

The Value of Big Data in Clinical Decision Making

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Abstract: The healthcare industry is witnessing unprecedented challenges and demands. Cost pressures have driven providers and payors to embrace evidence-based medicine. At the same time, a need for effective personalized medicine and treatments tailored to patients' individual characteristics has been created owing to advances in genetics, biomedics and computing technology. The era of open information is now underway with healthcare stakeholders having access to promising new threads of knowledge. Despite the abundance of data, the healthcare industry continues to struggle to provide value-based, personalized care. So the question that arises is can a transformation similar to other industries be expected by big data initiative within the healthcare sector too? For the revolution to occur, the long term challenge in the healthcare industry of bringing together masses of data from disparate sources and synthesizing it into actionable information in real time needs to be addressed. Savvy use of data is the key in exploiting this opportunity in the healthcare industry that works with some of the most complex and disconnected data sets of any industry. This review articles will explain the forces that led to the big data revolution in the healthcare industry. It also explains the impact of big data on creating new value pathways that can reduce costs, improve patient outcomes and save millions of lives.

INTRODUCTION

The commercial value of "big data" has been appreciated and accordingly utilized by various sectors from banking to retail. The concept of big data in healthcare system is however new and in comparison to other industries, the healthcare industry has significantly lagged behind in using big data. Why has the healthcare industry been so late in embracing big data?

Several forces have contributed to the resistance to change from traditional approaches. Part of the resistance came from the healthcare providers, accustomed to functioning independently relying on their own clinical judgement and seldom depending on protocols based on big data. The other problems stemmed from the nature of the healthcare system. Under-investment in information technology by a majority of healthcare stakeholders resulted in use of older information systems, possessing limited ability in standardizing and consolidating data. Concern for privacy also created challenges in easy sharing of data among different providers or facilities. Lack of procedures for integrating data or communicating findings in a single hospital or pharmaceutical company often resulted in important information remaining soiled within a department of group.(1)

Big data in healthcare industry - reaching the tipping point

In 2012, worldwide healthcare data grew to 500 petabytes. It is estimated that this data will grow by 2020 to 25,000 petabytes. That is an enormous 50-fold increase within eight years. (2) Healthcare data has also increased in term of complexity and variety. Approximately 85 percent of the information today is composed of unstructured data arising from medical imaging, video and social media feeds. (3)The convergence of several trends has driven the health industry to a tipping point where big data can-now play a major role in innovation. These driving forces are described below. (1)

Demand for better data

The rapid rise in healthcare expenses in the US over the last two decades led both payers and providers to focus on lowering the cost of care. Their efforts in this direction resulted in a shift in the reimbursement landscape.

It was a practice for many years to compensate physicians under a fee-for-service system that only accounted for treatment volume and ignored patient outcomes or response to treatment. The advent of risk-sharing models began to replace many fee-for service plans. The intent behind the replacement was to curb expenses and encourage judicious use of resources. With this new system in place, compensation for physicians was based on patient outcomes or total cost control. With regard to payers too, reimbursement were offered to pharmaceutical companies, exclusively for drugs that produced a measurable improvement in patient health. These shifts in the reimbursement policies provided the necessary incentive to healthcare stakeholders to readily compile and exchange big data.

In the clinical setting, the standard medical practice from relatively ad-hoc and subjective decision making was being abandoned for evidence-based medicine (EBM). The practice of EBM relies on big data algorithms derived by aggregating individual data sets. EBM was beginning to be embraced by many stakeholders. The Health and Human Services (HHS) Departmentalsostarted"unlocking data" in an effort to provide clinicians with clinical decision support. It was believed that the data would empower consumers and open up new opportunities for researchers and developers.

Further the HHS department offered various incentives to professionals/hospitals to use Electronic Health Record (EHR) technology and share patient information. In 2005, electronic medical records (EMRs) were used by a meagre 30% of office-based physicians and hospitals. As a result of these incentives, the figure rose to more than 50% for physicians and nearly 75% for hospitals by 2011. As of now 45% of US hospitals are participating in local or regional health-information exchanges.

A huge amount of data was thus generated by the HHS's EHR Incentive Programs as well as the State Health Information Exchange Cooperative Agreement Program under the American Recovery and Reinvestment Act.

Technological advances

Many of the traditional obstacles to compiling, storing and sharing information securely are now being overcome by advances in technology. Unlike in the past, EMR systems are now more affordable and applicable for larger operations, permitting smoother exchange of data. An important contribution by new programs is the preservation of patient privacy, crucial in healthcare setting especially with regard to the Health Insurance Portability and Accountability Act (HIPAA). An important feature of some computer systems is the ability to examine the information across all data pools that can provide more insights than any individual data set.

Government agencies serving the role of a catalyst

In recent times, several countries have witnessed a flurry of activities in government sponsored big-data initiatives. These activities increase transparency and benefits patients in a big way. In the US too, the federal government through several policies and initiatives encouraged the use of healthcare data.

Motivating examples for Data Unlocking

The Heritage Health Prize

Results of a survey by the American Hospital Association revealed that more than 71 million individuals in the United States were admitted to hospitals each year, leading to huge healthcare spending. In the year 2006, well over \$30 billion was spent on unnecessary hospital admissions.

The Heritage Provider Network (HPN) believed it possible to identify patients at risk of hospitalization and ensure appropriate treatment, avoiding unnecessary hospitalization and expenditure of billions of dollars. To realize this goal, it was essential to develop a breakthrough algorithm using historical claims data that would identify patients who would be admitted to a hospital within the next years so as to prevent unnecessary hospitalizations. Thus the HPN held an incentivized competition to identify the best team that would develop this breakthrough algorithm that in turn would enable health care providers to develop new care plans and strategies to reach patients before emergencies occur. (4)

Penalties for Poor Care - 30-Day Readmissions

Hospital readmissions, planned or unplanned, and related or unrelated to the initial admission reflect poor quality of care and are a significant costs to payers. According to the Medicare Payment Advisory commission (MedPAC), nearly 2 million Medicare beneficiaries per year, discharged from a hospital return within 30 days. (5) On October 1, 2012 the Centres for Medicare and Medicaid Services (CMS) developed the Hospital Readmissions Reduction Program under which financial penalties to hospitals for excess readmissions would be assessed. In an effort to promote better outcomes in the nation's hospitals, the CMS institutes penalties. (6) According to recent reports a total of 2,610 hospitals in the U.S. are under the scanner for having excessive numbers of readmission with 30 days of discharge. (7)

White House unveils BRAIN Initiative

The BRAIN (Brain Research through Advancing Innovative Neurotechnologies) Initiative was launched to accelerate development and application of new technologies to enable researchers find new ways to treat, cure and even prevent brain disorders, such as Alzheimer's disease, epilepsy and traumatic brain injury. (8)

The absence of tools to explore how the brain records, processes, uses, stores and retrieves vast quantities of information and shed light on the complex links between brain function and behaviour provided the necessary stimulus for the BRAIN Initiative program. Recording signals from brain cells in much greater numbers and at even faster speeds would alone facilitate identifying the right treatment of neurological and psychiatric disease. Development of such technologies however lies at the intersections of nanoscience, imaging, engineering, informatics and other rapidly emerging fields of science and engineering. (8)

Thus, the success of the program depends on sharing data publicly and helping researchers learn new skills. This project also demands the need for development of tools for handling and processing vast amounts of data expected to be produced. (9)

GE Head Health Challenge

General Electric (GE) and the National Football League (NFL) joined forces to accelerate concussion research, diagnosis and treatment of early stage mild traumatic brain injuries and improve brain protection by launching the Head Health Initiative. The initiative aimed at improving the safety of athletes, members of the military and society overall. The two main components on the Head Health Initiative were: (10)

I. Open Innovation Program: A five-year open innovation program to improve:

- Understanding and diagnosis of mild traumatic brain injury
- Protection from brain injury

- Discovery of advance materials to mitigate impact in sport.

II. Mapping Brain Imaging Biomarkers

This four-year \$40 million research and development program aims to identify key Magnetic Resonance Imaging (MRI) biomarkers to improve the diagnosis, outcome prediction and therapy management for patients with mild traumatic brain injury. The research will be guided by an advisory board consisting of a cross-disciplinary team of medical professionals from various institutions. Needless to say, the success of this program depends on sharing and managing huge data.(10)

Philips innovation in India

A five year study with Philips' remote intensive care unit (eICU) programme on nearly 120,000 critical care patients found that eICU patients, compared to patients receiving usual ICU care, were 26% more likely to survive the ICU and were discharged from the ICU 20% faster. These benefits were possible as the programme enabled healthcare professionals from a centralized eICU centre to provide around-the-clock care for critically ill patients using bi-directional audio/video technology and a clinical decision support system.

A similar solution was being launched in India under the banner The IntelliSpace Consultative Critical Care (ICCC) solution to address the two big healthcare challenges in India i.e. lack of qualified critical care experts and access to quality critical care for people in smaller towns and villages. The ICCC solution connected the ICUs of several remote hospitals viz Aditya hospital at Warangal, Andhra Pradesh, Sreeranga Hospital at Chengalpet, Tamil Nadu, and Geetanjali hospital at Tiruchirapalli, Tamil Nadu to the Chennai-based In TeleICU, which served as the command centre monitoring the ICUs of the newly connected hospitals. ICUs of the remote hospitals was thus connected to a big specialist ICU care and the best in class critical care specialists could monitor and review patients remotely through online data from connected patient monitors and real-time video images of patient conditions. The application of the solution required hospitals and doctors to share data, an uncommon practice in Indian healthcare setting. (11)

Impact of Big Data on Healthcare

The release of big data has caused a transformation in discussion to what is right or appropriate for a patient. A paradigm change is being witnessed as new value pathways are being added to the healthcare ecosystem. The new value pathways include;(1)

Right living

This pathway focusses on empowering patients to actively participate in decisions pertaining to their treatment as well as disease prevention. The main focus of this pathway is to motivate patients take informed lifestyle choices such as diet and exercise to ensure they remain healthy. It also

supports active engagement of patients in their own care on falling sick.

Right care

This pathway focusses on clinicians embracing evidence based medicine as it is scientifically proven to deliver the right care for each patient while ensuring safety. This pathway demands a coordinated approach across settings and providers. It must be ensured that all caregivers have the same information and work towards the same goals. Such an approach would prevent implementation of suboptimal strategies and duplication of effort.

Right providers

This pathway supports selection of the "right care provider" to achieve best clinical outcome. Two definitions have been suggested for "right care provider"

1. Accurately matching the provider skill set to the complexity of the task i.e. a nurse or physician's assistant can only perform a task that does not require a doctor.
2. Being specific in the selection of the provider with best proven outcomes

This value system thus ensures that treatment must always be delivered by high-performing professionals that are best matched to the task.

Right value

Both the payors and the providers have a continuous responsibility to fulfil the goals of this pathway i.e. ensuring cost-effectiveness while preserving or improving its quality. Cost effective measures include linking provider reimbursement to patient outcome or eliminating fraud, waste or abuse in the healthcare system.

Right innovation

The focus of this pathway is to primarily boost the innovation engines by advancing medicine and boosting R&D productivity. The pathway also involves identification of new therapies and approaches to delivering care. It is essential for stakeholders to make better use of prior trial data in order to add value to this pathway. One can hit upon high-potential targets and molecules in pharma by looking up at historical data. Opportunities for improvising clinical trial and traditional treatment protocol including birth and inpatient surgeries can also be achieved by using prior data.

As new information becomes available to inform what is right and most effective, the value pathways will keep evolving.

Examples of value capture underway

Through the new value pathway some healthcare leaders have already captured value. The following examples highlight the same;(1)

- Kaiser Permanente fully implemented the HealthConnect system that enabled information exchange across all medical facilities and introducing EHR into clinical practice. Benefits offered

by this system included reduced office visit by 26.2 percent and more than eight-fold increase in the scheduled telephone visits.

- Sanofi's Lantus, a form of insulin was rejected coverage for premium by German payor G-BA. To counter its exclusion from the formulary, Sanofi conducted a comparative effectiveness study of Lantus versus human insulin. Data was used from the IMS Health's Disease Analyzer to prove that Lantus resulted in a 17 percent higher persistence and delayed the need for higher-priced intensive conventional therapy. This evidence forced G-BA to reverse its position. Further Sanofi could secure its contract with more than 150 individual payors in Germany that covers over 90 percent of German population.

Big data as a source of innovation in healthcare

There is strong evidence to support the creation of new species of healthcare innovators by the big-data revolution. The following are interesting examples of how big data inspired companies to develop healthcare applications or similar innovations.(1)

GPS-enabled tracker by Asthmapolis

This system was developed to monitor inhaler use by asthmatics. The information generated by the system gets ported to a central database and later used to identify individual, group and population trends. This data is further merged with available CDC information on asthma catalyst (for example pollen counts in the Northeast and the effect of volcanic fogs in Hawaii). The final data emerging on compilation and integration supports clinical decision with regard to personalized treatment and spot prevention opportunities.

Ginger.io mobile application

Approval is initially sought from patients along with the healthcare provider to be tracked through their mobile phones and assisted with behavioural health therapies. Information that get recorded with the help of mobile sensors in the patient's smart phones include calling information, texting information, location and even movement information. Surveys are regularly sent on the smart phones and patients are requested to respond to them. The information obtained by Ginger.io is further integrated with behavioural health data from the NIH or other authentic source. Revealing insight are obtained with the help of this application. For example irregular sleep patterns can serve as a warning signal that an anxiety attack is imminent. Similarly lack of movement or other activity could signal that the patient is physically unwell.

mHealth Coach

This interactive system supports patients on chronic care medication by providing education and promoting treatment adherence. This application leverages data from two sources. First from the Healthcare Cost and Utilization Project sponsored by the Agency for Healthcare Research and Quality. The second source is FDA's clinicaltrial.gov from where information on results and warning on drugs used for chronic condition is obtained. mHealth Coach also

find utility with the payors and providers to identify high-risk patients and deliver targeted messages and reminders to them.

Treo Solutions

Treo Solutions conducted a pilot project that linked one year of healthcare claims data (328,897 adult patients with diabetes receiving services during 2012) to the equivalent year of medical record data abstracted from the EHR system of a large Midwest commercial insurer to examine the relationship between diagnostic, demographic, clinical and patient financial data. Physical measures, health history, health behaviours, radiologic and endoscopic tests, select prescription data and laboratory values were included in the EHR database. Analysis of the combined database revealed that majority of patients with a diabetes diagnosis on claims had no diabetes test results for the study year and that a small number of patients without a known diabetes diagnosis had at least one out-of-range diabetes test. This pilot project is a striking example of the advantage of linking administrative claims with clinical data to obtain meaningful insight into patient care and health status. Most importantly this cannot be achieved using either data alone.(12)

Optum's Claims-Linked Registries Support Outcomes Research

Optum undertook a detailed approach to disease registries by combining multiple data sources to gain insight into a disease, to examine the disease's impact on patients and to determine how a therapy affects patients. The registry example for oncology and autism are presented below. (13)

Optum claims registry for oncology

This registry was created to have a better understanding of treatment patterns, patient outcomes and costs of care within relevant patient subpopulations for example, non-small-cell lung cancer or triple negative breast cancer. Large sample size was used for meaningful evaluation of important cancer subcohorts as well as a geographically and demographically diverse study population. Medical record and administrative claims data from patients were linked to conduct the outcomes research. Results of this study could identify unanticipated but significant side effects, fine-tune the use of a drug to ensure its use by those who would benefit most and compare the effectiveness of one treatment regimen against another.

Optum claims registry for Autism

Optum along with National Institute of Mental Health developed a registry of individuals with autism and associated disorders that combined the health history of patients with histories of their families to understand both the needs of all involved and the natural history of the disease. Knowledge generated from the registry enabled determination of treatment that would benefit the patients the most.

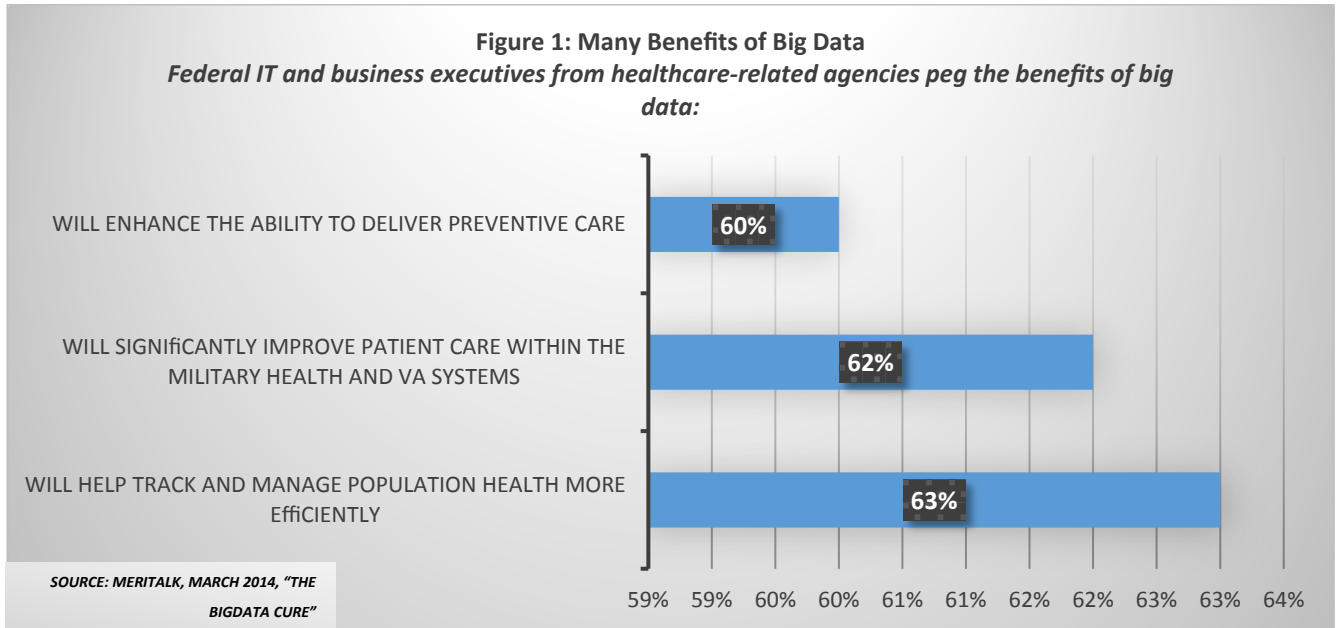
Evolving IT platforms to peg benefit of big data

Several healthcare organizations on the forefront of efficiency have adopted IT platforms that have simplified

processes and improved the scope and spread of care. These organization are already reaping the benefits of big data. Evolving IT platforms link disparate pools of data within and outside healthcare organizations. This information is then presented with visualization tools. Actionable insights are thereby supplied into the hands of caregivers and patients. This further enables providers to invent new healthcare practices as needed. According to a recent MeriTalk survey of 150 federal IT and business executives

from healthcare-related agencies the benefits of this approach included (Figure 1): (12)

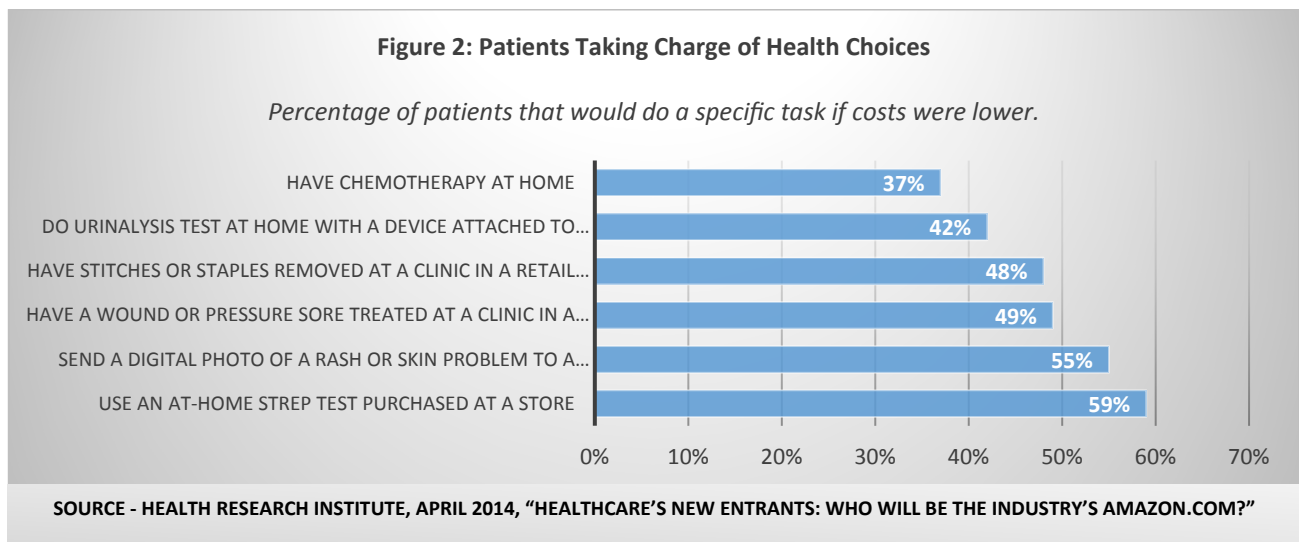
- Simplified IT
- Increased evidence-based and value-conscious medicine
- Superior preventive care
- Improved and more personalized treatment.



New health IT platform to extend its scope and spread to patients

It was noted by some experts that as of today patients have less as information about their healthcare than they do about their breakfast cereal. The Health Research Institute conducted a survey that revealed patients preference to non-traditional forms of healthcare, such as at-home urinalysis tests using a device attached to a smartphone, if they cost less—and if they knew about them (Figure 2). (14)

Simpler and easily available information can thus improve quality and reduce cost of health care. Results of the survey concluded that “Many consumers have high deductibles, and they are actively looking to reduce costs and improve quality.”It is therefore essential to simplify information to allow patients to make informed decisions and new health IT platform should extend its scope and spread to patients too.(14)



Progress with big data, big systems and better evidence

In just 20 years the repository of linked longitudinal medical and pharmacy claims data has begun to represent approximately 46 million lives. The growth and expansion of data environments is not singular. There has been a commensurate expansion of the health care analytics industry too along with tools to automate these functions. Analytics are generally broken down into three different categories: (i) descriptive data that provides the evidence base, (ii) predictive, and (iii) prescriptive insight. Predictive and prescriptive insights help to put the evidence to work. All forms need to work collectively to support decisions on a given therapeutic area.

An important point to remember before investing is that the evidence base that powers these analytics has to be sufficient and relevant to the individual patient or patient population to which the tools are being applied. Failure to precisely align available data and analytical tools with treatment interventions for the appropriate patient class will result in failure to make better decisions to improve quality and affordability.

It is also critical to start with not just big data, but deep data to generate the best evidence. There is also a need to have a comprehensive grasp of the types of data and improvements in the data that one possesses or would gain access. Data from disparate sources would then need to be integrated to get the best view into the individual's experience within the health care system and to power the descriptive, predictive and prescriptive analytics and tools that need to be developed. (15)

Big data revolution in India

A staggering amount of healthcare data is already generated in India from its government-private hospitals, primary health centres and health insurers. The data however needs to be classified to standard formats to maintain privacy. Issues of privacy, security, intellectual property and liability need to be addressed appropriately by big data analytics. Needless to say that big data and clinical decision support systems can effectively address Indian healthcare challenges of severe shortage of physicians and hospital beds, a mere 600-800 intensivists which is well below WHO standards and poor access to healthcare in tier 2 and 3 cities further aggravating inaccessibility to affordable diagnostics and treatment. Currently the highest fatality in India is from non-communicable diseases led by cardiovascular diseases. Decentralization is the key to these issues. Big data can enable identification of gaps in the Indian healthcare system and bring down costs. A paradigm shift in the Indian healthcare industry can thus be expected. Healthcare data analytics in India is a \$100-million opportunity expected to double within a few years. (16)

CONCLUSION

Big data initiatives can address major problems in the healthcare sector viz., variability in healthcare quality and escalating healthcare spend. All those stakeholders who are committed to investing in innovative data capabilities will gain the competitive edge and lead the industry into a new era. Before investing it is critical to have a comprehensive view of the individual built through integration of various

types of data in order for analytic tools to have the chance of achieving their potential. The insight derived by this way can help organizations measure and improve treatment quality, control rising costs, improve patient and physician satisfaction and also invent new healthcare practices as needed.

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