Computing the Future

The Evolving Roles of Informatics and Information Technology in Health Care

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Adjunct Faculties, Columbia University and Weill Cornell Medical College

Annual Meeting
Society for Technology in Anesthesia
Royal Palms Resort & Spa
Phoenix, AZ
January 8, 2014

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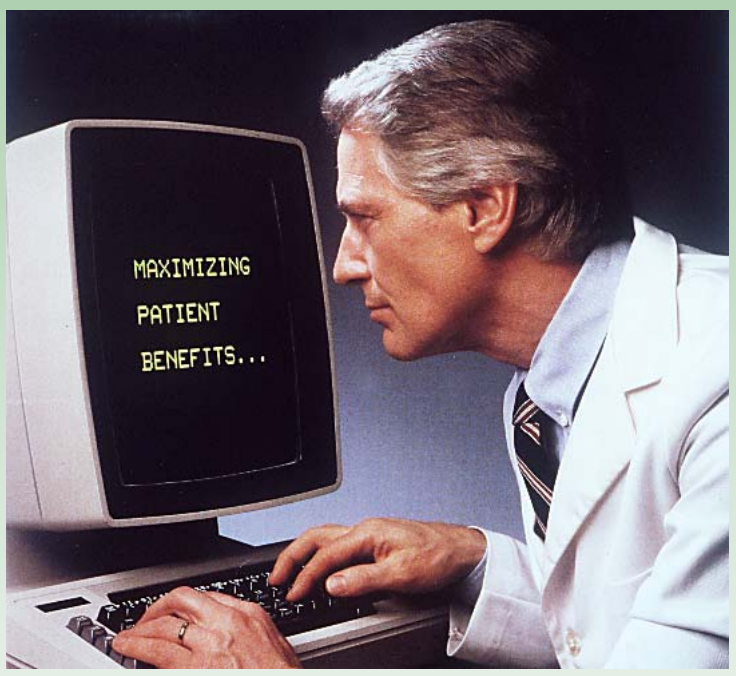
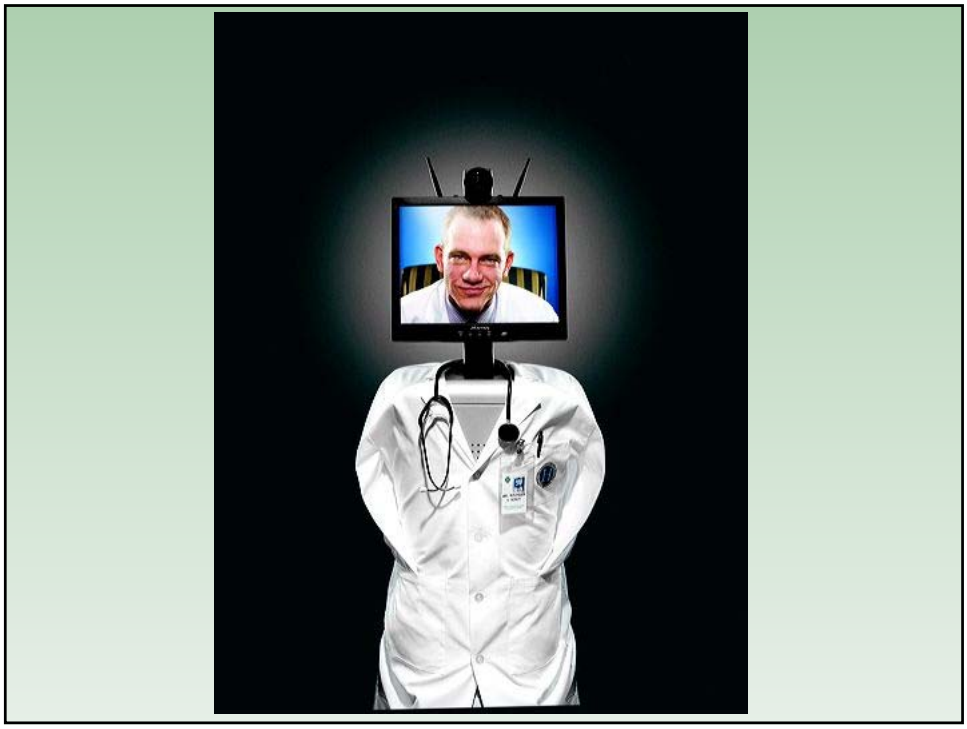

MAXIMIZING
PATIENT
BENEFITS...



What I Would Like to Discuss .

- Reflections on the evolution of technologies in our society, to provide context for considering health information technology (HIT) and its future
- Discussion of the evolution of informatics as a discipline
  - Some words about nomenclature
  - Relationship of informatics to HIT
- Assessment of our current state
  - Some examples from anesthesiology
- Anticipating future directions

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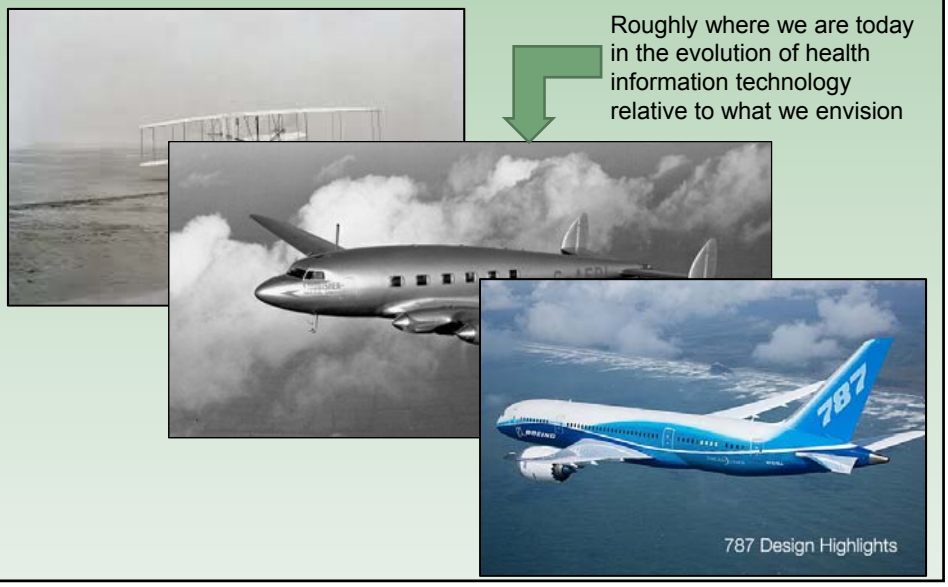
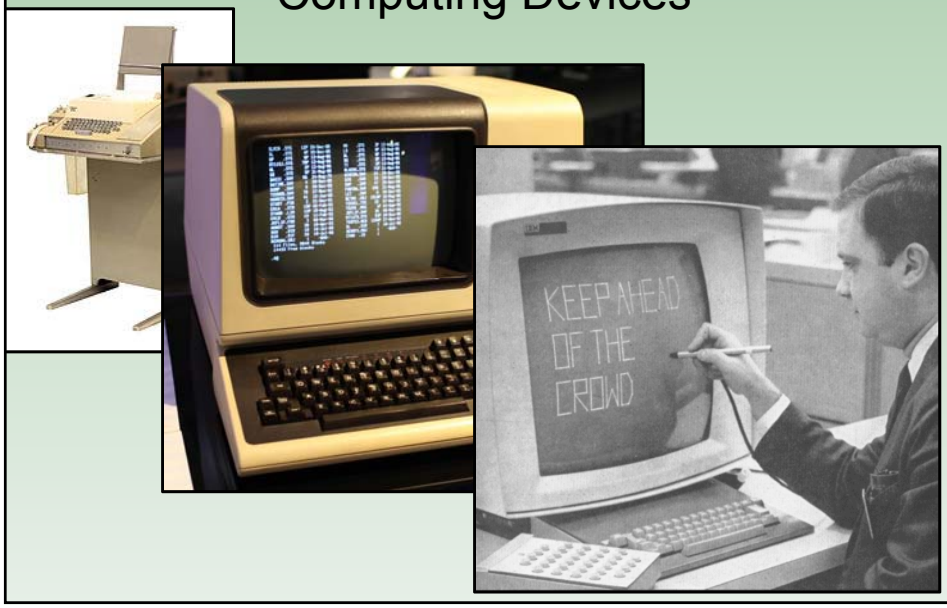
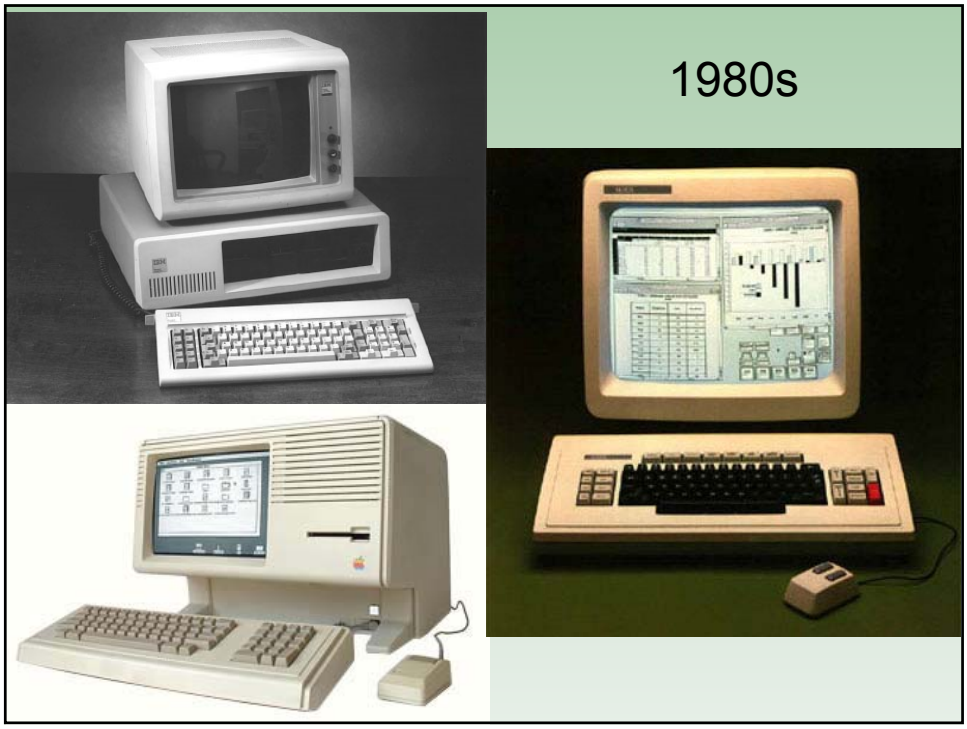
Analogy: Commercial Aviation



Analogy: Evolution of Personal Computing Devices





Subsequently ..

- Network connectivity (Internet and wireless)
- Modern PCs, Macs, netbooks, etc.
- Smartphones
- Tablet computing
- Smart devices
- Personal devices
- And more to come .

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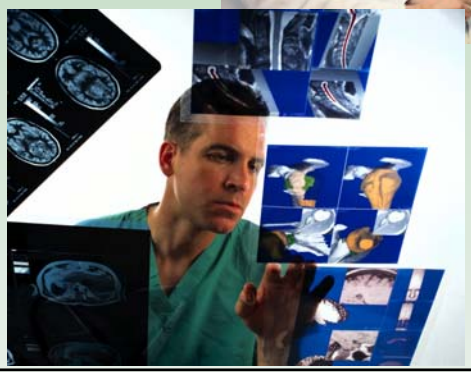
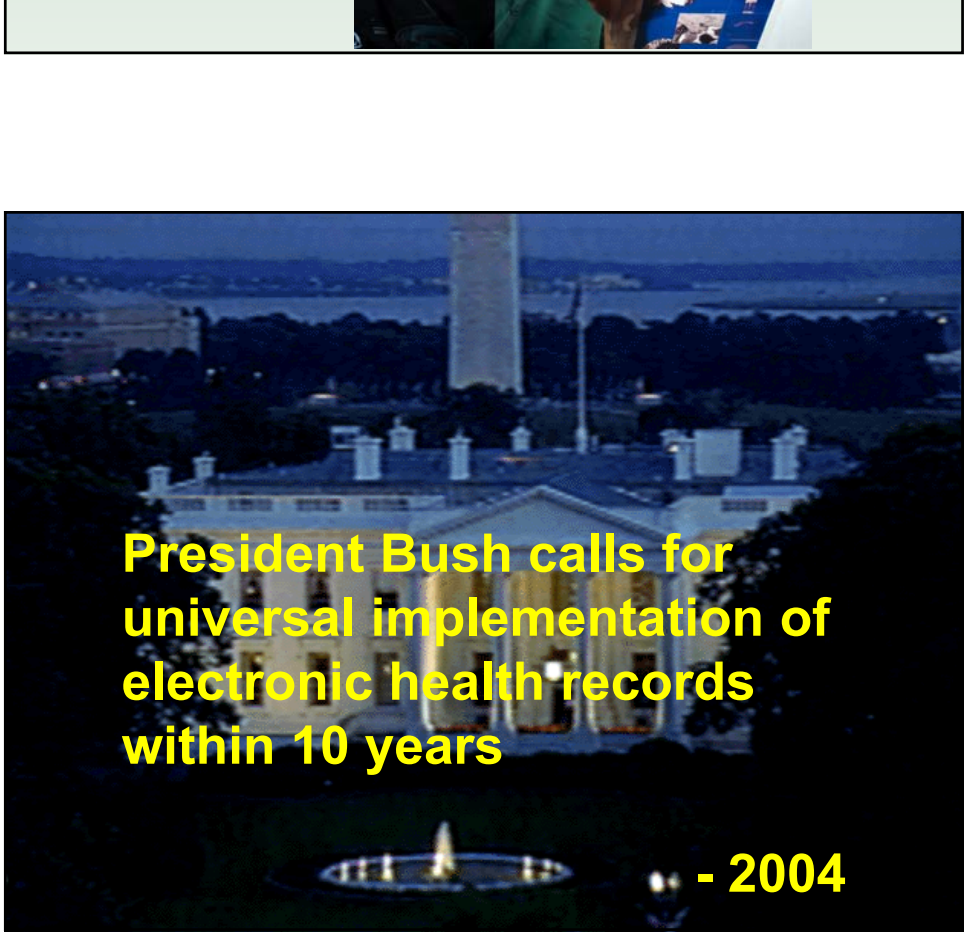
The Evolving Paradigm





Moving Beyond The Paper Record Envisioned Since the 1960s

1968-1970

SPECIAL ARTICLE ARCHIVE A Correction Has Been Published ›

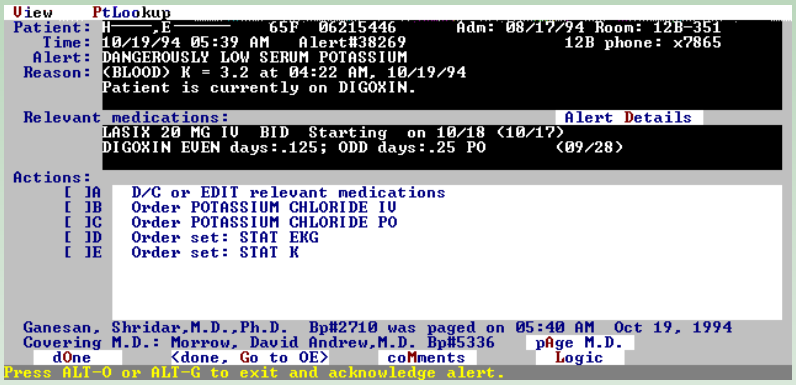
Recording, Retrieval and Review of Medical Data by Physician-Computer Interaction

Robert A. Greenes, M.D., Ph.D., G. Octo Barnett, M.D., Stuart W. Klein, M.D., Anthony Robbins, M.D., and Roderick E. Prior

N Engl J Med 1970; 282:307-315 | February 5, 1970 | DOI: 10.1056/NEJM197002052820605

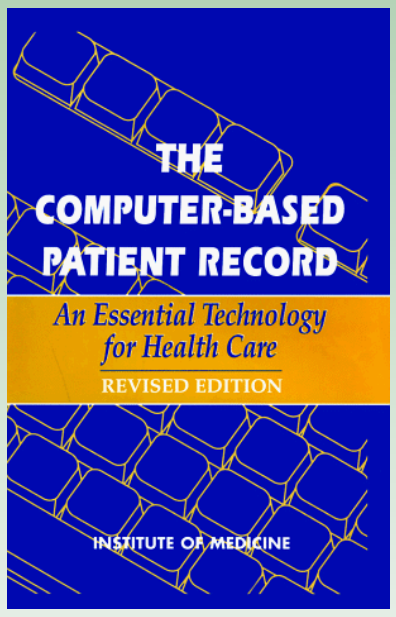
NEJM 1970

1990-1994



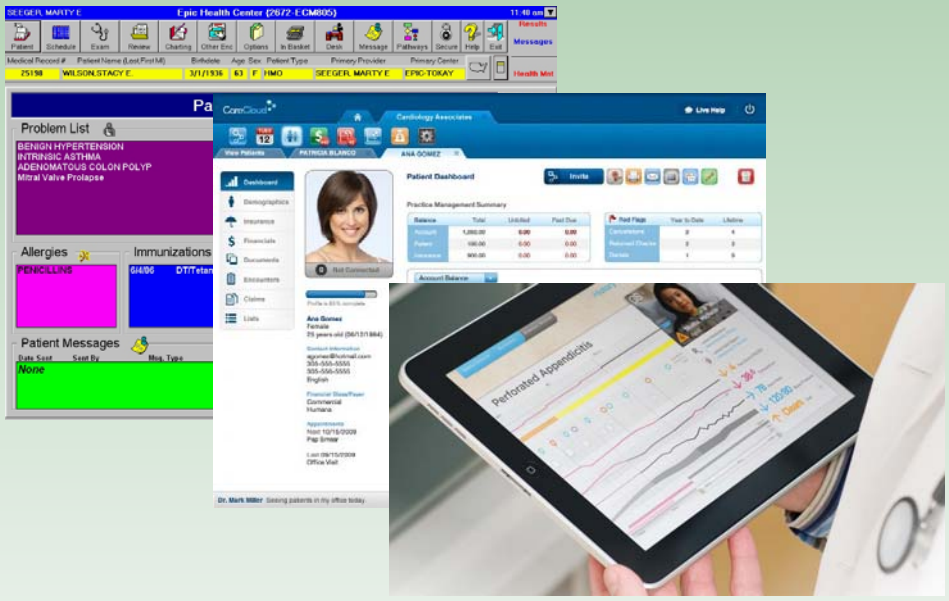
Institute of Medicine

THE NATIONAL ACADEMIES PRESS



256 pages
Revised edition (October 1997)
Originally published in 1991

Subsequent Evolution



What Lies Ahead?

Historical Perspective

- Seminal article: Earliest broad recognition of statistical issues in diagnosis and the potential role of computers occurred in the late 1950s
  - "Reasoning foundations in medical diagnosis" by Ledley and Lusted
  - Appeared in Science in 1959
- Computers began to be applied in biomedicine in the 1960s
  - Most applications dealt with clinical issues, including diagnostic systems

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A Discipline Emerges

- The word "informatics" has its roots in applications in clinical medicine
  - English term first coined by the medical informatics community in the late 1970s (borrowed from Europe)
- Data issues seemed "big" from the very beginning
  - Hospital information systems (1960s)
  - Early decision-support and expert systems (1970s)
  - Subsequent clinical research systems (1980s)
  - Human genome project (1990s)

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But what exactly is informatics?

J Am Med Inform Assoc *2012;19(6):931-938*

Perspective

AMIA Board white paper: definition of biomedical informatics and specification of core competencies for graduate education in the discipline

Casimir A Kulikowski,[1] Edward H Shortliffe,[2] Leanne M Currie,[3] Peter L Elkin,[4] Lawrence E Hunter,[5] Todd R Johnson,[6] Ira J Kalet,[7] Leslie A Lenert,[8] Mark A Musen,[9] Judy G Ozbolt,[10] Jack W Smith,[11] Peter Z Tarczy-Hornoch,[7] Jeffrey J Williamson[12]

Abstract: The AMIA biomedical informatics (BMI) core competencies have been designed to support and guide graduate education in BMI, the core scientific discipline underlying the breadth of the field's research, practice, and education. .. The AMIA BMI analysis highlights the central shared set of competencies that should guide curriculum design and that graduate students should be expected to master.

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AMIA's Definition (2012)

Biomedical informatics (BMI) is the interdisciplinary field that studies and pursues the effective uses of biomedical data, information, and knowledge for scientific inquiry, problem solving, and decision making, motivated by efforts to improve human health.

JAMIA *2012;19(6):931-938*

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Biomedical Informatics: Corollaries to the Definition

1. BMI develops, studies and applies theories, methods and processes for the generation, storage, retrieval, use, and sharing of biomedical data, information, and knowledge.
2. BMI builds on computing, communication and information sciences and technologies and their application in biomedicine.

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Biomedical Informatics: Corollaries to the Definition

3. BMI investigates and supports reasoning, modeling, simulation, experimentation and translation across the spectrum from molecules to populations, dealing with a variety of biological systems, bridging basic and clinical research and practice, and the healthcare enterprise.
4. BMI, recognizing that people are the ultimate users of biomedical information, draws upon the social and behavioral sciences to inform the design and evaluation of technical solutions and the evolution of complex economic, ethical, social, educational, and organizational systems.

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No One Name Is Universally Accepted

- Medical informatics?
- Health informatics?
- Biomedical informatics?
- One solution:
  - I use unmodified “informatics” as much as possible when referring to the discipline, but use “biomedical informatics” when referring to the core science of our field
  - Avoid using “bioinformatics” to refer to the full discipline

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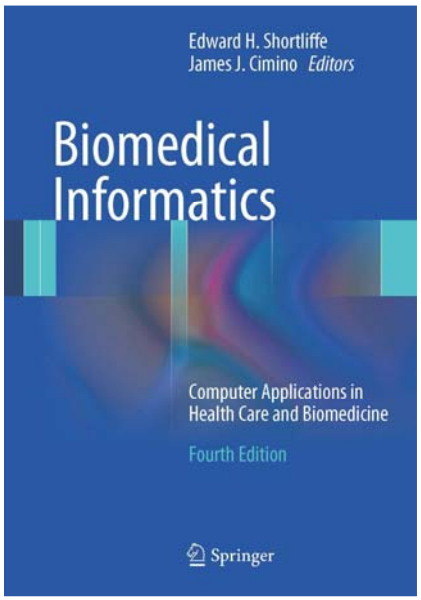
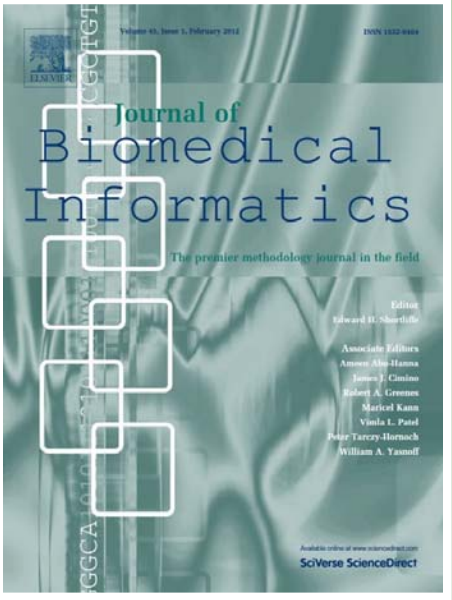
My Personal Commitment to these Terms

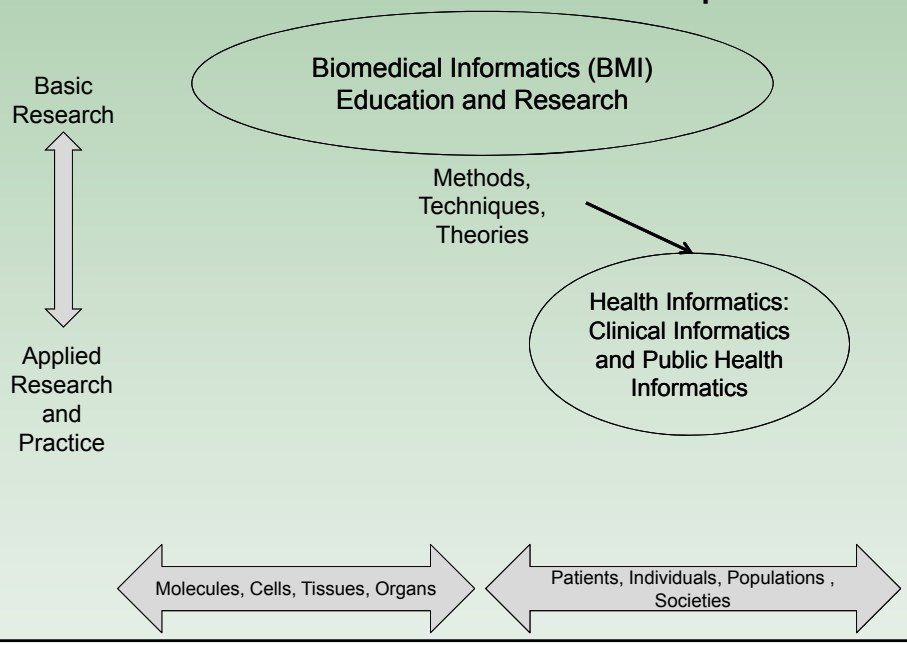
Textbook

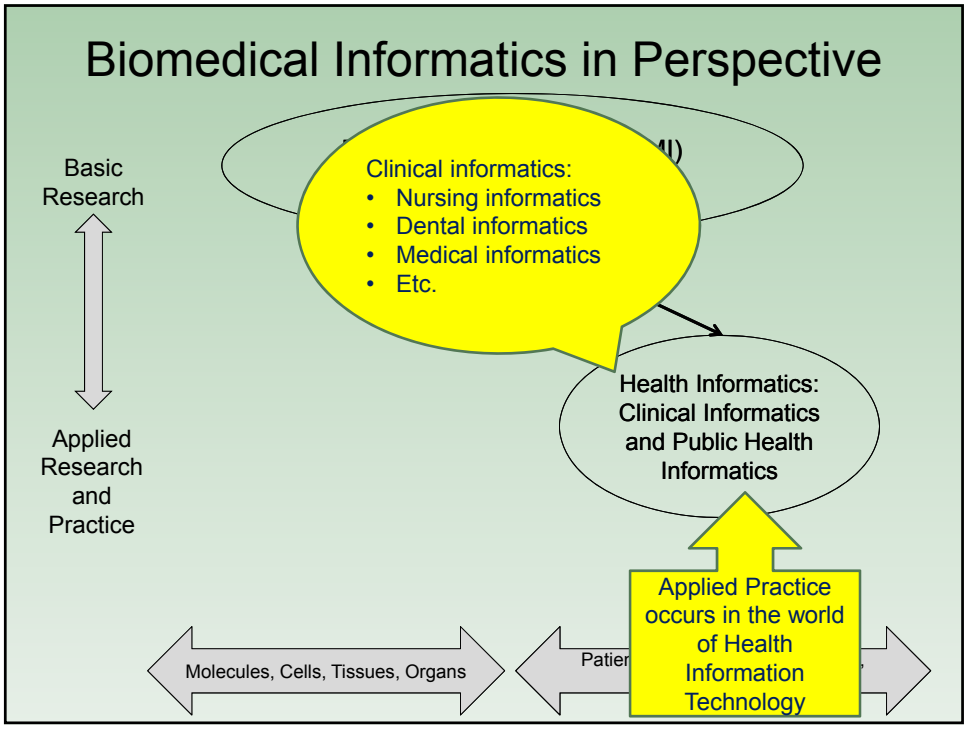


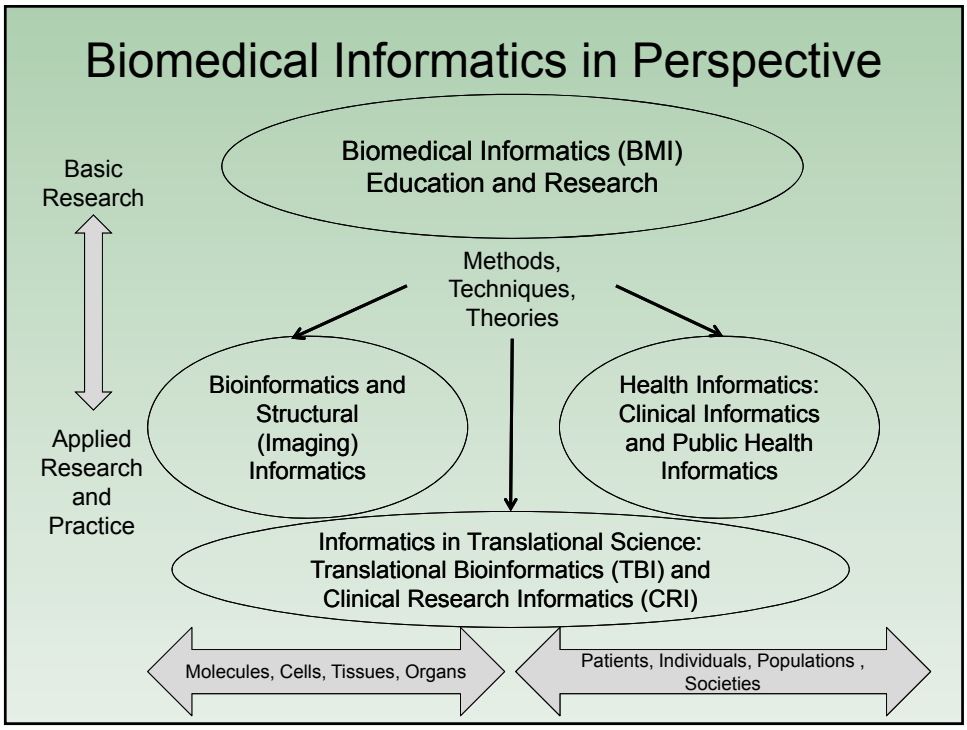
Journal



Biomedical Informatics in Perspective




Biomedical Informatics in Perspective
Basic Research
Applied Research and Practice
Clinical informatics:
• Nursing informatics
• Dental informatics
• Medical informatics
• Etc.
Health Informatics: Clinical Informatics and Public Health Informatics
Applied Practice occurs in the world of Health Information Technology
Molecules, Cells, Tissues, Organs


Biomedical Informatics in Perspective
Basic Research
Applied Research and Practice
Biomedical Informatics (BMI) Education and Research
Methods, Techniques, Theories
Bioinformatics and Structural (Imaging) Informatics
Health Informatics: Clinical Informatics and Public Health Informatics
Informatics in Translational Science: Translational Bioinformatics (TBI) and Clinical Research Informatics (CRI)
Molecules, Cells, Tissues, Organs
Patients, Individuals, Populations , Societies

Characteristics of BMI Academic Units

- Imbued with a health sciences culture
- Driven by a desire to address perceived problems in the biomedical setting
- Applied work always important, but impressive basic/generalizable results
- Interdisciplinary nature leads to challenging partnership requirements, both for teaching and research
- Often poorly understood by colleagues in medical and health-professional world

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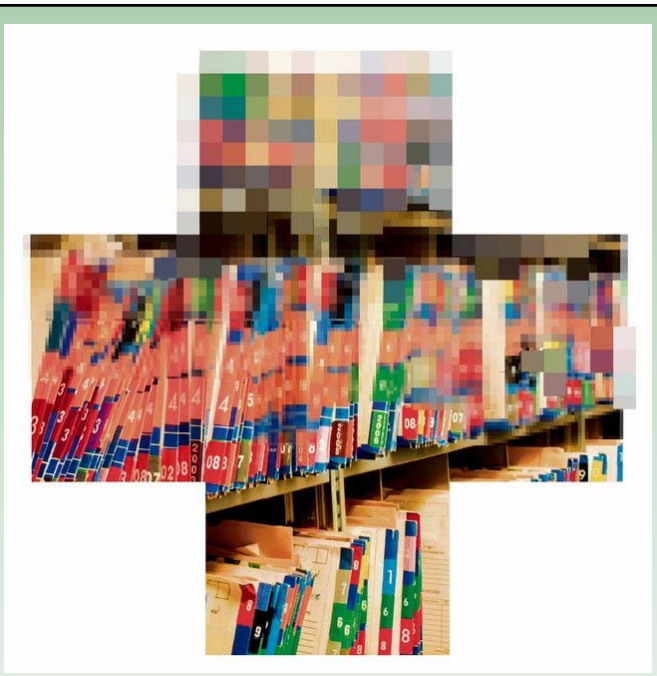


"Dr Obama" Aims to Treat the US Economy

and the US healthcare system!

department of biomedical informatics

Health Solutions

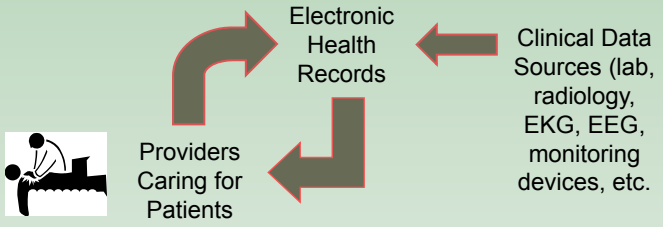
Enhancing Care, Knowledge, and Safety through Integrated EHRs

Providers Caring for Patients

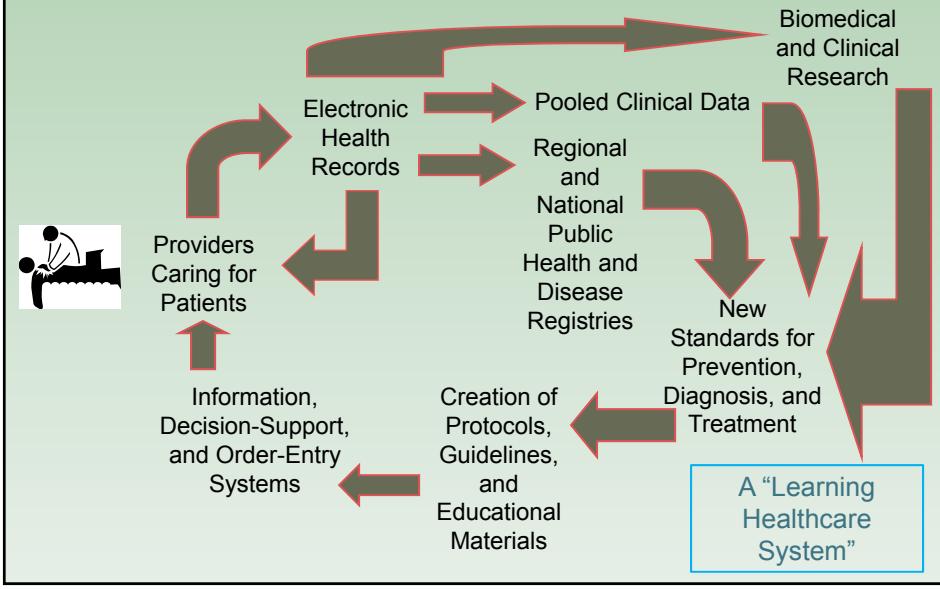
Electronic Health Records

"Meaningful Use"?

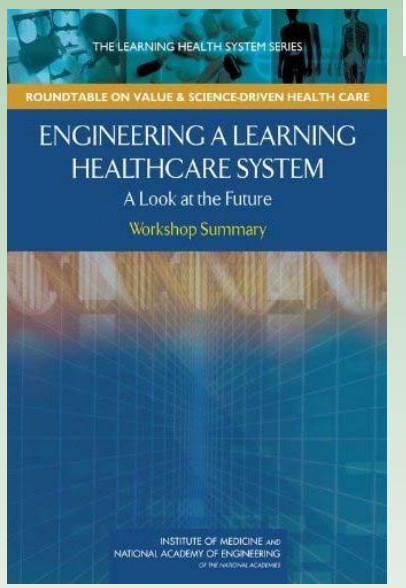
An Envisioned Cycle That Ties Patient Care with Knowledge Creation and Dissemination



An Envisioned Cycle That Ties Patient Care with Knowledge Creation and Dissemination



Institute of Medicine



340 pages
Published June 2011

An Optimistic Perspective

A spokeswoman from the Department of Health and Human Services has cited a Congressional Budget Office estimate that 90 percent of doctors would be using health IT by 2019, thanks to the stimulus bill

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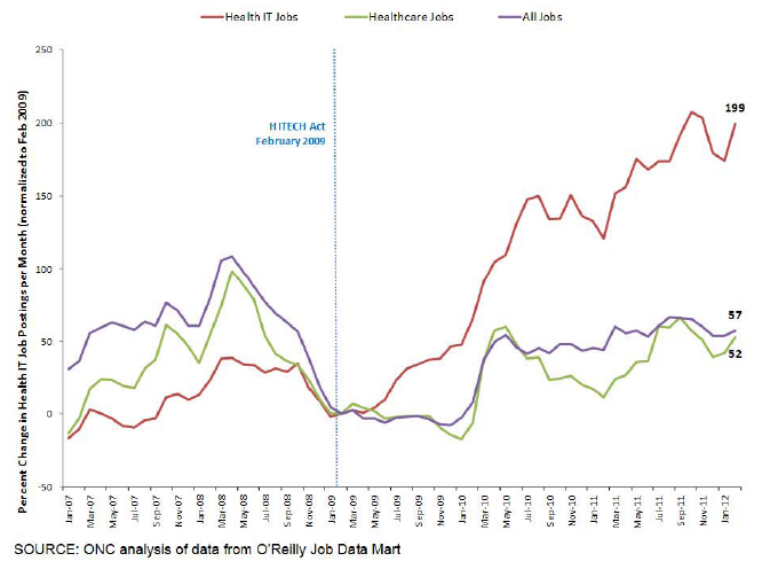
Percent change in online health IT job postings per month, relative to healthcare jobs and all jobs; normalized to February 2009



Since passage of HITECH in February 2009, online postings for Health IT jobs per month have increased by 199%

From ONC Databrief 2 May 2012

Anesthesia and Informatics/HIT

- Innovations and routine use in the area of patient monitoring
- Anesthesia-specific EMRs

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Kathleen Irwin, Market Research Associate
Last updated: December 27, 2014
Top 10 Most Reviewed Anesthesiology EMR Software Systems
Sort List By:
Number of revie
Find the right software systems based on your needs in 3 easy steps:
We need a few details about your organization to start narrowing down the list:


Becker's Healthcare:
ASC Review
Hospital Review
Spine Review
Infection Control
Health IT & CIO
CFO
BECKER'S
ASCREVIEW
TelePREOP
TelePREOP is the first and leading provider of telemedicine solutions suited to manage the complex workflows associated with the pre-surgical clinical environments. It is designed to streamline the process between surgeons, hospitals, ASCs, and anesthesia.
Print Issues
E-Weeklies
Infection Control E-Weeklies
Conferences
Webinars
Whitepapers
Multimedia
Lists
Anesthesia
Email Print
5 Essential Smartphone Apps for Anesthesiologists
Written by Taryn Tawoda | March 14, 2012

Anesthesia and Informatics/HIT

- Innovations and routine use in the area of patient monitoring
- Anesthesia-specific EMRs
- Some work on decision support
- Exceptional contributions in the area of simulation
  - Training and testing
  - Recognition of the role of cognitive science and innovative application of those methods and theories

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Simulation in Anesthesia Training and Evaluation

Cognitive Science and Informatics (Cognitive Informatics)

- Need to understand better how health professionals use personal heuristics, experience, data, and knowledge to arrive at decisions
  - Improve patient safety and error reduction
  - Improve clinical teaching
  - Improve decision-support systems
  - Better understand clinicians as computer users (and thereby build more usable systems)
- Need to understand patients as computer users—their mental models, fears, and perceptions

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National Research Council (CSTB)

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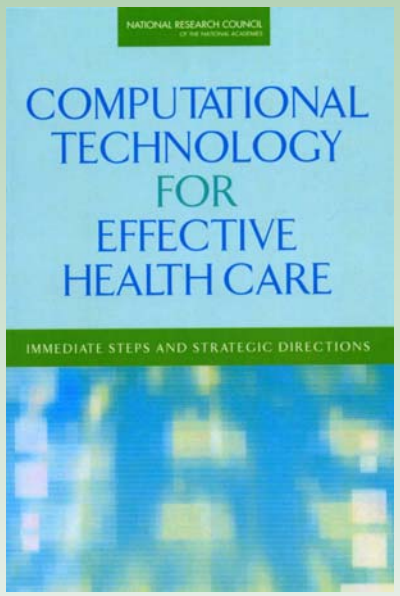


120 pages (March 2009)

The Grand Challenges:

- Patient-Centered Cognitive Support
- Modeling
- Automation
- Data sharing and collaboration
- Data management at scale
- Automated full capture of physician-patient interactions

Cognitive Informatics in Anesthesia

British Journal of Anaesthesia 108 (2): 229–35 (2012)
Advance Access publication 8 December 2011 · doi:10.1093/bja/aer387

BJA

CLINICAL PRACTICE

Cognitive errors detected in anaesthesiology: a literature review and pilot study

M. P. Stiegler[1*], J. P. Neelankavil[1], C. Canales[2] and A. Dhillon[1]

[1] Department of Anaesthesiology, David Geffen School of Medicine, UCLA, 757 Westwood Blvd-Suite 3325, Los Angeles, CA 90095-7403, USA

[2] Department of Anaesthesiology and Perioperative Care, UC Irvine School of Medicine, Irvine, CA, USA

* Corresponding author. E-mail: mstiegler@mednet.ucla.edu

www.anesthesiaillustrated.org/cogaids/

CogAIDS is a global crowdsourcing effort to improve the design of medical checklists.
Director: Larry Chu, MD, MS
Co-Director: Kyle Harrison, MD
A project of the Stanford AIM Lab

Cognitive Issues in Anesthesia Simulation

Situation awareness in anesthesiology.
Gaba DM, Howard SK, Small SD.
Hum Factors. 1995 Mar;37(1):20-31.

Role of experience in the response to simulated critical incidents.
DeAnda A, Gaba DM.
Anesth Analg. 1991 Mar;72(3):308-15.

Sim Healthcare 5:272–278, 2010:

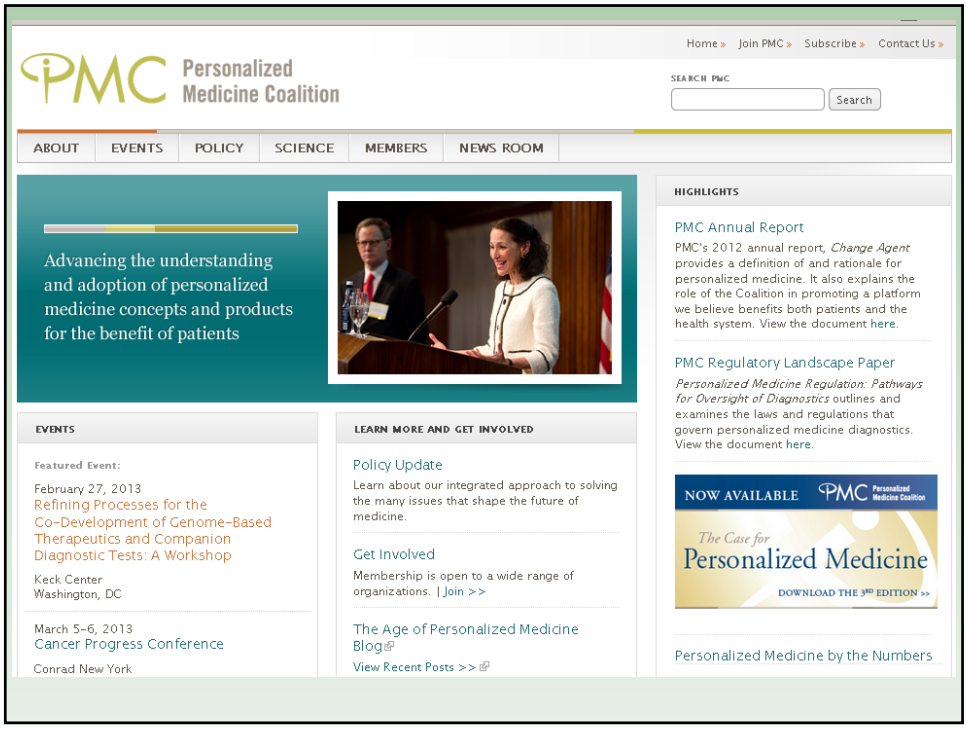
Empirical Investigations

Simulation vs. Traditional Tutorial-Based Training — Simulation in Healthcare

Effects of Simulation Versus Traditional Tutorial-Based Training on Physiologic Stress Levels Among Clinicians: A Pilot Study

Choon Looi Bong, MBChB, FRCA; Jenifer R. Lightdale, MD, MPH; Meghan E. Fredette, BS; Peter Weinstock, MD, PhD

Introduction: Emotionality and heightened anxiety during medical simulation encounters have been hypothesized to contribute to improved cognition and learning, but the overall stress "dose response curve" of experiential learning remains unclear. We sought to (1) identify the degree and time course of physiologic stress induced in physicians by simulation-based training (SBT), when compared with a traditional tutorial-based interactive-education training (IET) and (2) compare differences in stress responses to simulation activities among pediatric provider groups.
Method: Twenty-seven gastroenterology physicians were randomized among six crisis resource management courses taught by SBT versus IET. Eleven RNs and four


PMC Personalized Medicine Coalition
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SEARCH PMC
Search
ABOUT EVENTS POLICY SCIENCE MEMBERS NEWS ROOM
Advancing the understanding and adoption of personalized medicine concepts and products for the benefit of patients
HIGHLIGHTS
PMC Annual Report
PMC's 2012 annual report, Change Agent provides a definition of and rationale for personalized medicine. It also explains the role of the Coalition in promoting a platform we believe benefits both patients and the health system. View the document here.
PMC Regulatory Landscape Paper
Personalized Medicine Regulation: Pathways for Oversight of Diagnostics outlines and examines the laws and regulations that govern personalized medicine diagnostics. View the document here.
EVENTS
Featured Event:
February 27, 2013
Refining Processes for the Co-Development of Genome-Based Therapeutics and Companion Diagnostic Tests: A Workshop
Keck Center
Washington, DC
March 5-6, 2013
Cancer Progress Conference
Conrad New York
LEARN MORE AND GET INVOLVED
Policy Update
Learn about our integrated approach to solving the many issues that shape the future of medicine.
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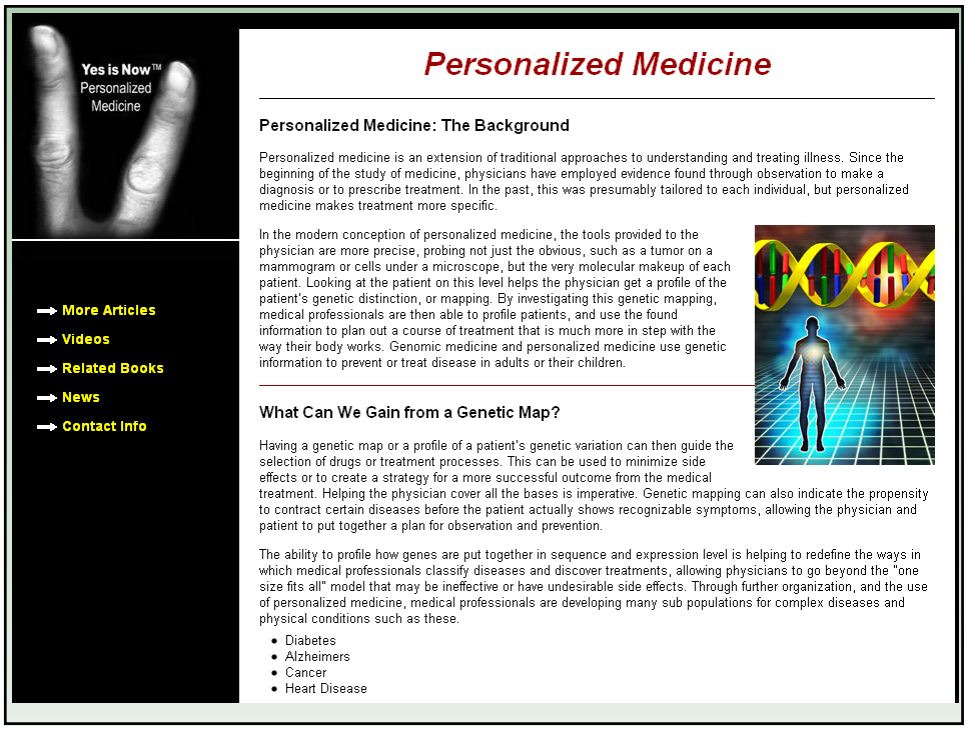
The Age of Personalized Medicine Blog
View Recent Posts >>
NOW AVAILABLE
The Case for Personalized Medicine
DOWNLOAD THE 3RD EDITION >>
Personalized Medicine by the Numbers


Yes is Now™ Personalized Medicine
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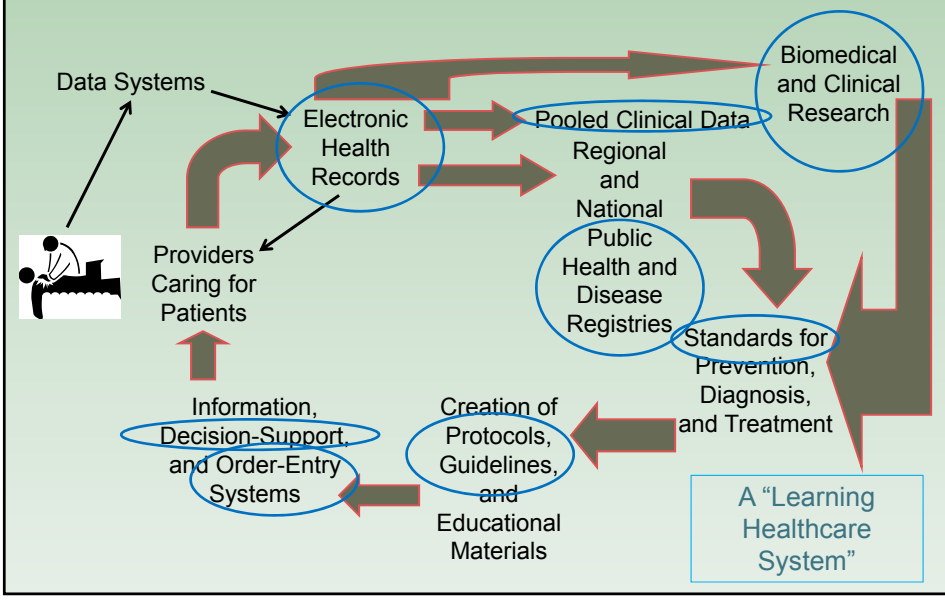
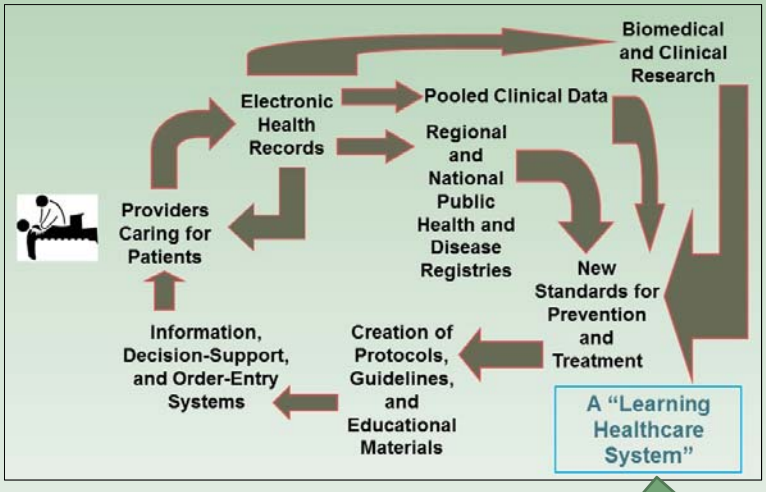
Personalized Medicine: The Background
Personalized medicine is an extension of traditional approaches to understanding and treating illness. Since the beginning of the study of medicine, physicians have employed evidence found through observation to make a diagnosis or to prescribe treatment. In the past, this was presumably tailored to each individual, but personalized medicine makes treatment more specific.
In the modern conception of personalized medicine, the tools provided to the physician are more precise, probing not just the obvious, such as a tumor on a mammogram or cells under a microscope, but the very molecular makeup of each patient. Looking at the patient on this level helps the physician get a profile of the patient's genetic distinction, or mapping. By investigating this genetic mapping, medical professionals are then able to profile patients, and use the found information to plan out a course of treatment that is much more in step with the way their body works. Genomic medicine and personalized medicine use genetic information to prevent or treat disease in adults or their children.
What Can We Gain from a Genetic Map?
Having a genetic map or a profile of a patient's genetic variation can then guide the selection of drugs or treatment processes. This can be used to minimize side effects or to create a strategy for a more successful outcome from the medical treatment. Helping the physician cover all the bases is imperative. Genetic mapping can also indicate the propensity to contract certain diseases before the patient actually shows recognizable symptoms, allowing the physician and patient to put together a plan for observation and prevention.
The ability to profile how genes are put together in sequence and expression level is helping to redefine the ways in which medical professionals classify diseases and discover treatments, allowing physicians to go beyond the "one size fits all" model that may be ineffective or have undesirable side effects. Through further organization, and the use of personalized medicine, medical professionals are developing many sub populations for complex diseases and physical conditions such as these.
Diabetes
Alzheimers
Cancer
Heart Disease

An Envisioned Cycle That Ties Patient Care with Knowledge Creation and Dissemination



Growing Role of Data Analytics



Add:

- "Big data" from massive data sets
- "Big data" from monitored behaviors
- Social media
- Personal health devices

JBI 45(3), June 2012, pp 419–422

Contents lists available at SciVerse ScienceDirect

Journal of Biomedical Informatics

journal homepage: www.elsevier.com/locate/yjbin

Technical desiderata for the integration of genomic data into Electronic Health Records

Daniel R. Masys [a,*], Gail P. Jarvik [b,c], Neil F. Abernethy [a], Nicholas R. Anderson [a], George J. Papanicolaou [d], Dina N. Paltoo [e], Mark A. Hoffman [f], Isaac S. Kohane [g], Howard P. Levy [h]

Report from a workshop on "Integration of Genetic Test Results into Electronic Medical Records" convened by the National Heart Lung and Blood Institute, and held in Bethesda, MD on August 2–3, 2011

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POLICY FORUM

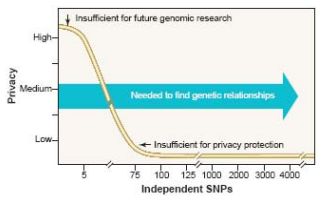
GENETICS

Genomic Research and Human Subject Privacy

Zhen Lin,[1] Art B. Owen,[2] Russ B. Altman [1]*

Interest in understanding how genetic variations influence heritable diseases and the response to medical treatments is intense. The academic community relies on the availability of public databases for the distribution of the DNA sequences and their variations. However, like other types of medical information, human genomic data are private, intimate, and sensitive. Genomic data have raised special concerns about discrimination, stigmatization, or loss of insurance or employment for individuals and their relatives (*1*, *2*). Public dissemination of these data poses nonintuitive privacy challenges.

Unrelated persons differ in about 0.1% of the 3.2 billion bases in their genomes



Trade-offs between SNPs and privacy.

entific data has led to a search for new technologies. However, the hurdles may be greater than had been suspected. For example, one approach to protecting privacy is to

mation. No genetic data will be provided unless a user can demonstrate that he or she is associated with a bona fide academic, industrial, or governmental research unit and agrees to our usage policies (including audit of data access) (*10*). Although this does not prevent data abuse, it provides a way to monitor usage.

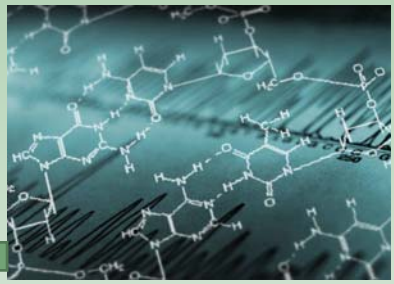
Social concerns about privacy are intricately connected to beliefs about benefits of research and trustworthiness of researchers and governmental agencies. In the United States, the Health Insurance Portability and Accountability Act of 1996 (HIPAA) and the associated Privacy Rules of 2003 (*11*) generally forbid sharing identifiable data without patient consent. However, they do not specifically address use or disclosure policies for human genetic data. Recent debates in Iceland, Estonia, Britain, and elsewhere (*12*–*15*), reveal a range of views on the threats posed by genetic information. The United States may be at one end of this spectrum, as its citizens seem to strongly desire health privacy. Whatever the setting, we recommend explic-

Science 2004;305(Jul 9);183

Individual Privacy in the Era of Genomic Medicine

New issue: Concern is not what is currently true but what might be true in the future (for individual or offspring)

New Needs for Decision Support



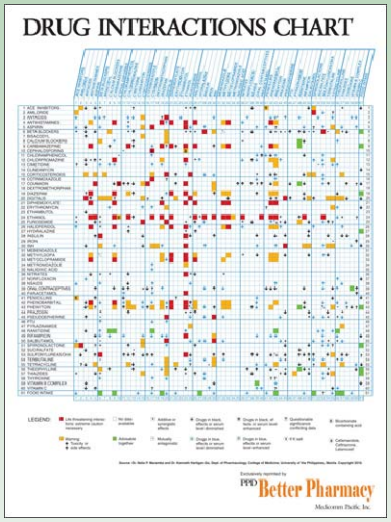
How to order
How to interpret
How to counsel

Opportunity
For New Research

Decision Support

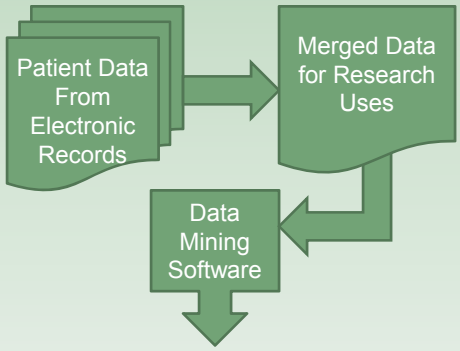
Data Analytics Example: Pooled EHR Data and "Big Data" for Drug Safety

Drug-Drug Interactions



How are new drug-drug interactions suspected, investigated, and proven?

By clinical observation, or:



Pairs of drugs associated with clinical side effects

Data Mining for Drug Surveillance

Detecting drug interactions from adverse-event reports: interaction between paroxetine and pravastatin increases blood glucose levels.

Tatonetti NP, Denny JC, Murphy SN, Fernald GH, Krishnan G, Castro V, Yue P, Tsao PS, Kohane I, Roden DM, Altman RB.

Clin Pharmacol Ther. 2011 Jul;90(1):133-42

- Database: the US Food and Drug Administration's (FDA's) Adverse Event Reporting System (AERS)
- Focus on side-effect profiles involving blood glucose (sugar) control
- Found a surprisingly strong signal when patients were receiving two drugs: pravastatin (for lowering lipids [fats] in the blood) and paroxetine (an antidepressant)
- Found that pravastatin and paroxetine, when administered together, interacted to elevate blood glucose
- Affected individuals with or without prior diabetes diagnosis
- Neither drug administered alone was associated with such changes in glucose levels
- The effect was not found in patients taking both a different lipid-lowering agent or a different antidepressant

Might There Be Another Approach?

- Individuals who experience clinical symptoms often explore them using Internet search engines
- They may also search for information on drugs they are taking
- Might there have been a drug interaction "signal" for paroxetine and pravastatin contained in Web searches even before the diabetes phenomenon had been discovered?

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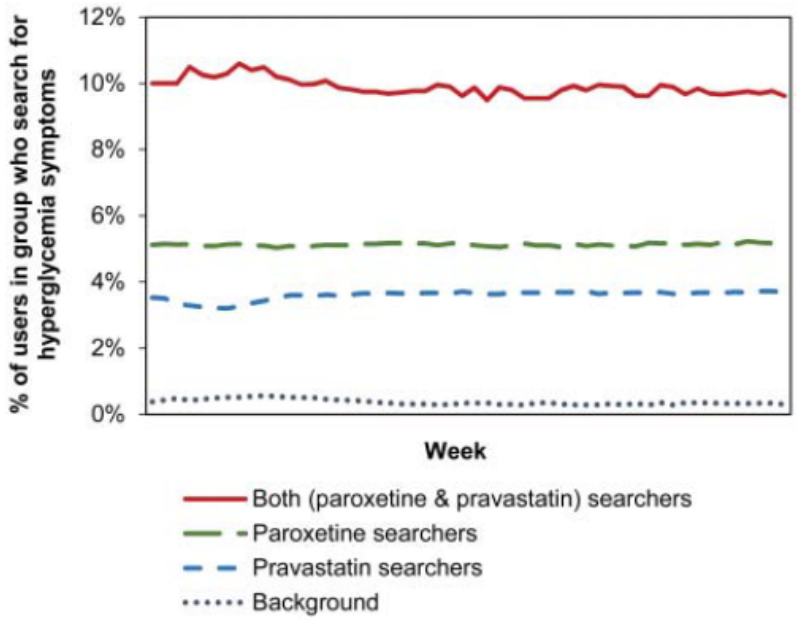
"Big Data" Example

Web-scale pharmacovigilance: listening to signals from the crowd

Ryen W White, Nicholas P Tatonetti, Nigam H Shah, Russ B Altman, Eric Horvitz

J Am Med Inform Assoc 2013;20:404-408

- Investigators hypothesized that Internet users may provide early clues about adverse drug events via their online information-seeking
- Conducted a large-scale study of Web search log data (82 million searches) gathered during 2010.
- Focused on the specific drug pairing of **paroxetine** and **pravastatin**, whose interaction was reported to cause hyperglycemia *after* the time period of the online logs used in the analysis
- Found that anonymized signals on drug interactions can be mined from search logs (and that the specific interaction could have been predicted in advance of the publication previously described)
- Conclude that logs of the search activities of populations of computer users can contribute to drug safety surveillance



Glimpses of the Future (Research Agenda)

- Decision support that is aware of complex clinical contexts
  - Models of patients and of the care process
  - Identification of context-specific information or knowledge needs
- Better integration of systems (and transferability of decision-support capabilities between systems)
- Integration of data from personal devices
- Translation of terminology to standards
- User education and engagement (including patients)

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2014 Standouts in Tech: Drones, Virtual Reality, Instant Translation and A.I.

Personal Tech, New York Times, December 31, 2014 (Farhad Manjoo)

- DJI INSPIRE 1: a remote-controlled quadricopter with camera
- SKYPE TRANSLATOR: performs near-instantaneous voice translation between people speaking English and Spanish
- GOOGLE'S IMAGE SUMMARIES: artificial intelligence project that can look at an image consisting of common items and describe, in comprehensible English words, what's going on in the picture
- OCULUS RIFT'S CRESCENT BAY: virtual-reality headset can track a user's head in a complete 360-degree swivel, allowing for a sense of being immersed in a picture without motion sickness

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A Chip In The Head (C/Net: October 28, 2013)

- In a bid to improve the mental health of soldiers and veterans, DARPA has launched a $70 million project to create an implant that tracks neuron activity and provides quantifiable brain data
- Project is being called the Systems-Based Neurotechnology for Emerging Therapies (SUBNETS)
- Goal is to be able to monitor the "mental health" of soldiers and veterans
- DARPA's device will be similar to deep brain stimulation, but rather than targeting one specific symptom, it will be able to monitor and analyze data in real time and issue a specific intervention according to brain activity
- One prediction: Brain Implants Will Be Connecting People To The Internet By The Year 2020

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Conclusions

A major constraint in making progress is the availability of individuals well trained at the intersection of computer science, information management, and clinical medicine

- Growing number of educational programs in biomedical informatics (MS and PhD levels, plus fellowships for health professionals)
- Growing number of training programs in applied health information technology
- Appointment of a CMIO (Chief Medical Information Officer) in a growing number of organizations
- Creation of ABMS-approved subspecialty in clinical informatics for physicians (first diplomats in 2013)

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A Final Point

There are limitations to current systems (including EHRs and decision-support systems), but progress over time is clear and imperfect systems still have value

Further progress depends on more informatics expertise and on informed feedback into research, design, and implementation of evolving systems

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