Why doesn't health IT work?

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"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)

The need for Health IT (HIT) seems to be one of the few topics upon which Democrats and Republicans agree. Both former President Bush and President Obama set 2014 as the goal date for computerizing medical records. However, a recent National Research Council report cautioned that "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." In this talk, I will discuss three reasons why current HIT is inadequate. First, IT is actually more precisely described as data (or datamation) technology since it processes data, not information (data + meaning). Second, health-related information has a large "semantic gap" compared to information in other fields such as accounting. In other words, in health care there is a large difference between information (data + meaning) and data. Third, there are substantial social and administrative barriers to HIT adoption. I will conclude by discussing promising research directions in biomedical informatics that have the potential to improve HIT.

Introduction

Widespread dissatisfaction with health care in America and rapid advancement in information technology has focused attention on Health IT (HIT) as a possible solution. The need for HIT is one of the few topics upon which Democrats and Republicans agree. Both former President Bush and President Obama set 2014 as the goal date for computerizing medical records. To many, HIT seems like an obvious solution to our health care woes. The government's HIT website says that HIT adoption will: improve health care quality, prevent medical errors, reduce health care costs, increase administrative efficiencies, decrease paperwork and expand access to affordable care . However, there is increasing evidence that HIT adoption does not guarantee these benefits. Unmitigated enthusiasm is dangerous for HIT adoption. Similar enthusiasm repeatedly threatens the field of artificial intelligence, resulting in cycles of excitement and disappointment ("AI winters"). Motivated by the desire to avoid "HIT winters," we will review the effects of HIT, discuss significant social and administrative barriers to HIT adoption and conclude with research challenges that must be addressed before the full promise of HIT is realized.

Effects of HIT

HIT is an "easy sell" to an American public increasingly dissatisfied with our health care system. Indeed, there is evidence that HIT can improve health care quality(Chaudhry, Wang et al. 2006), prevent medical errors(Bates, Cohen et al. 2001) and increase efficiency(Chaudhry, Wang et al. 2006). Thus, there is reason for optimism. However, many and perhaps even most HIT projects fail(Littlejohns, Wyatt et al. 2003). There is also evidence that HIT can worsen health care quality to the point of increasing mortality(Han, Carcillo et al. 2005), increasing errors(Levenson and Turner 1993; Koppel, Metlay et al. 2005) and decreasing efficiency(Han, Carcillo et al.

2005). There is even a term, “e-iatrogenesis,” that refers to the unintended deleterious consequences of HIT (Weiner, Kfuri et al. 2007).

We’ve been here before: AI Winters

During the 1950s, we were faced with a different problem: the Cold War. Similarly, the government saw IT as a promising (at least partial) solution. If researchers could develop automated translation, we could monitor Russian communications and scientific reports in “real time.” There was a great deal of optimism and “…many predictions of fully automatic systems operating within a few years.”(Hutchins 2006)

Although there were promising applications of poor-quality automated translation, the optimistic predictions of the 1950s were not realized. The fundamental problem of context and meaning remains unsolved. This made disambiguation difficult resulting in amusing failures. Anecdotal examples include: “the spirit is willing but the flesh is weak" translated English **à** Russian **à** English resulted in the phrase "the vodka is good but the meat is rotten."

In 1966, the influential Automatic Language Processing Advisory Committee (ALPAC) concluded that ‘‘there is no immediate or predictable prospect of useful machine translation’’ (ALPAC 1966). As a result, research funding was stopped and there was little automated translation research in the United States from 1967 until a revival in 1976-1989 (Hutchins 2006).

Similarly, there is currently tremendous interest in HIT. Although there is good evidence that HIT can be useful, some will certainly be disappointed. A recent report by the National Research Council (the same body that published the ALPAC report) concluded that “…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" (2009). Thus, there is reason for concern that HIT (and the field of biomedical informatics, in general) may be headed for a bust. Such an "HIT winter" would be unfortunate, since there are real benefits of pursuing research and implementation of HIT.

The problem: Health Information Technology is really Health Data Technology

Loosely speaking, information philosophers draw a distinction between data (syntax) and information, defined as meaningful data (i.e., data + meaning or syntax + semantics) (Floridi 2005). The fundamental problem is that existing technology stores, manipulates and transmits data, not information. Thus, the utility of HIT is limited by the extent to which data approximates meaning. Unfortunately, in health care, data do not fully represent the meaning. In other words, there is a large gap between data and information. Since the difference between data and information is meaning (semantics), we call this the "semantic gap."

Consider the differences between banking data and health care data, such as an account at a bank versus a patient (Table 1). One difference is that concepts relevant to health are relatively poorly defined compared to banking concepts. The symbols require significant background knowledge to interpret properly. For example, there are multiple ways that a patient can be "sick" including derangements in vital signs (e.g., extremely high or low blood pressure), prognosis associated with a diagnosis (e.g., any patient with a acute aortic dissection is sick), or other factors. Two clinicians when asked to describe a "sick" individual may legitimately focus on different facts. In contrast, a bank account balance (e.g., $1058.93) is relatively objective and is captured by the symbols. Thus, data-manipulating machines (IT) are much better suited to manipulating bank accounts than clinical descriptors.

Table 1: Comparison of health and banking data

	Banking data	Health data
Concepts and descriptions	Precise *Example* Account 123 balance = $15.98	General, subjective *Example* sick patient
Actions	Usually (not always) reversible *Example* Move money A **à** B	Often not easily reversible *Example* Give a medication Perform procedure
Context	Precise, constant *Example* US $	Vague, variable *Example* Normal lab values differ by lab
User autonomy	Well-defined and constrained *Example* What I can do with my checking account = what you can do	Variable and dependent on circumstance *Example* Clinical privileges depend on training, change over time, depend on circumstances
Users	Clerical staff	Varied, including highly trained professionals
Time sensitivity	Few true emergencies (seconds)	Many time sensitive tasks, highly variable time sensitivity depending on context
Workflow	Well-defined	Highly variable, implicit

Social and administrative barriers to HIT adoption

Manipulating data and not information has many consequences for HIT. Note that there is no shortage of computers in hospitals. While most hospitals do not manage their clinical data electronically, all of them manage their financial data electronically. Just like any other organization, many hospitals have functioning e-mail systems and maintain a Web presence. Many clinicians used personal digital assistants (McLeod, Ebbert et al. 2003), some even communicate with patients using e-mail.

The social and administrative barriers to HIT adoption have been discussed by multiple authors in countless papers. Such barriers include a mismatch between costs and benefits, cultural resistance to change, lack of an appropriately trained workforce to implement HIT and multiple others (Hersh 2004). To some, clinicians' resistance to computerization appears irrational. However, caution seems increasingly reasonable given the mixed evidence regarding the benefits of poorly-implemented HIT. Thus, the clinical enterprise is not computerized because of rational skepticism regarding the benefit of current HIT, not an irrational resistance to IT or computerization.

Selected research challenges

Significant research problems must be addressed before HIT becomes more attractive to clinicians. Many of these are outlined in a recent National Research Council report (2009). First, there is a mismatch between what HIT can represent (data) and concepts relevant to health care (data + meaning). This is a very difficult and fundamental challenge that subsumes multiple AI problems (e.g., context or common sense) that have proven very difficult to solve. It seems that until we have true information processing, rather than data processing, technology, the benefits of HIT will be limited.

Second, HIT must augment human cognition and abilities. Friedman recently expressed this elegantly as the "fundamental theorem of informatics": human + computer > human (Friedman 2009). In other words, there must be a clear and demonstrable benefit from HIT. In spite of the problems with current HIT, there are clearly situations where HIT can be beneficial. In some ways, human cognition and computer technology are very complementary. For example, monitoring (e.g., waveforms) is much easier for computers than for humans. In contrast, reasoning by analogy across domains is natural for humans but difficult for computers. Defining scenarios when HIT is beneficial with all relevant parameters and demonstrating that using HIT is *reliably* beneficial in these scenarios remains a research challenge. In its present form, HIT will not transform healthcare in the same way that IT has transformed other industries. This is due in part to the large semantic gap between health data and health information (concepts). In addition, many problems with healthcare require non-technological solutions, such as changes in healthcare policy and financing.

Conclusions

Clearly, we must improve health care in fundamental ways. I have no doubt that HIT has an important role to play in transforming health care. However, the promises made on behalf of HIT are not likely to be fully realized in the near future. Thus, disappointment seems inevitable. There is historical precedent for such cycles of enthusiasm and disappointment with technology, particularly in AI where boom and bust cycles appear to be the rule rather than the exception. To realize the promise of HIT to improve health care will require an unprecedented level of collaboration among communities that have traditionally had little in common, speak different languages and have very different world views. In my mind, this is both a challenge and an opportunity to bring multiple fresh perspectives on fundamental problems.

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