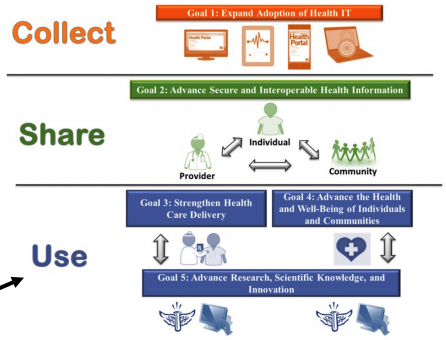
The Obama Administration led us into a new "ARRA" of health IT

- Viewed by some as a "down payment" on healthcare reform
- ARRA included the HITECH Act
  - Incentives for "meaningful use" of EHRs by physicians and hospitals starting in 2011 (up to $27B)
  - Direct grants administered by federal agencies ($2B)
- Also HIT-related provisions in other areas of ARRA, e.g.,
  - Comparative effectiveness research
  - NIH and other research funding
  - Broadband and other infrastructure funding

32

ONC enhancements during Obama Administration

- Appointed Dr. David Blumenthal as third National Coordinator for HIT
  - A well-known Harvard health policy leader with informatics research credentials
  - Led initial implementation of HITECH Act (Blumenthal, 2011; Blumenthal, 2011)
  - Followed by subsequent others
  - Current strategic plan (2015)
- "Putting the I in Health IT" – www.healthit.gov



http://www.healthit.gov/policy-researchers-implementers/health-it-strategic-planning

Putting the I in Health IT

OHSU

What is "meaningful use?"

- Concept introduced in the 2007-2008 Congress, HR 6898: Health-e Information Technology Act of 2008 but not passed at that time by Stark (2011)
- It is not enough to use EHRs but must use them in meaningful ways to achieve goals of healthcare system
  - Achieving criteria tied to five goals for healthcare
  - EHRs must be certified, able to exchange information, and able to report on clinical quality measures

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OHSU

HITECH infrastructure

- http://www.healthit.gov/policy-researchers-implementers/health-it-adoption-programs
- HIT Regional Extension Centers (RECs)
  - $677 million to fund 62 RECs that provide guidance, mainly to small primary care practices and critical access hospitals, in achieving meaningful use (Maxson, 2010)
- State-based health information exchange (HIE)
  - $547 million in grants to states to develop HIE programs
- Workforce development – $118 million for
  - Community college consortia ($70M)
  - Curriculum Development Centers ($10M)
  - Competency testing ($6M)
  - University-based training grants ($32M)

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HITECH infrastructure (cont.)

- Strategic Health IT Advanced Research Projects (SHARP) Program – still a need for research; $60M for four collaborative research centers
  - Security and Health Information Technology
  - Patient-Centered Cognitive Support
  - Secondary Use of EHR Information
  - Health Care Application and Network Design
    - Most persevering of these, has led to the SMART framework (Mandl, 2012)
- Beacon Program – shining the light forward with $250M funding 17 advanced demonstration projects (Maxson, 2010; McKethan, 2011)

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There is still plenty of room for free-marketeers

- HIT industry estimated to reach
  - $228B overall globally by 2020, with 13.4% annual growth rate (Markets & Markets, 2015)
  - $84B for mobile solutions globally by 2020, with 28.4% annual growth rate (Markets & Markets, 2015)
  - $18.7B for data analytics globally by 2020 (Markets & Markets, 2015)
- Many investment activities, e.g.,
  - Rock Health – http://rockhealth.com
  - New York Digital Health Accelerator – http://digitalhealthaccelerator.com
  - Massachusetts Digital Health Initiative – http://massdigitalhealth.org
  - Cambia Grove – www.cambiagrove.com

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HIT is not limited to the United States

- England – NHS Connecting for Health
  - Most ambitious in world but ultimately failed after spending $18 billion for developing nationwide EHRs and HIE (Brennan, 2007; Hayes, 2008; Payne, 2011; NHS, 2011)
  - More recent approaches based on scaled-back goals (Wachter, 2016)
- Denmark
  - Near-universal adoption of EHRs and other technologies (Protti, 2010)
- Canada Health Infoway
  - http://www.infoway-inforoute.ca/
- Singapore National EHR (Accenture, 2012)
  - https://www.moh.gov.sg/content/moh_web/home/Publications/educational_resources/2015/national-electronic-health-record--nehr-.html
- Argentina (Quiros, 2009)
- Australia My Health Record
  - https://myhealthrecord.gov.au/internet/mhr/publishing.nsf/content/home

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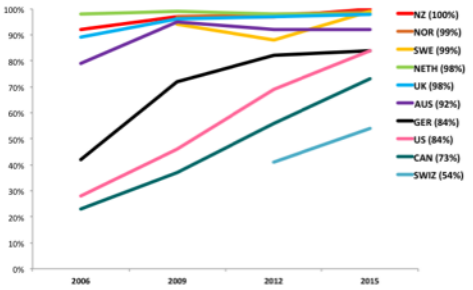
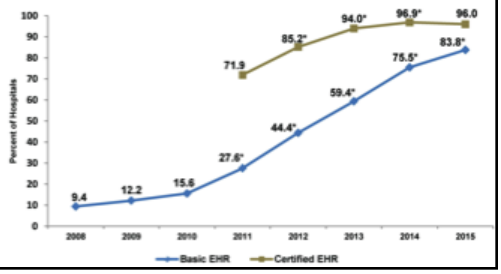
US has been a laggard but is now catching up



(Osborn, 2015)

(Henry, 2016)



Informatics also requires us to address harms and limitations

- IOM HIT safety report documented concerns about dangers (2012)
- Key issues to address are workflow (Carayon, 2010) and usability (Lowry, 2012)
- EHR must move from being a monolithic, transaction-based application to a platform (Glaser, 2012; Mandl, 2012)
- Has EHR undermined medicine or are we in "transitional chaos" (Rosenbaum, 2015; Martin, 2016)?

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OHSU

Pause

- Turn to a different neighbor and describe activities in your work that
  - Showed the benefit of informatics
  - Showed some harm from informatics
- I will ask for a few to volunteer their answers

41

Who does biomedical and health informatics?

- Opportunities for the informatics workforce
- What we know about the health information technology (HIT) workforce
- What we know about informatics leaders
- Education and certification
- HIT salaries
- Informatics competencies for informaticians and non-informaticians

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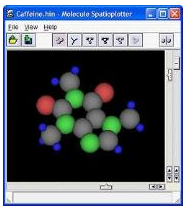
Opportunities for the informatics workforce

- Most prevalent in clinical informatics, but plenty of other opportunity in other areas of informatics
  - Bioinformatics – leading and assisting computational analysis of genomics and related technologies
  - Clinical and translational research – using informatics to aid biomedical research
  - Public health – using information to protect the public and promote health
  - Consumer health – helping the general population maintain and improve health
  - Imaging informatics – using images for biomedical research, clinical care, etc.



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Why is it critical to have a competent HIT workforce (Hersh, 2010)?

- Senior HIT leaders persistently list staffing concerns among their most important
  - Chief information officers (CIOs) state "clinical software implementation and support" as their top need (CHIME, 2012)
  - Key barrier in meeting priorities; top needs include clinical application support, network/architecture support, and clinical informatics professionals (HIMSS, 2014)
- HIT has a "talent shortage" (HealthITJobs.com, 2015)
- Growing role of physicians (Shaffer, 2016; SSiSearch, 2015), including new clinical informatics subspecialty (Detmer, 2014); nurses (Manos, 2012; HIMSS, 2014); and others, including non-clinicians (Fenton, 2012)

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Needs for workforce (Fenton, 2012)

- Survey of Texas HIT employers found need for "diverse knowledge and skills ranging from basic to advanced, while covering information technology, privacy and security, clinical practice, needs assessment, contract negotiation, and many other areas."
- Consistent themes – employees must
  - Be able to learn on the job
  - Possess the ability to think critically and problem solve
  - Have technical skills, yet also knowledge and understanding of healthcare operations
- Employers uncertain about career pathways and advancement in HIT

45

What we know about the HIT workforce (Hersh, 2010)

- Limited by lack of presence in federal labor statistics (Standard Occupational Classification), which may be changing (AMIA, 2016)
- Traditional groupings of professionals in healthcare
  - Information technology (IT) – usually with computer science or information systems background
  - Health information management (HIM) – historical focus on medical records
  - Clinical informatics (CI) – often from healthcare backgrounds, performing analysis, training, etc.
  - Others – librarians, managers, etc.
- What do the data show?

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HIMSS 2014 Workforce Survey

- About 79% reported plans to hire in the following year in 2013 survey, with 84% reporting that they did actually
- About 82% reported planning to hire in 2014, with about half planning to hire 1-5 FTE and the remainder planning to hire more (10% plan to hire more than 20 FTE!)
- Top hiring needs for provider organizations
  - Clinical Application Support - 64%
  - Help Desk - 57%
  - IT Management - 45%
  - Project Management - 35%
  - IT Security - 34%
- Top hiring needs for vendors and consultants
  - Sales/Marketing Team - 78%
  - Field Support Staff - 75%
  - Support Staff - 73%
  - Executive Team - 60%

Demand strong for experienced HIT staff (CHIME, 2012)

- Skills most often in demand
  - Clinical software implementation and support staff (e.g., EHR, CPOE) – 74%
  - Infrastructure staff – 47%
  - Business software implementation and support staff – 45%
- 71% said IT staff shortages could jeopardize an enterprise IT project, while 58% said they would definitely or possibly affect meeting meaningful use criteria for incentive funding
- 85% also expressed concerns about being able to retain current staff

HIM

- HIM is a field in transition, with leadership promoting advanced skills, degrees, and work (Calhoun, 2012; Kloss, 2012)
  - Career map – http://hicareers.com
  - Call to "adapt or disappear" (Butler, 2014)
- HIM is only informatics-related area seen in US Bureau of Labor Statistics (BLS) data
  - Occupational employment projections 2014-2024 (BLS, 2015)
    - Medical Records and Health Information Technicians (RHIT and CCS) – about 188,600 employed in 2014, increasing by 29,000 by 2024 (15% growth)
  - RHIAs and other roles not counted in these numbers

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Clinical informatics

- Individuals who bring skills at intersection of healthcare and IT (Hersh, 2010)
- Becoming harder to distinguish from IT (HealthITJobs.com, 2015) – "The primary skill gap in healthcare IT -- specifically Clinical Systems (EMR/EHR) -- is that most leaders are looking for employees with both hands-on clinical experience and technical expertise. Historically, these have been two very separate skillsets."
- Estimates of need
  - One physician and nurse in each US hospital (~10,000) (Safran, 2005)
  - Probably much larger – many US hospitals now have clinical informatics departments, often reporting to Chief Medical Informatics Officer (CMIO) (Shaffer, 2016)

50

Certification of physicians and others

- Physician subspecialty certification approved by American Board of Medical Specialties in 2011 (Detmer, 2014), based on core curriculum (Gardner, 2009) and training requirements (Safran, 2009)
  - Subspecialty of all medical specialties
  - "Grandfathering" of training requirements initially, to be followed by formal fellowships after 2022 (originally 2017; extended in 2016)
  - Certification first offered in October, 2013 – now over 1300 passed
  - http://www.amia.org/clinical-informatics-medical-subspecialty
  - http://www.theabpm.org/abpm_clinical_informatics.pdf
- Needed or desired for others?
  - AMIA Health Informatics Certification (AHIC) Task Force has developed plans for certification of other health professionals in informatics (Gadd, 2016; Gadd, 2016)
    - https://www.amia.org/advanced-health-informatics-certification

51

Pause

- Turn to a neighbor and describe an instance in your work where informatics expertise contributed to improving some aspect of your organization's activities
- I will ask for a few to volunteer the answers

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Resources for field

- Organizations
- Information
- Education

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Other professional organizations

- American Medical Informatics Association (AMIA) – www.amia.org
- Healthcare Information and Management Systems Society (HIMSS) – www.himss.org
- American Health Information Management Association (AHIMA) – www.ahima.org
- Association of Medical Directors of Information Systems (AMDIS) – www.amdis.org
- Alliance for Nursing Informatics (ANI) – www.allianceni.org
- Public Health Informatics Institute (PHII) – www.phii.org
- International Society for Computational Biology (ISCB) – www.iscb.org
- Society for Imaging Informatics in Medicine (SIIM) – www.siim.org
- Association for Computing Machinery (ACM) – www.acm.org
- Medical Library Association (MLA) – www.mlanet.org

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Important role for government agencies

- National Library of Medicine (NLM) has been historic leader in research and training
  - www.nlm.nih.gov
  - Other institutes of National Institutes of Health (NIH) have supported informatics in various ways
- Agency for Healthcare Research & Quality (AHRQ) has focused on applied clinical informatics
  - www.ahrq.gov
- Office of the National Coordinator for Health IT (ONC) has led health IT and standards adoption
  - www.healthit.gov
- Critical role of other federal agencies in Dept. of Health and Human Services, e.g.,
  - Centers for Disease Control and Prevention (CDC)
  - Centers for Medicare and Medicaid Services (CMS)
  - Food and Drug Administration (FDA)

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Medical and nursing specialty societies (non-exhaustive)

- American Medical Association (AMA) – www.ama-assn.org
- American Nurses Association (ANA) – www.nursingworld.org
- Association of American Medical Colleges (AAMC) – www.aamc.org
- American College of Physicians (ACP) – www.acponline.org
- American Academy of Family Physicians (AAFP) – www.aafp.org

56

Where does one find more information? Textbooks

- Shortliffe and Cimino (eds.), *Biomedical Informatics: Computer Applications in Health Care and Biomedicine* (4th Edition), Springer, 2014
- Hoyt and Yoshihashi (eds.), *Health Informatics: Practical Guide for Healthcare and Information Technology Professionals* (6th Edition), Lulu.com, 2014
- Sengstack and Boicey, *Mastering Informatics: A Healthcare Handbook for Success*, Sigma Theta Tau International, 2015
- Abdelhak et al., *Health Information: Management of a Strategic Resource* (5th Edition), Saunders, 2015
- LaTour and Eichenwald, *Health Information Management – Concepts, Principles, and Practice* (3rd Edition), AHIMA, 2013
- Sayles and Trawick, *Introduction to Computer Systems for Health Information Technology* (2nd Edition), AHIMA, 2014
- Wilson and McEvoy, *Health IT JumpStart - Your Best First Step Toward a Career in Health IT*. Wiley, 2012

Where does one find more information (cont.)? Textbooks

- Weaver et al. (eds.), *Nursing and Informatics for the 21st Century,* HIMSS, 2010
- Richesson and Andrews (eds.), *Clinical Research Informatics*, Springer, 2012
- Kann and Lewitter (eds). *Translational Bioinformatics*, PLoS, 2013
- Magnuson and Fu (eds.), *Public Health Informatics and Information Systems* (2nd Edition) , Springer, 2014
- Bui and Taira (eds.), *Medical Imaging Informatics,* Springer, 2010
- Hersh, *Information Retrieval: A Health and Biomedical Perspective* (3rd Edition), Springer, 2009
- Berkowitz and McCarthy, *Innovation with Information Technologies in Healthcare*, Springer, 2012
- Berner (ed.), *Informatics Education in Healthcare: Lessons Learned*, Springer, 2014
- Sarkar, (ed.), *Methods in Biomedical Informatics: A Pragmatic Approach*, Academic Press, 2014
- Lesk, *Introduction to Bioinformatics* (4th Edition), Oxford University Press, 2014
- Giannangelo, K, (ed.), *Healthcare Code Sets, Clinical Terminologies, and Classification Systems, Third Edition*. Chicago, IL, 2015
- Reddy and Agarwal (eds.), *Healthcare Data Analytics*, Chapman & Hall, 2015
- Benson and Grieve, *Principles of Health Interoperability - SNOMED CT, HL7 and FHIR, Third Edition*. Springer, 2016
- Dixon, B (ed.). He*alth Information Exchange - Navigating and Managing a Network of Health Information Systems*. Amsterdam, Netherlands, Elsevier, 2016
- Skochelak et al. (eds.). *Health Systems Science*. Elsevier, 2017

More information (cont.), Journals

- *Journal of AMIA* (JAMIA, http://jamia.oxfordjournals.org)
- *Journal of Medical Internet Research* (JMIR)
- *Applied Clinical Informatics* (ACI)
- *International Journal of Medical Informatics* (IJMI)
- *Journal of Biomedical Informatics* (JBI)
- *Methods of Information in Medicine* (MIM)
- *Bioinformatics*
- *Journal of Digital Imaging* (JDI)
- Biomed Central (BMC, www.biomedcentral.com)
  - *BMC Medical Informatics and Decision Making*
  - *BMC Bioinformatics*

More information (cont.), Meetings

- AMIA-related meetings
  - AMIA Annual Symposium
  - AMIA Summits on Translational Sciences
  - AMIA iHealth
  - Medinfo (biennial)
- Other clinical informatics meetings
  - HIMSS, national meeting and local chapters
  - AMDIS Physician-Computer Connection
- Bioinformatics meetings
  - Pacific Symposium on Biocomputing (PSB)
  - International Society for Computational Biology (ISCB)

More information (cont.), Web sites

- US government
  - NLM – www.nlm.nih.gov, including www.pubmed.gov
  - HHS ONC – www.healthit.gov
  - AHRQ National Resource Center for Health IT – http://healthit.ahrq.gov
  - HRSA Health IT Toolbox – part of AHRQ National Resource
  - US Health Information Knowledgebase – http://ushik.ahrq.gov
- Other
  - HITECH Answers – www.hitechanswers.net
  - Clinfowiki – http://clinfowiki.org
  - Electronic Medical Informatics Repository of Resources (e-MIR^2; de la Calle, 2012) – http://www.gib.fi.upm.es/eMIR2/

More information (cont.), email lists and blogs

- Email lists
  - HISTalk – http://histalk2.com
  - HIT Strategist – http://www.modernhealthcare.com/section/HITSarchive/
  - From organizations such as AMIA, HIMSS, AMDIS, etc.
- Blogs – (many!)
  - Geek Doctor (John Halamka, MD) – http://geekdoctor.blogspot.com
  - Healthcare Standards (Keith Boone) – http://motorcycleguy.blogspot.com
  - Health IT Buzz (ONC) – http://www.healthit.gov/buzz-blog/
  - The Healthcare Blog – http://thehealthcareblog.com
  - Informatics Professor (Hersh) – http://informaticsprofessor.blogspot.com

More information (cont.), acronyms

- Always asked, so here is a list
  - HITECH Answers – http://www.hitechanswers.net/ehr-adoption-2/key-acronyms/
  - AMIA – https://www.amia.org/glossary
  - Shortliffe glossary, which includes acronyms (2014) – http://people.dbmi.columbia.edu/shortliffe/docs/Glossary%20-%204th%20ed.pdf
  - Wikipedia – https://en.wikipedia.org/wiki/List_of_abbreviations_used_in_health_informatics

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Education and training in informatics

- Education has historically focused on academics but has been expanding to meet the needs and opportunities of practitioners and users
- An ever-growing number of programs at associate, baccalaureate, and graduate levels
  - Also shorter, continuing education courses, such as 10x10 ("ten by ten") – https://dmice.ohsu.edu/hersh//10x10.html
- Informatics programs come in many flavors: medical, clinical, biomedical, health, bio-, nursing, etc.
- Major funder of programs is NLM, which funds fellowships to train future researchers at doctoral and postdoctoral levels
- New Accreditation Council for Graduate Medical Education (ACGME)-accredited clinical fellowship programs emerging – ~20 accredited and ~10 launched

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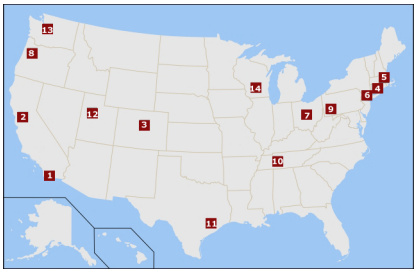
Academic programs

- List of US informatics programs on AMIA Web site
  - http://www.amia.org/education/programs-and-courses
- International compendium of programs at Health Informatics Worldwide (HIWW)
  - www.hiww.org
- NLM-funded programs
  - http://www.nlm.nih.gov/ep/GrantTrainInstitute.html



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Inventory of competencies for various groups (Hersh, 2010)

- Competencies differ by group
  - Informaticians
    - Developing, implementing, and evaluating systems
    - Making optimal use of information
    - Recent elucidation of core competencies by AMIA (Kulikowski, 2012)
  - Clinicians
    - Applying informatics in delivery of care
    - Competencies for medical education (Hersh, 2014)
  - Patients
    - Health information literacy

Table 2 Inventory of competencies in biomedical and health informatics.

Organization or Journal [Reference]	Year	Discipline	Title
Association for Computing Machinery [49]	1978	Computer science	Health Computing: Curriculum for an Emerging Profession
[50]	1992	Informatics	Recommendations of the German Association for Medical Informatics, Biometry and Epidemiology
Association of American Medical Colleges [51]	1999	Medical students	Medical School Objectives Project: Medical Informatics
International Medical Informatics Association [52]	2000	Informatics	Recommendations of the International Medical Informatics Association (IMIA) on education in health and medical informatics (updated in 2010)
UK National Health Service [53]	2001	Informatics	Health Informatics Competency Profiles for the NHS
American Nurses Association [54]	2001	Nursing	A Delphi Study to Determine Informatics Competencies for Nurses at Four Levels of Practice
...			
Nursing Clinics of North America [68]	2008	Nursing	Technology and informatics competencies
AMIA-OHSU 10x10 Course [69]	2009	Informatics	AMIA-OHSU 10x10 Program - Detailed Curriculum, Learning Objectives
AMIA Core Content for Clinical Informatics [35]	2009	Informatics	Core content for certification of physicians (with others to follow later)
TIGER Nursing Informatics [70]	2009	Nursing Informatics	TIGER Informatics Competencies Collaborative (TICC) Final Report
Office of the National Coordinator for Health IT [71]	2009	Electronic health record adoption	HIT Workforce Competencies by Role
Centers for Disease Control and Prevention, [72]	2009	Informatics	Public Health Informatics Competencies
International Medical Informatics Association [73]	2010	Informatics	Recommendations of the International Medical Informatics Association (IMIA) on education in biomedical and health informatics

Clinical informatics education for clinicians

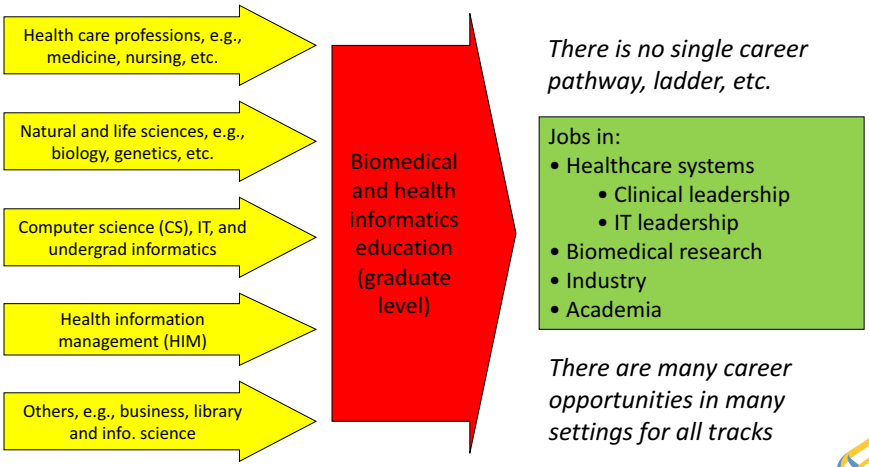
Started with medical students (Hersh, 2014), but in reality applicable to all clinical students and professionals

Part of larger health systems science (Skochelak, 2017; Hersh, 2017)

Table 9.2 Competencies in Clinical Informatics for Health Care Professionals

1. Find, search, and apply knowledge-based information to patient care and other clinical tasks
   a. Information retrieval/search: Choose correct source for specific task, search using advanced features, apply results
   b. Evaluate information resources (e.g., literature, databases) for their quality, funding sources, biases
   c. Identify tools to assess patient safety (e.g., medication interactions)
   d. Utilize knowledge-based tools to answer clinical questions at the point of care (e.g., text resources, calculators)
   e. Formulate an answerable clinical question
   f. Determine the costs/charges of medications and tests
   g. Identify deviations from normal (laboratory tests/radiographs/results), and develop a list of causes of the deviation
2. Effectively read and write from the electronic health record for patient care and other clinical activities
   a. Graph, display, and trend vital signs and laboratory values over time
   b. Adopt a uniform method of reviewing a patient record
   c. Create and maintain an accurate problem list
   d. Recognize medical safety issues related to poor chart maintenance
   e. Identify a normal range of results for a specific patient
   f. Access and compare radiographs over time
   g. Identify inaccuracies in the problem list/history/medication list/allergies
   h. Create useable notes
   i. Write orders and prescriptions
   j. List common errors with data entry (e.g., drop-down lists, copy and paste)
3. Use and guide implementation of clinical decision support (CDS)
   a. Recognize different types of CDS
   b. Be able to use different types of CDS
   c. Work with clinical and informatics colleagues to guide CDS use in clinical settings
4. Provide care using population health management approaches
   a. Utilize patient record (data collection and data entry) to assist with disease management
   b. Create reports for populations in different health care delivery systems
   c. Use and apply data in accountable care, care coordination, and the primary care medical home settings
5. Protect patient privacy and security
   a. Use security features of information systems
   b. Adhere to HIPAA privacy and security regulations
   c. Describe and manage ethical issues in privacy and security
6. Use information technology to improve patient safety
   a. Perform a root-cause analysis to uncover patient safety problems
   b. Become familiar with safety issues
   c. Use resources to solve safety issues
7. Engage in quality measurement selection and improvement
   a. Recognize the types and limitations of different types of quality measures
   b. Determine the pros and cons of a quality measure, how to measure it, and how to use it to change care
8. Use health information exchange (HIE) to identify and access patient information across clinical settings
   a. Recognize issues of dispersed patient information across clinical locations
   b. Participate in the use of the HIE to improve clinical care
9. Engage patients to improve their health and care delivery though personal health records and patient portals
   a. Instruct patients in the proper use of a personal health record (PHR)
   b. Write an e-mail to a patient using a patient portal
   c. Demonstrate appropriate written communication with all members of the health care team
   d. Integrate technology into patient education (e.g., decision-making tools, diagrams, patient education)
   e. Educate patients to discern quality of online medical resources (e.g., websites, apps, patient support groups, social media)
   f. Maintain patient engagement while using an EHR (e.g., eye contact, body language)
10. Maintain professionalism through use of information technology tools
    a. Describe and manage ethics of media use (cloud storage issues, texting, cell phones, social media professionalism)
11. Provide clinical care via telemedicine, and refer those for whom it is necessary
    a. Be able to function clinically in telemedicine/telehealth environments
12. Apply personalized/precision medicine
    a. Recognize the growing role of genomics and personalized medicine in care
    b. Identify resources enabling access to actionable information related to precision medicine
13. Participate in practice-based clinical and translational research
    a. Use EHR alerts and other tools to identify patients and populations for offering clinical trial participation
    b. Participate in practice-based research to advance medical knowledge

Career pathways have diverse inputs and outputs (Hersh, 2009)



There is no single career pathway, ladder, etc.

Jobs in:
- Healthcare systems
  - Clinical leadership
  - IT leadership
- Biomedical research
- Industry
- Academia

There are many career opportunities in many settings for all tracks

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OHSU

Example: OHSU informatics

http://www.ohsu.edu/informatics

Degrees Awarded 1998-2016 (653 people)			
Track	CI	BCB	Total
Certificate	406	0	406
MBI/MMI	190	8	198
MS	72	16	88
PhD	18	6	24
Total	686	30	716

International students from: Argentina, Singapore, Egypt, Israel, Saudi Arabia, Zimbabwe, Thailand, China, and other countries

Track Degree/Certificate	PhD	MS	MBI	Grad Cert
Clinical Informatics	On-campus	On-campus On-line	On-campus On-line	On-campus On-line
Bioinformatics and Computational Biology	On-campus	On-campus		

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How have OHSU students and graduates done?

- About 25 years of experience…
- General observation: What people do when they graduate is partially dependent on what they did when they entered, e.g.,
  - Physicians, nurses, public health, etc. draw on their clinical/professional background
  - Information technology professionals draw on their unique background and experience
- Graduates have obtained jobs in a variety of settings, e.g., clinical, academic, and industry
- Some obtain jobs before finishing program

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Conclusions

- These are exciting times for biomedical and health informatics, with many opportunities in a wide variety of settings
- Attention must also be paid to the professional practice and education of informaticians
- But the main focus of the field must be how to optimally use information and technology properly to advance human health and improve delivery of healthcare