Health information technology: promise and progress

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ABSTRACT

Healthcare costs have risen faster than the rate of inflation for decades. The resulting resource constraints have placed substantial burden on organizations, governments, and societies. While the problem is most prominent in the United States, it is a substantial problem all over the world as populations age. Health information technology holds great promise at helping to alleviate these problems. In this commentary, we use the lens of health economics to outline how health IT holds the potential reduce of some these inefficiencies, highlight the progress that has been made, and provide a framework to connect the lessons learned in health economics with the current efforts in health IT. We discuss ideas at the population, organizational, and individual levels. To this end, we highlight the papers in this special issue which deal with both organizational level healthcare deliver issues and individual-level self-care.

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1. Introduction

The ever rising cost of healthcare is an ongoing problem for many organisations, governments, and societies. In some countries, such as the United States, the rising cost of healthcare is arguably among the biggest problems the country faces since it consumes a large and ever rising share of available resources. People die due to a lack of care caused by too little prevention, treatment, and management, which are increasingly influenced by cost issues. Since cost is a driving concern in healthcare, lessons from health economics can provide relevant guidance as to what the main issues are.

Costs can roughly be divided into production and transaction costs. Production costs, those associated with producing something of value, are our focus here. Transaction costs are different, associated with coming to an agreement as to what to produce at what price and the costs of enforcing that agreement. While these costs have not received as much attention, they are substantial in healthcare. Administrative costs represent 25% of overall healthcare costs in the U.S. and anywhere from 12% to 19% in other developed economies (Himmelstein et. al., 2014; Rosenthal, 2017). In part this is because healthcare is usually paid for with insurance and highly regulated, which generates substantial paperwork. It is here that IT can make a significant contribution since it can reduce transaction costs (Malone, Yates, & Benjamin, 1987). If paperwork costs could be reduced, those resources could be redirected into actual life-saving care.

In addition to reducing transaction costs, IT holds potential to reduce production costs in healthcare.

The late Nobel Laureate, Ken Arrow, is widely attributed with starting the sub-field of health economics with his 1963 article (Arrow, 1963). Fundamental assumptions related to how markets and organisations operate are violated in healthcare, which makes cost containment more difficult than in other contexts. For example, there is generally an obvious answer to the question “who is the customer?”. However, in healthcare it is not clear if it is the patient or the insurance company. This is known as a third-party payer issue. Arrow also pointed out that healthcare is dominated by information issues, both between providers and between patients and providers. Since information issues are particularly important and healthcare information technology is explicitly designed to help solve such information-related problems, health IT holds promise to reduce healthcare costs.

2. People, data and information, and devices

Unfortunately, to-date, evidence of cost reduction benefits has been inconsistent. IT investment alone often does not yield value, but rather yield value when used in combination with other complementary investments such as training or new processes (Jones, Heaton, Rudin, & Schneider, 2012). Also, many IT investments are complex technologies that require research, development, learning, and training time; thus, it takes time to yield value. Finally, many of the process improvements come not from IT developers, but rather over a period of time from users. In short, IT investment often requires time, complementary

investments, and user input to yield value (Jones et al., 2012). The papers in this issue are several excellent examples of these intermediate steps. In medicine and healthcare, IT affects different groups with diverse needs and preferences: consumers, patients, caregivers, clinicians, and researchers. Because it is healthcare, it touches all of our lives through the different people involved, the data that is created and used, and the devices that are being developed.

3. People

Following the health economics theme, one of the earliest and most fundamental models in health economics is the Grossman Model on the demand for health (Grossman, 1972). The Grossman Model is a human capital model that outlines several of the basic factors driving the demand for healthcare at an individual level. Since this is a “human capital” model, health is seen as an asset and the model outlines key ways that asset could come to be. Among the issues Grossman pointed out was that the demand for healthcare is a latent demand. People do not want healthcare per se, they want health. He also pointed out that health is somewhat unique in that it can be both purchased, through healthcare, and produced by the individual through lifestyle choices. People can make themselves healthier – produce health capital, in Grossman’s words – through healthier living. While this seems a simple point, a key observation flowing from this is that people vary substantially in how well they produce their own health. Furthermore, it was observed that there was a strong link between education and health, resulting in arguments that more educated people are more efficient at producing their own health. They are better equipped to process complex medical information, and they more efficiently seek out information as it relates to their health. As context, this link is so strong that in development economics this can imply that once some basic health conditions are met, if you want to improve population health in the long run, the resources might be better spent on education than healthcare. While this highlights only one aspect, the link between the ability to process information and human health is a very old and important one. This matters going forward because the well-known effects of education could be quite similar to the effects of IT designed to help the general public better understand issues related to their health. In short, IT holds great promise for healthcare.

The effects of IT affect all, but are obvious when considering the different stakeholders. For almost a decade now, health information is just a search engine away and 80% of online users (Fox, 2011) read health- and medical-related information on the

Internet. This number can be expected to be at least as high today if not higher. However, not all the information is of equal quality. As many physicians will lament, “Dr. Google” is often a source of misinformation for patients. However, one recent nationally representative study in the U.S. showed use of health-related information was positively associated with a wide range of health behaviours, such as exercise, and preventative care measures (Wimble, 2016). This shows early evidence that use of health information online is, on average, a good thing. This information is generally considered available to a broad part of the population, with more than 75% of adult Americans owning a smartphone and more than half (62% of adults, 75% of those 18–29 year olds) using it to look for health information (Smith, 2015). Additional, often complementary, types of information are also shared, eg, through the devices being created, eg, apps to monitor health status, and access to online support and information sharing sites (eg, PatientsLikeMe, CaringBridge.com). In addition to this direct and visible impact on this large group of stakeholders, there are many advances providing indirect benefits such as effects on availability of experts, eg, telehealth for expert diagnosis, record keeping through electronic health records (EHR), and other administrative tasks, eg, through patient portals.

Clinicians and other medical professionals have similarly seen significant changes in their occupation. It may have made executing their profession easier in many cases, but it has also increased the expectations from patients and others they interact with. They benefit from easy access to information for furthering their education, ranging from listservs for professional question-answering to online courses for CME (continued medical education credit) and online degrees. In addition, many software systems have been introduced to support and improve current care. Examples include EHR to maintain patient information and software to support decision-making, eg, dose calculations, as well as providing alerts and reminders, eg, for medication interaction, clinical trial opportunities, or immunisation. Naturally, expectations have increased, and overall the goal and expectation is to use IT for better care with optimised treatments, fewer errors, and faster response times.

4. Data and information

In addition to the people component, information technology has had enormous effects on the types, diversity, and amounts of data and information being collected as well as its use for research and product development. Medical research information is accessible using the Entrez system, provided by the

National Library of Medicine, which provides access to seven different types of information including published research (eg, PubMed, and PubMed Central with free full-text journal articles), gene and protein information, and taxonomies among other types of data. In addition to these federally curated resources, there are several very useful resources, such as Wikipedia and several lesser known online encyclopaedias, that provide high-quality information, such as ganfyd.com (a free medical knowledge base) or the Cochrane site for summaries and reviews of evidence from research (<http://www.cochrane.org>).

Besides these information sources, raw datasets are slowly but increasingly being made available for research. A difficulty with making these datasets available is the need for de-identification of the data to protect the privacy of those whose data are contained in it. For example, the MIMIC corpus (Johnson et al., 2016) (<https://mimic.physionet.org/>) contains de-identified health records for more than 40,000 critical care patients. Several datasets are available for cost and usage calculation, such as Medicare provider datasets (C.f.M.M. Services, 2017) containing information on services and providers and the H-CUP administrative databases (AHRQ, 2017) containing information on inpatient stays, emergency department visits, and ambulatory surgery in the U. S. Several more are available online, eg, at HealthData.gov.

Knowledge sources useful to integrate and combine data are also widely available. They provide opportunities for adding meta-information and cross walks between disciplines. One of the most well-known resources is the unified medical language system (UMLS) (McCray & Nelson, 1995), which combines vocabularies from different medical sub-disciplines in a variety of languages. The Gene Ontology (Ashburner et al., 2000) provides descriptions of gene functions and their relationships. Access, creation, and overviews of ontologies are also being facilitated. For example, Bioportal (National Center for Biomedical Ontology, 2017) provides access to hundreds of ontologies useful to biomedical researchers.

5. Devices and algorithms

Devices have undergone an exciting revolution with both inventive and novel hardware and software approaches. There are many options for healthy living, including sensors to track sleep and track movement as exercise or as warning systems with elderly users, and a variety of apps to calculate food intake or display warnings about a variety of conditions (eg, air pollution). Recent progress with the Internet of Things may facilitate and fasten much of the progress, although few projects focusing on

the Web of Things are directly related to healthcare at this time (Tran, Sheng, Babar, & Yao, 2017). There are similarly many exciting developments for medical practice and clinical encounters, sometimes held back by policy. Policy and non-IT issues often impede progress; for example, being licensed in one state or country does not allow clinicians to practise remotely in other countries, or services performed using telehealth require different reimbursement approaches.

Several algorithms and knowledge sources are being developed to create and use this data and information. An exciting development is the increasing availability of libraries containing standard, but often sophisticated, algorithms that can be used by everyone with basic programming skills. While some may argue that many misuse the algorithm because they lack understanding, in general, it is an exciting development that using a classification or clustering algorithm does not require days of programming but only installation of a library in the preferred programming environment (Java, Python, R). Today we see this evolution all over again with the popularisation of deep learning and the increasing availability of libraries in Python and Java.

6. Future work needed

Thinking about people, data and information, and devices/algorithms in terms of the mechanisms by which they can reduce cost and inefficiency in healthcare can provide us with guidance as to what future work remains at the intersection of healthcare and IT. These can roughly be divided into the effect on producing health, either by healthcare providers or by patients making healthier choices, and reducing the paperwork costs associated with providing healthcare. Most research in health IT focuses upon the former – things that directly produce health. This category comprises a broad set of processes ranging from medication adherence intervention with patients to data mining in bioinformatics to increase the effectiveness of (personalised) medicine. These are the focus of the studies in this special issue, but we also want to highlight the potential gains from research focusing upon the latter issue. A graphical depiction of this is shown in Figure 1.

IT research and development projects in the medical domain vary widely. Some focus on creating data and knowledge sources, others on evaluating and understanding outcomes of policy and guidelines on usage and costs, and many focus on creating new programmes, applications, and software packages. However, the field is very broad and much work remains to be done. Below we provide a broad overview with example projects that would be beneficial and move the field forward.

Figure 1. Mechanisms for IT to improve health and healthcare.

As with all IT, there is improvement that can be made in interface, use of new interaction methods, and ease of and opportunity to access. However, in medicine there are two interacting stakeholders in the clinical process: patients and clinicians. For patients, the increase of available information provides them with a significant improvement. However, this is also abused, and fake news, discoveries, and cures are rampant. New technologies are needed that can inform, warn, or protect consumers from this information. Tools to increase healthy behaviours will continue to be important research streams, but there is much room for new tools for different populations, such as those with mental or physical disabilities, different age groups, and different goals for their health and condition. For clinicians, better decision tools are needed that learn and improve through use and adapt to each unique environment. For example, a 2011 review (Jaspers, Smeulders, Vermeulen, & Peute, 2011) showed that slightly more than half (57%) of 91 studies showed improved practitioner performance and only a third (30%) of 82 studies showed improved patient outcomes through use of decision support systems. We should aim for much better impact and approaches to measuring improvements, problems, and errors.

The existing resources would benefit from easier integration, open source access, and more comprehensive coverage. For example, the UMLS does not contain occupational health ontologies. Resources for processing social media language are nearly non-existent, eg, libraries of slang or emoticons. Continued use of software libraries will help increase research and development. These should focus on providing both basic algorithms and development tools for apps for all types of mobile devices, both those that are specifically useful for healthcare, as well as those that can serve indirectly, such as smartphones or watches. With all new development, much more attention should be paid to privacy, security, and protection of data and information. Better tools to avoiding hacking through records, medical

devices, or human error and negligence are needed. Cybersecurity and privacy courses should be part of the medical curriculum to provide a minimum knowledge base about proper security methods and are needed even more for people in leadership roles who bear responsibility for others and their information. Finally, seamless integration in practice and daily life cannot be ignored. Current use of IT in clinical encounters is often awkward and clumsy. Research on better interfaces is urgently needed, as is research on workflow in the clinical environment to make optimal use of IT.

7. Conclusion

The papers in this section, while not directly addressing costs, do address intermediate outcomes related to cost and follow the general reasoning we outline above. More specifically, two of the papers address issues related to how healthcare is provided. The third paper addresses how health is produced by individuals. The first paper presents a technology tool to help better understand how processes occur in the healthcare setting, which is a key step in understanding how to improve efficiency and lower costs in healthcare provisioning. The second paper develops a model to forecast factors that are likely to lead to readmission, a well-known cost driver in healthcare. The final paper presents the results from a health infomediary that allows patients to share knowledge with other patients, which should allow patients to better care for themselves. We feel these studies represent important new knowledge that can help researchers and practitioners better understand how to improve health production by both providers and the patients themselves. Additionally, we hope to bring attention to the potential to improve health production as well as the potential for IT to reduce the inefficiency caused by the paperwork associated with healthcare provision.

Disclosure statement

No potential conflict of interest was reported by the authors.

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