THE UNIVERSITY of TEXAS
SCHOOL OF HEALTH INFORMATION SCIENCES AT HOUSTON

THE UNIVERSITY OF TEXAS
HEALTH SCIENCE CENTER AT HOUSTON
Center for Clinical and Translational Sciences
IN PARTNERSHIP WITH
THE UNIVERSITY OF TEXAS
M.D. ANDERSON CANCER CENTER
AND
MEMORIAL HERMANN HOSPITAL SYSTEM

Elmer V. Bernstam, MD

Associate Professor

School of Health Information Sciences and

Department of Internal Medicine

UT-Houston

Key research questions for our group:

1.How do we enable reuse routinely-collected clinical data for research?

2.How can we empower (non-expert) consumers to evaluate the accuracy of online health information?

3.Can we leverage graph algorithms over citation networks to identify the most “important” articles in response to queries?

4.How do we define biomedical informatics as a scientific discipline? What are the implications for training, practice and research?

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Why doesn't health IT work?

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UT-Houston

Acknowledgements

- Todd Johnson
- Jack Smith
- CTSA informatics community
- Luciano Floridi
  - philosophy of information

- Portions adapted from:
  - Bernstam EV, Smith JW and Johnson TR. What is biomedical informatics? J BioMed Inf, *in press.*
  - Bernstam EV, Hersh WR, Johnson SB, *et al.* Synergies and Distinctions between Computational Disciplines in Biomedical Research: Perspective from the Clinical and Translational Science Award Programs. Acad Med, 2009 Jul;84(7):964-70.
  - Bernstam EV, Hersh WR, Sim I , *et al.* Unintended consequences of health information technology: a need for biomedical informatics. J Biomed Inf, *in press.*

- *"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.*** *This will* ***cut waste, eliminate red tape, and reduce the need to repeat expensive medical tests… it will save lives by reducing the deadly but preventable medical errors that pervade our health care system."***
  - Barack Obama

    (Speech on the Economy, George Mason University, January 8, 2009)

“It slices! It dices!
But wait there’s more!”

http://healthit.hhs.gov accessed: 7/2/2009)

Health IT fact vs. fiction

- Disclaimer: I am an informatician
  - Informaticians live for health IT
- But…
  - Overpromising is a bad long-term strategy

“AI winters” (plural) – cycles of boom (enthusiasm) and bust (disappointment) associated with technology

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AI winter

From Wikipedia, the free encyclopedia
(Redirected from AI Winter)

In the history of artificial intelligence, an **AI winter** is a period of reduced funding and interest in artificial intelligence research.[1] The process of hype, disappointment and funding cuts are common in many emerging technologies (consider the railway mania or the dot-com bubble), but the problem has been particularly acute for AI. The pattern has occurred many times:

- 1966: the failure of machine translation,
- 1970: the abandonment of connectionism,
- 1971–75: DARPA's frustration with the Speech Understanding Research program at Carnegie Mellon University,
- 1973: the large decrease in AI research in the United Kingdom in response to the Lighthill Report,
- 1973–74: DARPA's cutbacks to academic AI research in general,
- 1987: the collapse of the Lisp machine market,
- 1988: the cancellation of new spending on AI by the Strategic Computing Initiative,
- 1993: expert systems slowly reaching the bottom,
- 1990s: the quiet disappearance of the fifth-generation computer project's original goals,
- and the generally bad reputation AI has had since.

The worst times for AI were 1974–80 and 1987–93. Sometimes one or the other of these periods (or some part of them) is referred to as "the" AI winter.[2]

http://en.wikipedia.org/wiki/AI_Winter, accessed 7/3/2009

E-patient Dave

So I went into my patient portal, PatientSite, and clicked the button to do it. I checked the boxes for all the options and clicked Upload. It was pretty quick.

But WTF?
An alarm: "! Requires immediate attention"

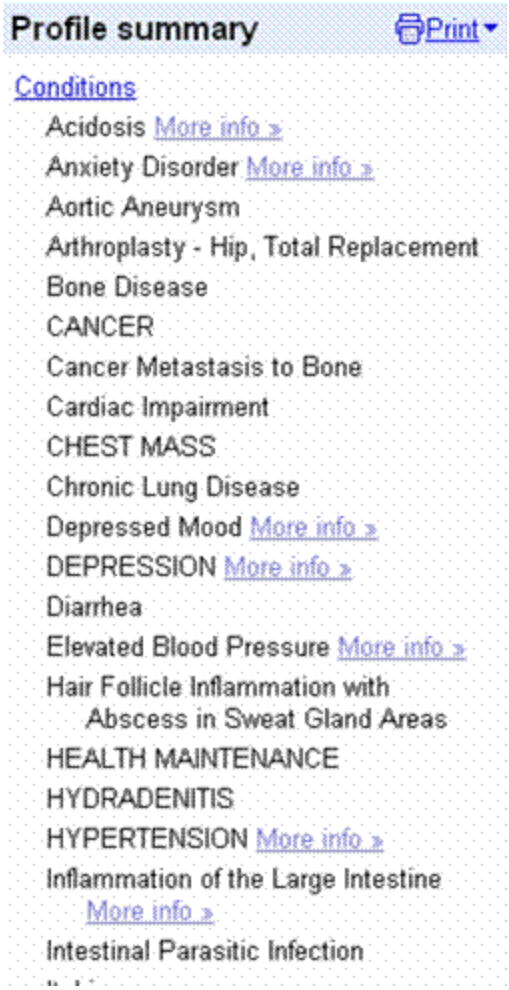
Requires immediate attention Discuss with your doctor soon

Hydrochlorothiazide and Low Amount of Potassium in the Blood

Medications given to people who have certain conditions can lead to an increase in side effects and/or worsening of the condition. Hydrochlorothiazide Oral generally should not be given to people with Hypokalemia. This health profile includes this condition.

Okay, yes, HCTz is my blood pressure medication.

But low potassium? That was true when I was hospitalized two years ago, not now. What's going on?



http://e-patients.net/archives/2009/04/imagine-if-someone-had-been-managing-your-data-and-then-you-looked.html, accessed 7/3/2009

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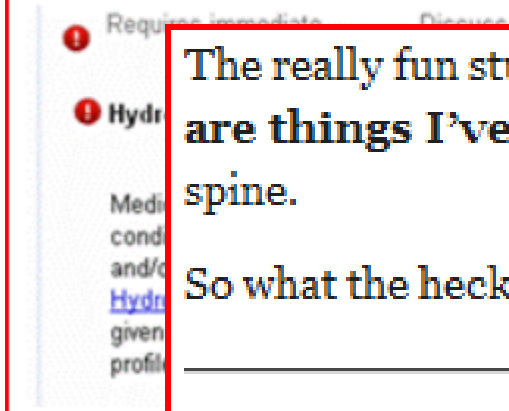

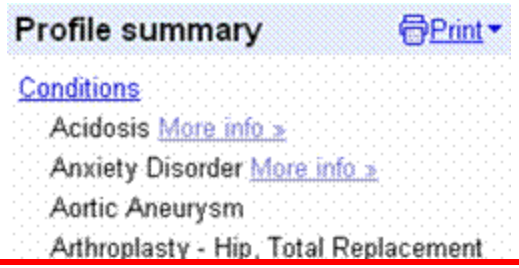

The really fun stuff, though, is that **some of the conditions transmitted are things I've never had:** aortic aneurysm and mets to the brain or spine.

So what the heck??

I've been discussing this with the docs in the back room here, and they quickly figured out what was going on before I confirmed it: **the system transmitted insurance billing codes** to Google Health, **not doctors' diagnoses.** And as those in the know are well aware, in our system today, insurance billing codes bear no resemblance to reality.

http://e-patients.net/archives/2009/04/imagine-if-someone-had-been-managing-your-data-and-then-you-looked.html, accessed 7/3/2009

Health IT doesn't (always) work as promised

Evaluating computerised health information systems: hard lessons still to be learnt

Peter Littlejohns, Jeremy C Wyatt, Linda Garvican

Enormous investment has gone into computerised hospital information systems worldwide. The estimated costs for each large hospital are about $50m (£33m), yet the overall benefits and costs of hospital information systems have rarely been assessed.[1] When systems are evaluated, about three quarters are considered to have failed,[2] and there is no evidence that they improve the productivity of health professionals.[3]

Littlejohns P, Wyatt JC, Garvican L. Evaluating computerised health information systems: hard lessons still to be learnt. BMJ. 2003 Apr 19;326(7394):860-3. PMID: 12702622

Han YY, Carcillo JA, Venkataraman ST, Clark RSB, Watson RS, Nguyen TC, Bayir H, Orr RA. Unexpected increased mortality after implementation of a commercially sold computerized physician order entry system. Pediatrics 2005; 116:1506-12.

Computerized provider order entry implementation: no association with increased mortality rates in an intensive care unit. Pediatrics 2006; 118:1,290-5.

ORIGINAL INVESTIGATION

High Rates of Adverse Drug Events in a Highly Computerized Hospital

ARCHIVES EXPRESS

Jonathan R. Nebeker, MS, MD; Jennifer M. Hoffman, PharmD; Charlene R. Weir, RN, PhD; Charles L. Bennett, MD, PhD, MPP; John F. Hurdle, MD, PhD

Background: Numerous studies have shown that specific computerized interventions may reduce medication errors, but few have examined adverse drug events (ADEs) across all stages of the computerized medication process. We describe the frequency and type of inpatient ADEs that occurred following the adoption of multiple computerized medication ordering and administration systems, including computerized physician order entry (CPOE).

Methods: Using explicit standardized criteria, pharmacists classified inpatient ADEs from prospective daily reviews of electronic medical records from a random sample of all admissions during a 20-week period at a Veterans Administration hospital. We analyzed ADEs that necessitated a changed treatment plan.

Results: Among 937 hospital admissions, 483 clinically significant inpatient ADEs were identified, accounting for 52 ADEs per 100 admissions and an incidence density of 70 ADEs per 1000 patient-days. One quarter of the hospitalizations had at least 1 ADE. Of all ADEs, 9% resulted in serious harm, 22% in additional monitoring and interventions, 32% in interventions alone, and 11% in monitoring alone; 27% should have resulted in additional interventions or monitoring. Medication errors contributed to 27% of these ADEs. Errors associated with ADEs occurred in the following stages: 61% ordering, 25% monitoring, 13% administration, 1% dispensing, and 0% transcription. The medical record reflected recognition of 76% of the ADEs.

Conclusions: High rates of ADEs may continue to occur after implementation of CPOE and related computerized medication systems that lack decision support for drug selection, dosing, and monitoring.

Arch Intern Med. 2005;165:1111-1116

ORIGINAL CONTRIBUTION

Role of Computerized Physician Order Entry Systems in Facilitating Medication Errors

Ross Koppel, PhD
Joshua P. Metlay, MD, PhD
Abigail Cohen, PhD
Brian Abaluck, BS
A. Russell Localio, JD, MPH, MS
Stephen E. Kimmel, MD, MSCE
Brian L. Strom, MD, MPH

Context Hospital computerized physician order entry (CPOE) systems are widely regarded as the technical solution to medication ordering errors, the largest identified source of preventable hospital medical error. Published studies report that CPOE reduces medication errors up to 81%. Few researchers, however, have focused on the existence or types of medication errors facilitated by CPOE.

Objective To identify and quantify the role of CPOE in facilitating prescription error risks.

Design, Setting, and Participants We performed a qualitative and quantitative study of house staff interaction with a CPOE system at a tertiary-care teaching hospital (2002-2004). We surveyed house staff (N=261; 88% of CPOE users); conducted 5 focus groups and 32 intensive one-on-one interviews with house staff, information technology leaders, pharmacy leaders, attending physicians, and nurses; shadowed house staff and nurses; and observed them using CPOE. Participants included house staff, nurses, and hospital leaders.

Main Outcome Measure Examples of medication errors caused or exacerbated by the CPOE system.

Results We found that a widely used CPOE system facilitated 22 types of medication error risks. Examples include fragmented CPOE displays that prevent a coherent view of patients' medications, pharmacy inventory displays mistaken for dosage guidelines, ignored antibiotic renewal notices placed on paper charts rather than in the CPOE system, separation of functions that facilitate double dosing and incompatible orders, and inflexible ordering formats generating wrong orders. Three quarters of the house staff reported observing each of these error risks, indicating that they occur weekly or more often. Use of multiple qualitative and survey methods identified and quantified error risks not previously considered, offering many opportunities for error reduction.

Conclusions In this study, we found that a leading CPOE system often facilitated medication error risks, with many reported to occur frequently. As CPOE systems are implemented, clinicians and hospitals must attend to errors that these systems cause in addition to errors that they prevent.

JAMA. 2005;293:1197-1203 www.jama.com

ADVERSE DRUG EVENTS (ADEs) are estimated to injure or kill more than 770 000 people in hospitals annually.[1] Prescribing errors are the most frequent source.[2-5] Computerized physician order entry (CPOE) systems are widely viewed as crucial for reducing prescribing errors[2,3,6-17] and saving hundreds of billions in annual costs.[18,19] Computerized physician order entry system advocates include researchers, clinicians, hospital administrators, pharmacists, business councils, the Institute of Medicine, state legislatures, health care agencies, and the lay public.[2,3,6-10,12,14-17,20-22] These systems are expected to become more prevalent in response to resident working-hour limitations and related care discontinuities[23] and will supposedly offset causes (eg, job dissatisfaction) and effects (eg, ADEs) of nursing shortages.[24,25] Such a system is increasingly recommended for outpatient practices (BOX).

Adoption of CPOE perhaps gathered such strong support because its promise is so great, effects of medica-

See also pp 1223 and 1261.

Author Affiliations: Department of Sociology (Dr Koppel), Department of Medicine, Cardiovascular Division (Dr Kimmel) and General Medicine Division (Drs Metlay and Strom), Center for Clinical Epidemiology and Biostatistics (Drs Koppel, Metlay, Cohen, Kimmel, and Strom and Mr Localio), Department of Biostatistics and Epidemiology (Drs Metlay, Kimmel, and Strom and Mr Localio), Department of Pharmacology (Dr Strom), Center for Education and Research in Therapeutics (Drs Metlay and Strom and Mr Localio), University of Pennsylvania School of Medicine (Mr Abaluck), Philadelphia; and Center for Health Equity Research and Promotion, Department of Veterans Affairs, Philadelphia (Dr Metlay).
Corresponding Author: Ross Koppel, PhD, Center for Clinical Epidemiology and Biostatistics, Room 106, Blockley Hall, School of Medicine, University of Pennsylvania, Philadelphia, PA 19104 (rkoppel@sas.upenn.edu).

ARCHIVES EXPRESS

r, RN, PhD;

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ADVERSE DRUG EVENTS (ADEs) are estimated to injure or kill

ARCHIVES EXPRESS

r, RN, PhD;

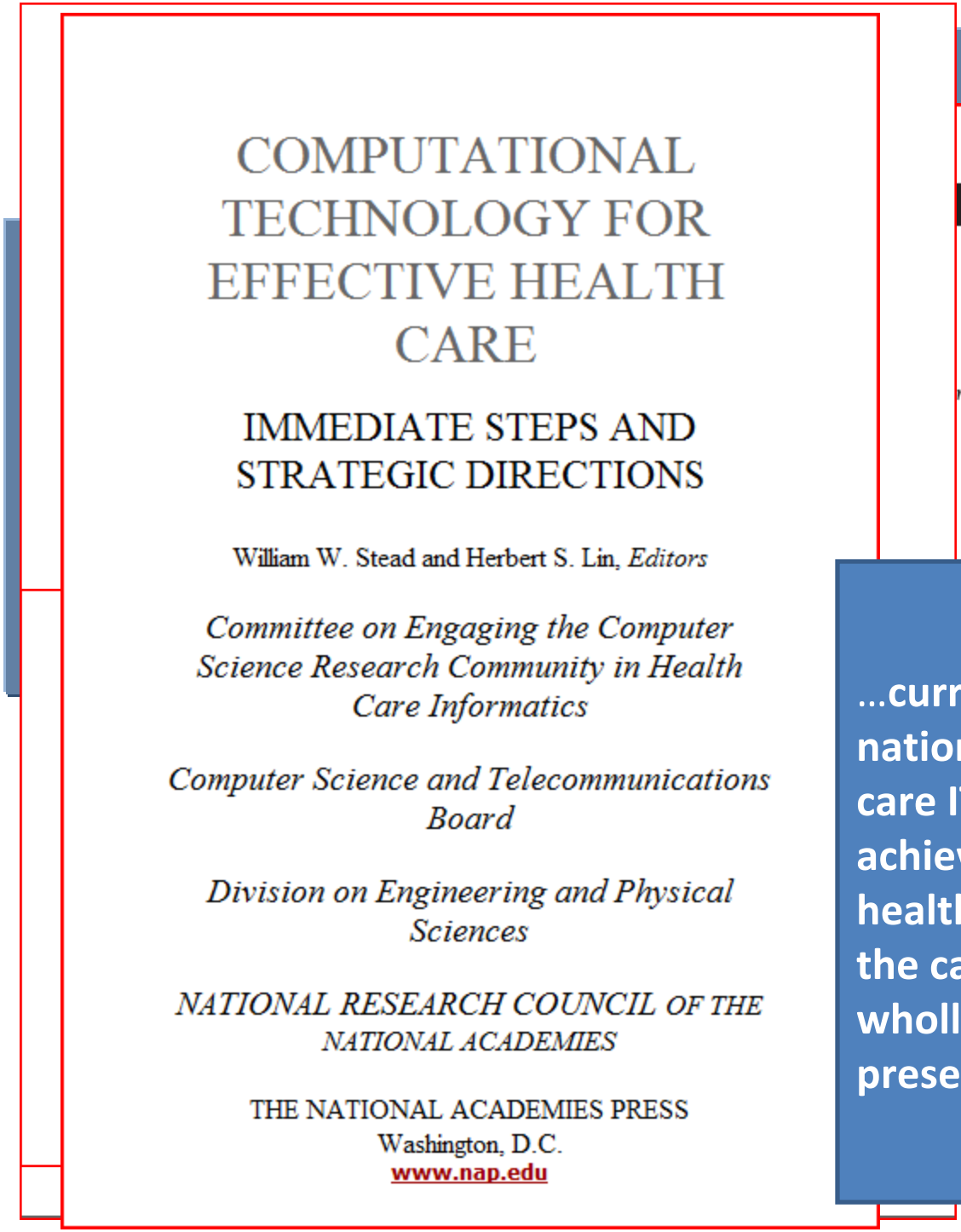
Journal of the American Medical Informatics Association Volume 14 Number 3 May / June 2007

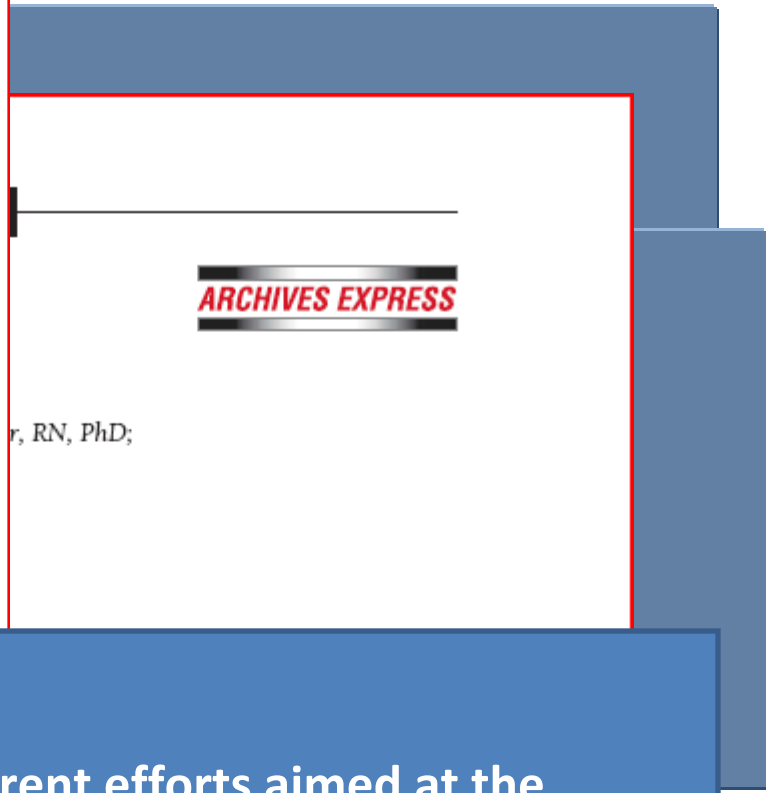
Comment ■

"e-Iatrogenesis": The Most Critical Unintended Consequence of CPOE and other HIT

JONATHAN P. WEINER, DRPH, TONI KFURI, MD, MPH, KITTY CHAN PHD, JINNET B. FOWLES, PHD

■ **J Am Med Inform Assoc.** 2007;14:387–388. DOI 10.1197/jamia.M2338.





…current efforts aimed at the nationwide deployment of health care IT will not be sufficient to achieve the vision of 21st century health care, and may even set back the cause if these efforts continue wholly without change from their present course.

Joint Commission Sentinel Event Alert

Sentinel Event Alert

Issue 42, December 11, 2008

Safely implementing health information and converging technologies

As health information technology (HIT) and "converging technologies"—the interrelationship between medical devices and HIT—are increasingly adopted by health care organizations,[1,2] users must be mindful of the safety risks and preventable adverse events that these implementations can create or perpetuate. Technology-related adverse events can be associated with all components of a comprehensive technology system and may involve errors of either commission or omission. These unintended adverse events typically stem from human-machine interfaces or organization/system design.[3] The overall safety and effectiveness of technology in health care ultimately depend on its human users, ideally working in close concert with properly designed and installed electronic systems. Any form of technology may adversely affect the quality and safety of care if it is designed or implemented improperly or is misinterpreted. Not only must the technology or device be designed to be safe, it must also be operated safely within a safe workflow process.

HIT is a hard sell

The NEW ENGLAND JOURNAL of MEDICINE

SPECIAL ARTICLE

Use of Electronic Health Records in U.S. Hospitals

Ashish K. Jha, M.D., M.P.H., Catherine M. DesRoches, Dr.Ph., Eric G. Campbell, Ph.D., Karen Donelan, Sc.D., Sowmya R. Rao, Ph.D., Timothy G. Ferris, M.D., M.P.H., Alexandra Shields, Ph.D., Sara Rosenbaum, J.D., and David Blumenthal, M.D., M.P.P.

From the Department of Health Policy and Management, Harvard School of Public Health (A.K.J.); the Division of General Medicine, Brigham and Women's Hospital (A.K.J.); the Veterans Affairs Boston Healthcare System (A.K.J.); and the Institute for Health Policy (C.M.D., E.G.C., K.D., S.R.R., T.G.F., A.S., D.B.) and the Biostatistics Center (S.R.R.), Massachusetts General Hospital — all in Boston; and the Department of Health Policy, George Washington University, Washington, DC (S.R.). Address reprint requests to Dr. Jha at the Harvard School of Public Health, 677 Huntington Ave., Boston, MA 02115, or at ajha@hsph.harvard.edu.

This article (10.1056/NEJMsa0900592) was published at NEJM.org on March 25, 2009.

N Engl J Med 2009;360:1628-38.

ABSTRACT

BACKGROUND

Despite a consensus that the use of health information technology should lead to more efficient, safer, and higher-quality care, there are no reliable estimates of the prevalence of adoption of electronic health records in U.S. hospitals.

METHODS

We surveyed all acute care hospitals that are members of the American Hospital Association for the presence of specific electronic-record functionalities. Using a definition of electronic health records based on expert consensus, we determined the proportion of hospitals that had such systems in their clinical areas. We also examined the relationship of adoption of electronic health records to specific hospital characteristics and factors that were reported to be barriers to or facilitators of adoption.

RESULTS

On the basis of responses from 63.1% of hospitals surveyed, only 1.5% of U.S. hospitals have a comprehensive electronic-records system (i.e., present in all clinical units), and an additional 7.6% have a basic system (i.e., present in at least one clinical unit). Computerized provider-order entry for medications has been implemented in only 17% of hospitals. Larger hospitals, those located in urban areas, and teaching hospitals were more likely to have electronic-records systems. Respondents cited capital requirements and high maintenance costs as the primary barriers to implementation, although hospitals with electronic-records systems were less likely to cite these barriers than hospitals without such systems.

CONCLUSIONS

The very low levels of adoption of electronic health records in U.S. hospitals suggest that policymakers face substantial obstacles to the achievement of health care performance goals that depend on health information technology. A policy strategy focused on financial support, interoperability, and training of technical support staff may be necessary to spur adoption of electronic-records systems in U.S. hospitals.

"…only **1.5% of U.S. hospitals have a comprehensive electronic-records system** (i.e., present in all clinical units), and **an additional 7.6% have a basic system** (i.e., present in at least one clinical unit)."

(NEJM 360:16, 4/16/2009)

Two Questions

- Why isn’t health information technology working?
- What can we do to improve it?

Why isn't HIT working?

- Multiple reasons
  - Complexity of healthcare and healthcare "system"
  - HIT designed for billing and legal, not to improve quality
  - Lack of attention to human factors issues
  - Perverse incentives
  - Standards and vocabularies
  - and many more...

Why is Health IT not working?

- Health IT is a misnomer
  - Health **data** (not information) technology
- But… many fields have been successfully computerized
  - Banking and finance
- Health data != (certain kinds of) financial data
  - “Semantic gap”

Information Theory (Shannon, 1948)

Reprinted with corrections from *The Bell System Technical Journal*,
Vol. 27, pp. 379–423, 623–656, July, October, 1948.

A Mathematical Theory of Communication

By C. E. SHANNON

INTRODUCTION

THE recent development of various methods of modulation such as PCM and PPM which exchange bandwidth for signal-to-noise ratio has intensified the interest in a general theory of communication. A basis for such a theory is contained in the important papers of Nyquist[1] and Hartley[2] on this subject. In the present paper we will extend the theory to include a number of new factors, in particular the effect of noise in the channel, and the savings possible due to the statistical structure of the original message and due to the nature of the final destination of the information.

The fundamental problem of communication is that of reproducing at one point either exactly or approximately a message selected at another point. Frequently the messages have *meaning*; that is they refer to or are correlated according to some system with certain physical or conceptual entities. These semantic aspects of communication are irrelevant to the engineering problem. The significant aspect is that the actual message is one *selected from a set* of possible messages. The system must be designed to operate for each

Informatics should help us, but...

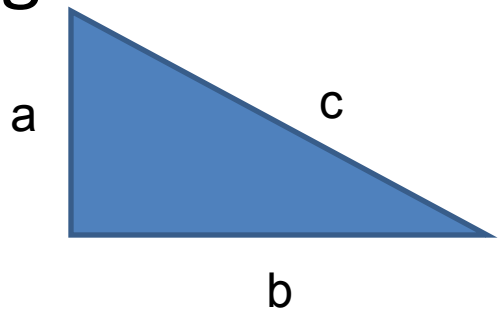
- *"...the study of how clinical knowledge is created, shaped, shared and applied"* Coiera
- *"...the scientific field that deals with biomedical information, data, and knowledge—their storage, retrieval, and optimal use for problem solving and decision making."* Shortliffe
- *"...the science that deals with biomedical information, its structure, acquisition and use."* Stead
- *"...has to do with all aspects of understanding and promoting the effective organization, analysis, management, and use of information in health care."* AMIA
- *"...primary focus is the acquisition, storage, and use of information in the health/biomedical domain."* Hersh

Philosophy of Information

- New field defined by Luciano Floridi over the past 15 years
- Investigates “the conceptual nature and basic principles of information, including its dynamics, utilisation, and sciences.”
  http://en.wikipedia.org/wiki/Philosophy_of_information Accessed 7/24/2009

Definition

- Data = non-uniformity (symbols)
  - a, b, c, 0, 1, 2, k, =, /, +
- Information = Data + Meaning
  - $c^2=a^2+b^2$



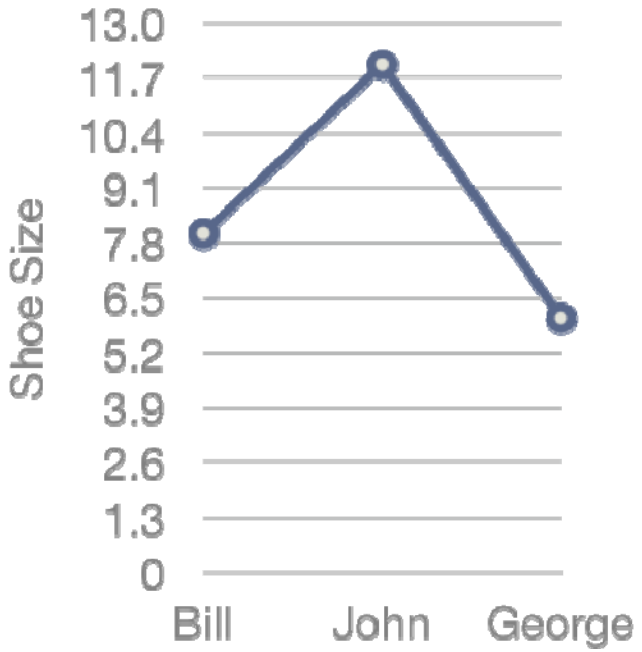
- Informatics = study of information = study of data + meaning

Information

- Data + Meaning
- “A difference that makes a difference” Gregory Bateson, 1972
- More precisely, σ is information if:
  - σ consists of one or more *data*
  - the data in σ are *well-formed*
  - the well-formed data in σ are *meaningful*
  - *“Colorless ideas sleep furiously” -- Not information*

Equivalence of Information

- If σ_1 and σ_2 are both well-formed meaningful data and their meaning is equivalent, then σ_1 and σ_2 represent the same information.
- Consider:
  - John's shoe size is 12
  - John has a shoe size of twelve
- Or, nearly equivalent
  - Breast cancer
  - Breast carcinoma
  - Mammary neoplasm



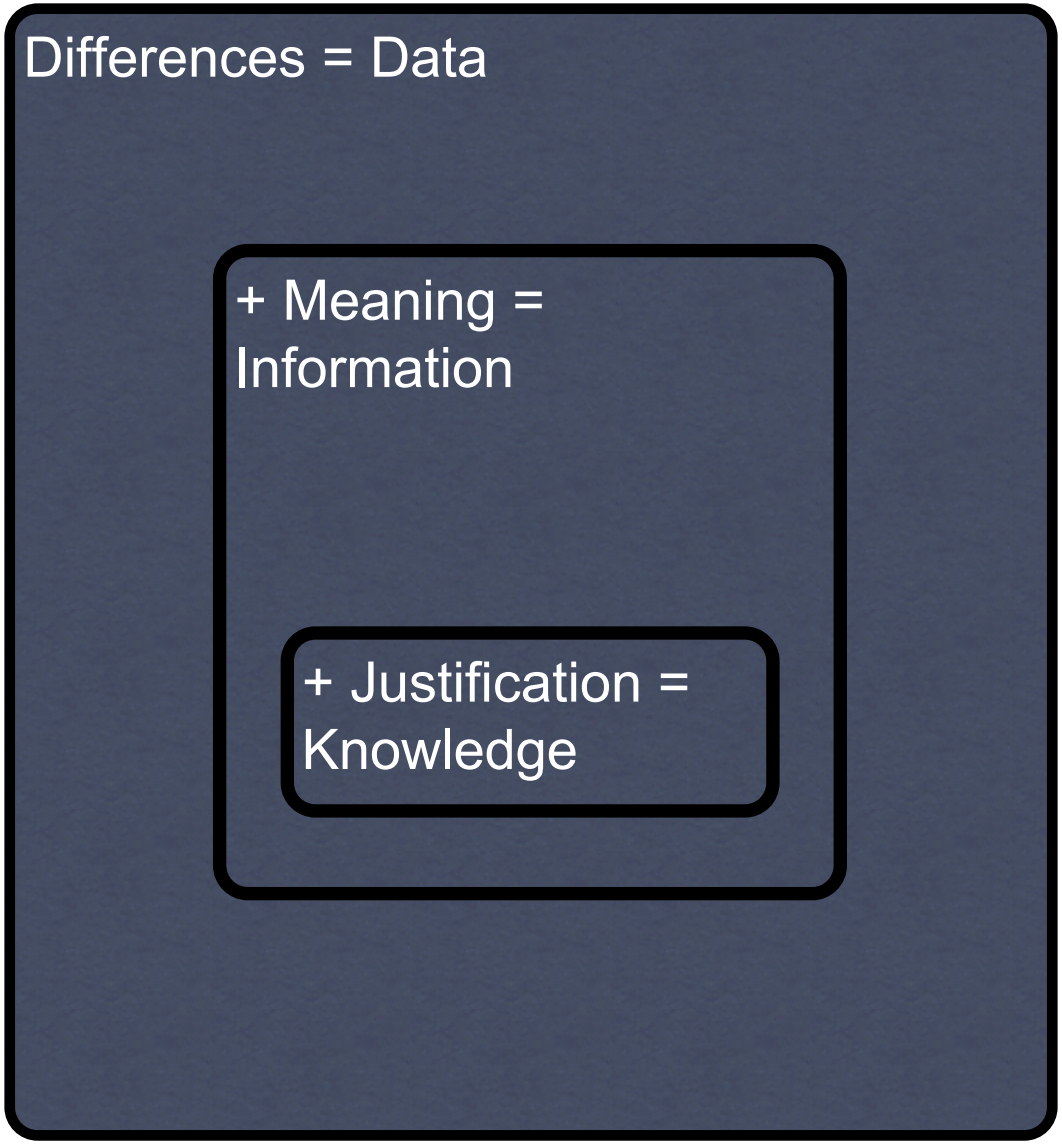
Context crucial

- To interpret data as information we need to know the relevant question
  - Example: “12”
  - John’s shoe size? Minutes on a treadmill? Number of apostles?
- The question guides our interpretation of data
  - Example: “I”
    - Could be a personal pronoun or the number 1 or just a line
- Unfortunately, EMR entries often stripped of context
  - Example: e-Patient Dave

What is Knowledge?

Knowledge is Justified True Belief

- Information that
  - is justified (has a relevant explanation, involves understanding)
  - is true
  - is believed
- More useful: Information that is general and thought to be justifiably true enough to follow
  - Smoking causes lung cancer


Differences = Data
+ Meaning = Information
+ Justification = Knowledge

Summary on Data, Information and Knowledge

- Data is just an observatoin, it need not be meaningful
- Information = Data + Meaning
  - But meaning depends on context
  - 174.9 Malignant neoplasm of female breast: Breast (female), unspecified
- Knowledge = General Information that is justifiably true

Computers vs. Humans

- Humans process information (meaning, content, in context)
- Computers process data (symbols)
  - Symbol manipulation (form) without any sense of what the symbols mean (content)
  - **Form**al methods: Manipulate form without regard for content

Why is this Important?

- **Our tools**
  - Computers, pencil and paper, books, forms, etc.
- **Are much better at manipulating data (symbols)**
  - Move a value from column A to column B
  - If symbol A and B appear together, replace it with symbol C
- **Than meaning**
  - Our tools manipulate form (“FORMal methods”) and hope that meaning follows form
  - Long division: move numbers around according to certain rules and “magically” get the right answer

Semantic gap

- Distance between data and information
- Sometimes low
  - Banking data
  - Business inventories
- Sometimes high
  - Financial planning (e.g., hopes/dreams)
  - Health care data
- Low semantic gap → high IT penetration
- High semantic gap → low IT penetration

Health data vs. banking data

Health data

- General description
  - Sick patient
- Diagnosis
  - Pneumonia
- Procedure
  - Appendectomy

- Fuzzy, ill-defined
- Data != meaning
- Context complex but critical

Banking data

- Account number
  - 1234
- Balance
  - $1076.58
- Date
  - 7/2/2009

- Numerical, well-defined
- Data ~= meaning
- Context relatively simple

Consequences of large semantic gap

- Hard to capture meaning [using computers]
- “Formal methods” = methods that manipulate data fail
  - Clinical reality != billing codes
    - E-patient Dave: brain metastases when data are imported

Implications

- Data overload
  - Computers can only provide data
  - Humans need information and/or knowledge, they don't need data
  - More data != information
- Mapping issues
  - Strip context → errors when combining data sets
- Faulty reasoning
  - Manipulate data, hope to get meaningful answers

HIT requires a paradigm shift

- Not about computer applications, computation, statistics, math, or AI, but all are very important related disciplines
- Focus on meaningful data (information)

Key Research Areas for Informatics

- Techniques at information (and knowledge) level
  - Data → information → knowledge
  - Allow computers to process data "as if" they understand meaning
  - Display/organize data/information in ways that optimize human information processing (human factors engineering)
    - Allow humans to discover new meaning → better decisions (data mining)
- Concept oriented ontologies
  - Logical definitions of concepts

HIT as clinical interventions

- HIT should be seen as a clinical interventions– like drugs
  - HIT can affect decisions → outcomes
  - **Positive and negative effects are possible**

Promising research directions

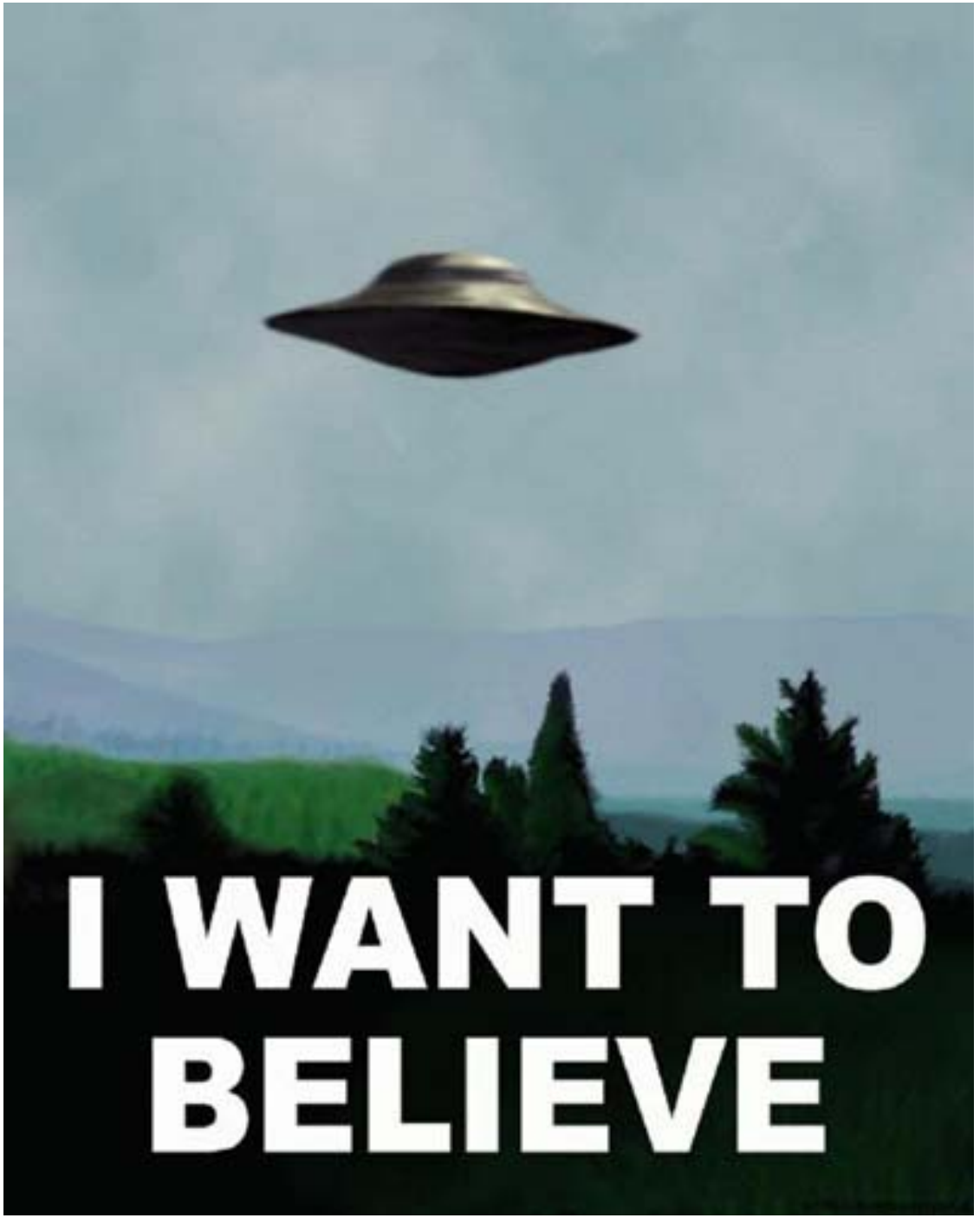
- Emphasis on cognitive science
  - How does this technology improve human performance?
- Comparative effectiveness research
  - Just like the eye doctor: Better 1? Better 2?
  - Emphasized recently by federal government
- Natural language processing
  - Clinical knowledge is in free text, not billing data
    - ePatient Dave, mammogram = breast cancer diagnosis
- Outcome-based informatics research
  - Does system improve outcome?

Summary

- Health IT has real potential
  - May be compromised by over-promising
- Health INFORMATION technology must focus on meaning, not data
  - Not easy, need new ideas
- Health IT can significantly affect health care
  - For good or ill

Summary

- To realize promise of HIT requires unprecedented collaboration
- Different disciplines
  - philosophy, computer science, psychology, biomedicine...
  - Different cultures, very different values
- Challenge and opportunity
  - Fundamentally different perspectives on old stubborn problems


I WANT TO
BELIEVE