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Mobile Clouds Empowering Future Healthcare Services using Big Data-Issues, Challenges, Needs, and Trends

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ABSTRACT

Healthcare industry is traditionally data-intensive and data-driven industries. Large amounts of data are generated from health care providers, public and private payers, ancillary service providers such as labs and pharmacies, and health care consumers alike. With the developments and new inventions in mobile devices, wearable devices, and social networks, even personal health data are accumulated and available. Storage and efficient access of those data have been primary concern and interests. The challenge is, however, not just in storage and access, but also in making this data usable. Applying big data analytics to this myriad of data will help provide better insights to make well-informed decisions in use of technology in healthcare as well as other healthcare related research opportunities. Ongoing investments and efforts in the solutions, infrastructure and expert knowledge will broaden the opportunity to more positively impact outcomes. Such initiatives will cause us to look at data that have not been studied before or simply weren't available, thereby opening up a whole new set of analysis opportunities — opportunities to dramatically transform the various practices in health care industry

KEYWORDS: Big Data, Mobile, Healthcare

1. INTRODUCTION

In today's world, massive amounts of digital information are generated, stored and accessed in the cloud. Those data originate from various sources including online transactions, emails, POSTs to social media sites, sensors, and mobile devices. Much of this information has an intrinsic business value when it is captured and analyzed. These data and information are in form of big data not only for its sheer volume but for its variety, velocity and veracity. Enterprise and researchers are under pressure to develop technologies for fast and effective solutions to communicate, analysis, and utilize big data in cloud storage. Big data on cloud is becoming very active research and application subjects in academic research, industry practice, and government management. According to recent data includes IDC's prediction in 20131, the big data market will reach to $16.1 billion in 2014, growing 6 times faster than the overall IT market. One of the hottest application areas is big data based healthcare services and applications. As pointed out by McKinsey report in 2011[17], healthcare big data market size is expected to snowball to an estimated $10 billion by 2020.

Healthcare industry traditionally has created large amounts of data due to record keeping, compliance and regulatory requirements, patient care, research and developments. In addition to the sources described above, "new" kinds of health data created and managed by patients have emerged. Recent technical advances in mobile devices and networks have made it easier to collect personal health information as well as mobile network data from multiple sources. This includes fitness and personal health data capture devices, social media, and mobile devices. There are massive volume of patient and medical data, rapid velocity with which data is collected, real-time data that can be structured, semi- structured or unstructured, thereby resulting in variety of data and the error-free analytics of data which attributes to its veracity.

Datasets in healthcare are so vast and complex which cannot be managed using traditional analytic software and data management systems. Applying big data analytics to this myriad of data will help provide better insights to make well-informed decisions in use of technology in healthcare as well as other healthcare related research opportunities [24, 29]. The application of big data analytics in the domain of healthcare exists across many different scenarios. Some of the

examples are listed here: Patient profiling to identify patients who can benefit from preventive or lifestyle changes; collecting and publishing data on medical procedures; assisting pharmaceutical companies in order to identify patients to include them in clinical trials when a new drug is developed; reducing fraud while making claims by checking the accuracy and consistency of claims. With big data in healthcare, the potential benefits include but are not limited to identifying and diagnosing diseases in earlier stages, and managing individual as well as public health.

With the fast advance of data science, analytics and technology for big data, researchers and application professionals are empowered with diverse data mining and machine learning algorithms, open-source platforms, tools, and cloud database technologies and analytic service solutions. Healthcare stands to benefit from several major developments in data management and analytics: data collection through electronic medical records; data sharing through health information exchanges; and improved data analysis thanks to enterprise data warehouses and new analytical tools [6]. However, it is still challenge how data is analyzed to drive smarter and well-informed decisions and make correct and timely decisions about intervention and treatment options. The availability of hardware and software systems to perform analysis of the generated data, as well as the need for a user-friendly interface to access the applications is another challenge. Along with the benefits, these issues must be addressed in order to garner immensely from big data analytics in healthcare.

The next section provides the background on mobile big data in healthcare services and related research works. Section 3 elaborates source of mobile big data in healthcare, its importance and impacts on paradigm shift in the health care industry. In section 4, various type of mobile cloud services for healthcare are discussed. Section 5 presents future healthcare service issues, needs, and research trends using big data and big data analytics. Future works are presented as a conclusion.

2. BACKGROUND

The volume of data that we use and work with everyday has been on the rise exponentially. As the advances of mobile technologies, mobile devices are widely used to access data and services on Internet. Users subscribe to services and access remotely stored applications and associated data over the Internet using mobile devices. With an explosive growth of the mobile applications and emerging of cloud computing concept, the Mobile Cloud Computing has become a potential technology for the mobile service users [13, 15]. According to ABI Research, the number of mobile cloud computing subscribers is expected to reach 998 million by 2014.2 The market for cloud-based mobile applications will grow 88% from 2009 to 2014 and will reach $9.5 billion by 2014.3 According to a research carried out by MGI and McKinsey's Business Technology Office, big data was studied in five different domains – healthcare in the US, public sector in Europe, retail in the US, manufacturing and personal-location data across the globe [17]. If big data related to healthcare were to be utilized creatively and efficiently, the sector would garner over $300 billion every year in the US, by reducing nearly two-thirds of healthcare expenditure.

In order to promote a healthier lifestyle and aide healthcare providers harness their resources and skills in a more effective manner, Accenture, one of the world's largest consulting firm proposed the integration of cloud-hosted analytics and public health [1]. Analytics as a service can be used to model and profile large data sets, along with providing state of the art access control to such sensitive data. This data will not only help an individual's lifestyle by making it healthy but also provide with predictive solutions which may suggest the individual to eat out at a healthier restaurant based on a personal health data. This data will help understand and predict the general health of the public in future and could also help healthcare providers in research and treatments of the various health conditions. This would benefit the society and healthcare providers alike.

Pervasive healthcare is the conceptual system of providing healthcare to anyone, at any time, and anywhere by removing restraints of time and location [29]. This vision includes prevention, healthcare maintenance and checkups; short-term monitoring (home healthcare monitoring), long-term monitoring (nursing home), and personalized healthcare monitoring; and incidence detection and management, emergency intervention, and transportation and treatment. With the development and popularity of mobile devices and networks, pervasive healthcare systems are interested as a solution to increase coverage as well as quality of healthcare in the rural areas where healthcare facilities and other healthcare resources are very limited.

The big data revolution in the healthcare sector emerged with digitizing medical records by creating electronic databases for storing and managing patient and medical data used extensively. The pharmaceutical companies and researchers in the field of medicines used these electronic data to analyze and obtain an understanding in order to provide important information which would assist patients and researchers alike. Collecting and analyzing this wide spectrum of data included challenges in dealing with the variety and volume of data and the related technology to be used. Recent advancement in technology has improved the potential of engaging different technical aspects in working with such data. Various

pharmaceutical and medical companies has made use of the emerging medical information systems to practice high quality and low cost medical treatments [28].

Big data is difficult to process or analyze using common database management tools. Obviously, capturing, storing, searching, and analyzing healthcare big data will improve the outcomes of the healthcare systems through smarter decisions and will lower healthcare cost as well. However, it requires efficient analytical algorithms and powerful computing environments. The increased reliance on networked healthcare data brings new challenges to securing medical records in EHR systems. Authenticating individuals and authorizing global secure access to patients' records are vital security requirements. Physical face-to- face methods of identifying and authenticating patients and providers no longer apply; methods of electronic identification and authentication are required. Moreover, electronic records are susceptible to inappropriate access, compromised data integrity, or widespread unauthorized distribution. New security measures are needed to secure patients' records on Healthcare Information Systems. Recently, there are numerous research publications on big data healthcare applications. These publications can be classified into big data opportunities in healthcare, big data analytics, secure healthcare systems, and personalized medicines based on big data and personalized healthcare.

3. MOBILE BIG DATA FOR HEALTH CARE

Over the last decade, payers and providers in healthcare industry have digitized large amounts of data due to record keeping, compliance & regulatory requirements and patient care. Pharmaceutical companies have been aggregating data obtained from research and developments into electronic databases.

Figure 1. Big Data in Healthcare

Meanwhile, the US federal government and other public stakeholders have been opening their vast stores of data from clinical trials and information on patients covered under public insurance programs.

Diverse healthcare related data are generated with the advances of smart sensing technologies, developments in wireless communication technologies, and the increasing popularity of social networks. New technologies such as capturing devices, body sensors, and mobile applications becomes another major source of healthcare data. Additional personal and shared data are added every day as patient social network communications in digital forms are increasing. Collection of genomic information became cheaper and more medical knowledge and discoveries are being accumulated. Capturing, storing, searching, and analyzing healthcare data will find useful insights and improve the outcomes of the healthcare systems through smarter decisions. This will lower healthcare cost as well.

3.1. Where Are Mobile Big Data for Healthcare?

Data in healthcare domain are originated from multiple types of sources including mobile devices, sensors, individual archives, social networks, Internet of Things, enterprises, software logs, digitalized health data etc. Sources of mobile data can be classified into the following groups:

Figure 2. A Mobile Big Data Tree

Mobile Healthcare Applications – With the boom in big data and the rapid growth of mobile applications including software, there has been staggering advancement in the healthcare domain with new innovators coming into the foray – Asthma polis, Ginger.io, m Health Coach, Rise Health are a few of them. According to [7], there are over 96,000 mobile apps in healthcare and most of them are developed for chronic diseases. Applications supporting the embedded mobile sensors are being developed, adding to the list of innovative fitness and health related applications [22]. Mobile healthcare applications will enrich the healthcare experience for patients. These applications improve the accessibility to healthcare by virtual delivery of health services to patients in rural and/or remote locations and provide new provider business models to handle huge number of patient and medical data [12].

They also will improve patient engagement by eliminating long waiting queues and employing mobile notification systems such as reminders for medications. These mobile applications reduce Medicare fraud by tracking transactions as well as people using digital apps, and improve Patient Safety by digitizing patient's data and manage healthcare delivery system. Users of healthcare mobile applications can be classified into healthcare providers, health educators, practitioners, patients and family, home aides, fitness coaches, physical therapists, discharge planners and occupational therapists (Fig 3)

Figure 3. A Classification of Healthcare Mobile App Users

Recent survey reported that 66% of Americans would use mobile health apps to manage their health.4 The survey finds the top interests when downloading and using mobile health apps reflect proactive desires for informative, functional and interactive programs:

- Tracking diet/nutrition (47%)
- Medication reminders (46%)
- Tracking symptoms (45%)
- Tracking physical activity (44%)

Similarly, 79 percent of Americans would be willing to use a wearable device to manage their health – but with slightly different preferences when selecting a wearable compared to mobile apps:

- Tracking physical activity (52%)
- Tracking symptoms (45%)
- Managing a personal health issue or condition (43%)
- Tracking sleep patterns (41%), and
- Tracking diet/nutrition (39%).

Mobile Body Sensors – Embedding sensors in mobile phones and analyzing the resulting data could give groundbreaking results about a patient's daily activities and help manage and monitor his/her health. This data can be elucidated to produce valuable health inferences at the population level and arrive at conclusive decisions about health practices and related research. Researchers from the University of Virginia have conducted their research on how to use body area sensor networks (BASNs) to measure physiological, biokinetic, and ambient phenomena [20]. BASN consists of a wireless network with sensors and data collector. Wireless network is formed by sensors located on and/or biosensors transplanted into the human body [10, 4]. Data collector is used for medical data collection in real time. BASN can gather medical data of the monitored patient, perform classified learning, and analyze data in real time, thus realizing an early medical warning [3, 14]. At present, BASN are still at an early developing stage and facing a series of challenges, such as the existence of heterogeneous sensor protocols and "big data" computing and mining.

Another important class of mobile sensor applications in the healthcare domain is the Medical Body Area Networks (MBANs). According to the market intelligence company ABI research (http://www.abiresearch.com/), over the next five years, close to five million disposable wireless MBAN sensors will be shipped. A new report [26] projects wearable wireless sensors for fitness and wellness monitoring will approach 80 million devices by 2016, growing at a 46% CAGR from 2010 to 2016. MBANs enable a continuous monitoring of patient's condition by sensing and transmitting measurements such as heart rate, electrocardiogram (ECG), body temperature, respiratory rate, chest sounds, and blood pressure etc. MBANs will allow real-time and historical monitoring of patient's health, infection control, patient identification and tracking, and geo-fencing and vertical alarming. ABI Research principal analyst Jonathan Collins [26] has identified the primary reason for the high growth as the simplicity of devices and less regulations for them.

Social network data on mobile – As mobile and web applications are growing, social networking, which originally started as an online space, now has been extensively used in mobile platforms. It is expected that 50% of the world's population will augment the use of Internet using mobile phones by mid-2016. In healthcare domain, social media have been used to maintain or improve communication in peer-to-peer and clinician- to-patient. Social media are also adopted to promote institutional branding, and improve the speed of interaction between and across different health care stakeholders. There are number of indicators for the growth of using social media in the health care context. Social media applications in healthcare are used in many different area; to access to educational resources by clinicians and patients, to generate content rich reference resources, to evaluate and report real-time flu trends, to catalyze outreach during (public) health campaigns, and to recruit of patients to online studies and in clinical trials.

Mobile network data – Today's mobile users obtain their mobile services on diverse mobile networks, including 2G/3G/4G, WiFi, NFC, Bluetooth, and so on. This suggests that mobile network carriers hold a great amount of big data through mobile networks.

GPS data – With the availability of GPS technology, more and more location-based applications and services are developed to mobile users (including drivers). Using these location-based applications can generate anther kind of mobile big data relating to locations.

3.2. Why Is Mobile Big Data Important to Healthcare Services

Improved healthcare analytics leads to improved programs and the ability to create new ones. The potential to improve outcomes and contain costs from the analyzing big data in healthcare are, well, big. It has been reported that preventive actions – such as early cholesterol screening for patients with associated histories, hypertension screening for adults or smoking cessation – could reduce the total cost of care by over $38 billion, through the prevention of downstream medical episodes, earlier identification of the most appropriate treatment and avoidance of interim chronic care.

The consulting giant, McKinsey believes that using big data analytics in healthcare can help save billions of dollars in savings per year in the United States.[17] Wastage and inefficiency can be reduced in the following domains;

- **Clinical Operations:** clinically relevant and cost-effective ways to treat and diagnose patients.
- **Research and Development:** use of a predictive modeling in designing new drugs and devices; statistical tools and algorithms to refine patient trials in order to reduce trial failures
- **Public Health:** analyzing disease patterns to improve public health surveillance and remediation; rapid development of vaccines; transforming large volumes of data into useful information for facilitating better public health,
- **Patient Profile Analysis:** by analyzing patient health records and providing required care or administering lifestyles changes.
- **Others:** The other domains include remote patient monitoring, genomic analytics, and evidence based medicine and fraud analysis.

Using big data analytics to digitized health related data is of significant benefit not just to hospitals and healthcare providers but also to smaller physician clinics and offices. It makes early stage detection of diseases be possible and manages treatment effectively and quickly. Managing individual and population health will be more efficient and allows early detection and management of healthcare related fraud. Patient healthcare system related decisions can be made – surgical and/or non-surgical methods and can estimate complications involved in surgeries [8].

3.3. Paradigm Shifts in Healthcare Services

With recent developments in information technologies, the healthcare industry has gone through several paradigm shifts with multiple stages. Each stage provides evolutional improvements in healthcare operations and services from conventional practice in the past two decades.

Stage #1: eHealth – eHealth (also known as e-health) is introduced as a term for healthcare practice in 1999 [30] to refer to the electronic processing and communication for healthcare operations. There are numerous forms to support eHealth operations, including electronic health recording, ePrescribing, consumer heath informatics, health knowledge management, and healthcare information systems.

Stage #2: Mobile Healthcare - mHealth (also known as m- health) is an abbreviation for mobile health. It is a term used for the practice of medicine and public health supported by mobile devices. mHealth was coined by Robert Istepanian as use of "emerging mobile communications and network technologies for healthcare" [25]. Later, it was defined as "the delivery of healthcare services via mobile communication devices" at mHealth Summit of the Foundation for the National Institutes of Health (FNIH) [11]. Berg Insight forecasts that the number of home monitoring systems with integrated communication capabilities will grow at a compound annual growth rate (CAGR) of 26.9 percent between 2011 and 2017 reaching 9.4 million connections globally by the end of the forecast period. The number of devices

that have integrated cellular connectivity has increased from 0.73 million in 2011 to about 1.03 million in 2012, and is projected to grow at a CAGR of 46.3 percent to 7.10 million in 2017. A growing percentage of health-related smartphone apps are available, and some estimates predict 500 million patients will be using such apps by the year 2015.[5]

Stage #3: Mobile Cloud Healthcare Services Using Big Data

With the fast advance of mobile computing and cloud technologies, mobile cloud healthcare services using Big Data have been emerged [15, 21]. Big data used in mobile cloud healthcare services can be categorized by its source: Patient Big Data, Medicine Big Data, Test Big Data, Hospital Big Data, DNA Big Data, and Disease Big Data (Table 2)

Table 2. Big data used in mobile cloud healthcare services

 Patient Big Data	- Patient registration & visit records - Patient medical treatment records - Patient health exam records - Patient disease diagnosis records - Patient surgery operation records
 Medicine Big Data	- Medicine test data - Medicine production data - Medicine trial records - Medicine prescription data - Patient usage data - Medicine complaint data
 Test Big Data	- Rich media medical test data, i.e. CT and X-Ray images. - Diverse medical lab test records
 Hospital Big Data	- Patient registration and visiting logs - Medical diagnosis records - Medical exam records - Surgical operation records - Medical billing & payment records
 DNA Big Data	- Full DNA sequencing - Cognitive systems connected to the cloud - Focusses treatment plan - Continuous, on-going patient monitoring [6]
 Disease Big Data	- Disease Prevention - Broad Scale Disease Profiling - Early detection - Analyzing disease pattern - Disease surveillance - Disease Management [31]

3.3. Mobile Cloud Healthcare Services on Big Data

As a quick and easy place to share and store information, cloud-based services become popular in healthcare networks. According to the report [2], the average healthcare network uses 928 cloud services and the average healthcare employee uses 26 distinct cloud services, including eight collaboration services, four file-sharing services, four social media services and four content- sharing services. HIMSS Analytics' recent survey6 of cloud computing adoption in healthcare provider organizations found that 83% of IT executives report they are using cloud services today, with SaaS-based applications being the most popular (66.9%). Hosting of Clinical Applications and Data (43.6%), Health Information Exchange (38.7%) and Backups & Data Recovery (35.1%) are the common applications of cloud- based applications today.

With the development of mobile technologies, mobile devices are widely used to access applications, data, and services on the Internet. By a combination of cloud technologies and ubiquitous mobile devices, the mobile cloud services are core of a change in the healthcare services. Mobile devices are replacing the paper medical charts, the private cloud is to be able to secure access to medical records, and mobile cloud collaboration tools are improving the sharing of information between

health professionals and academics. Cloud and mobile medical services are also used to solve a wide range of challenges, such as remote diagnosis and patient CRM. In addition to storing and accessing medical records, cloud services are used to prevent and detect healthcare fraud. It is estimated that the loss from fraud accounts as much as $ 260 billion or 10% of annual healthcare costs in the United States. Predictive modeling, which was used in the financial services and telecommunications industries, enforce current general medical payments.

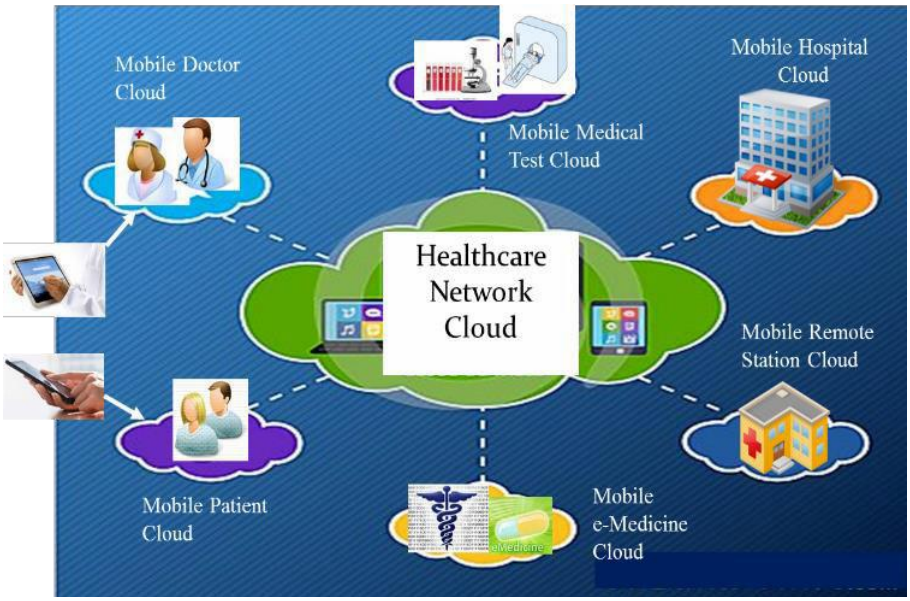

Figure 4.1 Healthcare Network Cloud

Four types of services on mobile cloud are popular in healthcare industry:

- Mobile cloud services for patients
- Mobile cloud services for doctors
- Mobile cloud services for hospitals and healthcare providers
- Mobile cloud services for medical test lab. Each service is described in next sections.

A. Mobile Cloud Service for Patient

Patient-Oriented mobile cloud provides diverse mobile enabled, patient-oriented healthcare services. This includes clinic appointments, medical lab tests, X-Ray and CT images, medical records, prescriptions and medicines, primary doctors, insurances, and medical bills. Patient-Oriented mobile cloud provides patients with three distinct benefits. First, it offers user friendly mobile applications for patients to access well-classified mobile enabled healthcare services. Secondly, it provides end users with a cloud- based personal information repository to allow them to store and manage their medical service information. Thirdly, it maintains transparent and seamless information connectivity channels among different mobile healthcare service providers. Figure 4.2 shows typical healthcare services in a mobile patient cloud.

Authors in [16] proposes a cyber-physical system for patient- centric healthcare applications and services, called Health-CPS, built on cloud and big data analytics technologies. This system developed with three layers; data collection, data management and data service layer. Data collection layer was built with a unified standard and a data management layer was designed for distributed storage and parallel computing. Data service layer provided with variety data-oriented services to end user. Authors show that the technologies of cloud and big data can be used to enhance the performance of the healthcare system.

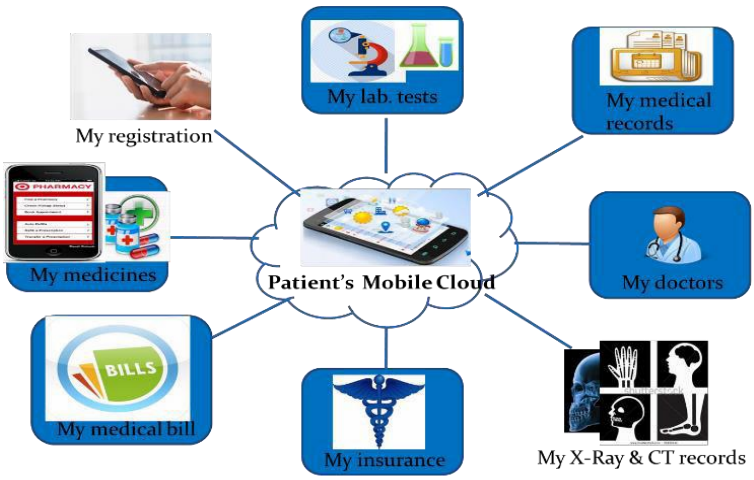

Figure 4.2 Enabled Mobile Cloud Services for Patients

The healthcare application presented in [18] is based on the mobile devices for end users and servers running in the cloud. Mobile devices embedded sensors measure the information about the monitored person such as position, temperature, breath frequency etc. Basic algorithms running on the smartphone evaluates current person's health status and informs to user. Measured data are sent to the cloud for deeper analysis. The healthcare personals access the data server via a secure internet connection to monitor the patient's health remotely.

Pan D et al [23] has designed and developed a mobile app on the Android platform to collect Parkinson's disease related motion data using the smartphone. Data has sent to a cloud service for storage, data processing, and symptoms severity estimation. To evaluate this system, data from the system were collected from 40 patients with Parkinson's disease and compared with experts' rating on standardized rating scales. The evaluation showed that a prototype mobile cloud-based application could effectively capture important motion features that differentiate severity and identify critical symptoms. In severity estimation, the captured motion features also demonstrated strong correlation with severity stage, hand resting tremor severity, and gait difficulty. The system is simple to use, user friendly, and economically affordable.

B. Mobile Cloud Service for Doctor

Unlike a patient-oriented mobile cloud where patients and their services are the major focus, a doctor-oriented mobile cloud is developed to provide medical doctors with various services through mobile networks. These include: clinic appointment schedules, patient records & tests, prescriptions, diagnoses, and patent treatments, surgeries, insurance providers, as well as monitored patients. Similar to a patient-oriented mobile cloud, this mobile cloud is also a personal cloud which provides medical doctors with unlimited personal information repository that is mobile accessible, customized management, and seamless connectivity to different mobile healthcare service providers and medical insurance vendors. Figure 4.3 shows typical healthcare services in a doctor-oriented mobile cloud.

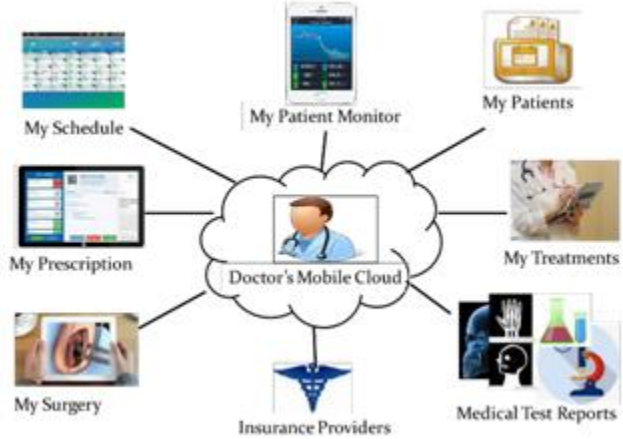

Figure 4.3 Enabled Services in a Doctor-Oriented Mobile Cloud

The widespread adoption of mobile devices by healthcare professionals has been derived by the need for better communication and easy access to information resources at the point of care. Healthcare professionals require access to many types of resources in a clinical setting, including: Communication capabilities, Hospital information systems and electronic health records, Electronic medical records, Informational resources, and Clinical software applications. Mobile devices and applications provide many benefits for healthcare professionals, which has been shown to support better clinical decision-making and improved patient outcomes [9]

C. Mobile Cloud Service for Hospitals

As healthcare information technology evolves, hospital cloud services start to replace the hospital's information technology infrastructure. Adoption of cloud computing is due to the rising need to curtail costs and enhance the quality of care. Proliferation of new payment models, the cost-efficiency of cloud technology, and the implementation of the Patient Protection and Affordable Care Act (PPACA) are also another factors for increasing adoption of cloud computing. At the same time, healthcare facilities are seeing an increase in mobile device adoption, as well as a surge in the use of tablets, thin clients and virtual desktops. Because clinicians typically need remote access capabilities, as well as multiple-device support across different locations, mobile cloud services become viable options in healthcare facilities.

This is likely to have positive effects in five areas of the healthcare information technology environment:

Device flexibility. Mobile devices, thin clients, tablets and e-books have the ability to connect to cloud and becomes a viable option to deliver consistent content and data securely to end users. Similarly, these devices are also able to connect to cloud-based services. Users can easily access clinical inform remotely across different locations.

System expertise. From an infrastructure standpoint, an on- premises services and application implementation requires a specific skill set and expertise and require a significant investment in training and knowledge. However, with cloud services, IT personal can roll out services and applications without any significant installation and deployment expertise.

Security and compliance. The use of cloud in hospitals is still concerning for some when it comes to security and compliance. Cloud service vendors, however, have business associate agreements available for their healthcare clients. And when it comes to hosted or cloud-based infrastructures, the availability of disaster recovery and business continuity processes provides assistance toward safeguarding data as part of HIPAA compliance.

Scalability and costs. Cloud services provide the advantage for many to simply pay for what they use. This reduces the up-front capital needed for systems. Similarly, cloud is significantly more scalable.

Manageability. Hosted on cloud do come with robust tools to help manage all the applications that may be needed by end users. It is also valuable for IT staff to be able to adjust the resources on demand without the need to physically get under an employee's desk.

Kuo AM-H summarized the uses of cloud computing technologies in healthcare in [19]. It included the cloud-based monitoring of patient's vital data, emergency medical systems, and home healthcare services. The paper also reviewed the adopting cloud computing technologies in bioinformatics research, such as colorectal cancer imaging analysis, and genetic testing models. He also presented the opportunities and challenges of cloud computing in healthcare regarding its management, technology, security, and legality.

A framework for secure HISs was introduced [5], which is based on big data analytics in mobile cloud computing environments. This framework provides a high level of integration, interoperability, and sharing of EHRs among HPs, patients, and practitioners. It integrates distinct EMRs of a patient from different HPs distracted among different cities, states, and regions and store them in the Cloud data storage areas. Because of the size, speed, and complexity of the data, the proposed framework employs big data analytics to find useful insights that help practitioners take critical decisions in the right time. The proposed framework applies a set of security constraints and access control that guarantee integrity, confidentiality, and privacy of medical data. Authenticated healthcare providers, practitioners, and patients are authorized by the Cloud Service Providers (CSPs) at different levels of privilege and permissions to securely access EHRs and retrieve patients' information.

A design for cloud computing-based Healthcare SaaS Platform (HSP) [27] was proposed to deliver healthcare information services with low cost, high clinical value, and high usability. This research was motivated to resolve the issues confronted by many small- and mid-sized hospitals as well as rural hospitals those who cannot afford to invest in Electronic Health

Record (EHR) systems or advanced healthcare information services, such as clinical decision support (CDS), which improve the quality of care and patient safety. They focused on the sharing of Clinical Decision Service (CDS) content services, basic order entry services, and mobile services for multi-platform and multi- device support in an EHR system.

An integrated cloud-based architecture for Emergency Medical Service has been developed [21] to support emergency care processes by evolving and cross-linking institutional healthcare systems. This system allows authorized users to access emergency case information in standardized document form for exchanging operational data with hospitals and incorporates an intelligent module that supports triaging and selecting the most appropriate ambulances and hospitals for each case. Mobile cloud services for hospital provide end users with following services: patient registrations, out-patient monitor, emergency response, mobile prescription, remote diagnosis, billing and payment, and remote medical test (Figure 4.4)

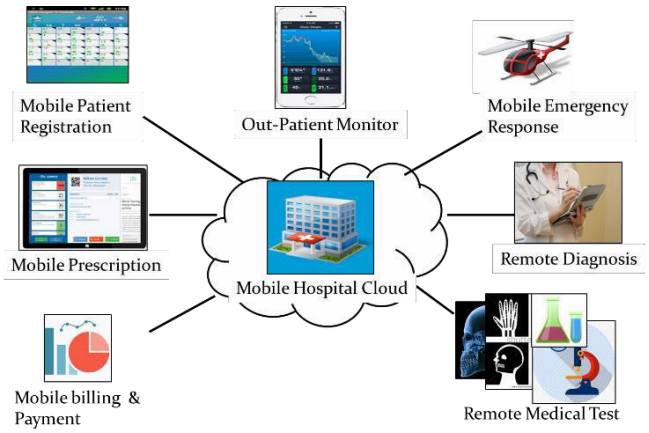

Figure 4.4 Mobile Cloud Services for Hospitals

4. HEALTHCARE RESEARCH NEEDS AND TRENDS

Big Data has become critical to business, government, and finance. It has yet to become a paramount cog in the healthcare industry engine and transforms the industry. Cloud services with mobile apps will support patients, medical workers, medical providers, and government agencies for data collection, analytics, monitor, and prediction. Those developments improve disease prediction and prevention, medical service quality and supports for self-care and providers in different level. It also has impact on researches for medicine, genomics and beyond. The info graphic below demonstrates how Big Data will transform healthcare industry, in the near future, with cost savings, quality of care, and care coordination.

Figure 5. How Big Data will transform healthcare industry [24]

There are many projects on the way utilizing Big Data and producing promising results. Healthcare organizations on the forefront of efficiency are already reaping the benefits of big data. According to the recent survey and our observations, we summarize top five future trends in big data healthcare services on mobile and discuss the associated emergent needs.

A. Smart Monitor, Altering and Prediction for Infectious Disease

Emerging infections are infections that are rapidly increasing in incidence or geographic range, including such previously unrecognized diseases as HIV/AIDS, severe acute respiratory syndrome (SARS), Ebola hemorrhagic fever, and Nipah virus encephalitis. Researchers for an infectious disease adapted computational modeling projects and turned to anonym zed social media and other publicly available data on Web to improve their ability to forecast emerging outbreaks and develop tools that can help health officials. Things need to be done would be to establish big data repository for infectious diseases, to define the big data policies and standards for infectious diseases, to develop prediction algorithms and solutions for infectious disease and to leverage and integrate with the existing hierarchical infectious disease monitoring and management systems.

B. Big Data Medicine Management and Control on Mobile

Medicines management and control encompassed clinical assessment, monitoring and review in individual patients, medicines delivery services, review of repeat prescribing systems, clinical audit, health education, risk management, disease prevention formularies and guidelines. The right data sets and workflows can make precision medicine which is the healthcare's grandest vision today. We need to collect massive population health data sets with individual's information – including genomics, lifestyle, chronic conditions – then analyze it to more effectively tailor treatments and preventative care plans for patients. At the heart of that, of course, is data. Big Data has its value and will drive precision medicine. Future research will focus on Big Data medicine evaluation and monitoring, and Big Data management for medicine production and usage.

C. Big Data Based Personalized Healthcare on Mobile

Personalized medicine is about tailoring medical treatment to the individual characteristics of each patient, classifying individuals into groups that differ in their susceptibility to a particular disease or their response to a specific treatment. It relies on biomarkers that present signs of normal or abnormal processes. With the amount of data being mined and analyzed, it will be easier to identify genetic correlations, identify patterns in patient and population data, identify patient specific patterns and predict physiological conditions and provide better patient self- management for enhanced clinical outcomes.

Big data and predictive analytics are having a moment in healthcare and pave the way for new breakthroughs in personalized medicine. Though still an evolving field, advances in genomic research over the last decade have contributed to this form of medicine becoming a real possibility. Personalized healthcare research includes personalized disease prevention and personalized medicine prescription. DNA research will be an active research area and includes personalized healthcare based on DNA, tracking & monitoring DNA-based diseases, medical diagnosis using DNA analysis results, and personalized treatment using DNA.

D. Mobile Smart Medical Diagnostics and Treatment on Big Data

Researchers are developing new techniques for processing medical data, to make it more accessible to both physicians and patients and to find correlations that could improve diagnosis or choice of therapies. Big data tools and software could help doctors expand their scope of diagnosis. Data analytics software used to compare and process medical records of patients with similar symptoms, habits, and demographic details could lead to more accurate diagnostic results. Not only would that lead to a better course of treatment, but it would also eliminate the need to conduct multiple, unnecessary tests. Accurate diagnosis with less testing would lead to an overall reduction in medical expenses for patients, and lighten the load on the entire medical system.

Real-time, highly personalized medical insights from any source enhance preventive care. Making information easy for caregivers to consume and act on is another key to be successful. The ability to connect systems and display targeted information also enabled the hospital to better coordinate care. By pulling real- time data from different locations and displaying it in easy-to-use ways, the hospital reduced referral wait times and provide better service. Focuses for future research and developments would be to define the big data policies and standards in telemedicine, medical tests, and rich media records (i.e. CT/X-Ray). To set-up mobile cloud-based big data infrastructure to support for telemedicine and mobile

treatments, development of big data based intelligent solutions for medical diagnostics and treatments and to establish a big data repository for telemedicine and mobile treatments are important tasks to be addressed. We need to create a mobile cloud with mobile apps to support mobile patients, mobile doctors, and remote healthcare agencies. To leverage and integrate with the existing hierarchical telemedicine systems and systematically connect to other big data resources are also important.

E. Big Data Healthcare Service Management on Mobile

It is important for government agencies and consumers to evaluate and monitor a primary health care services, integrating hospital and community services. One great advantage of the new- generation data analytic platform is that it can harness all the disparate information within clinical, laboratory, claims, and other systems. It can allows us to do provider profiling and physician performance analytics: Normalize (both severity and case mix- adjusted profiling), evaluate and report the performance of individual providers (primary care physicians and specialists) compared with established measures and goals. To support government agencies, tools and systems are developed and matured to closely and accurately evaluate and monitor healthcare service providers, drug industry and manufacturers, and medical insurance providers. Also we need to understand and measure people health

CONCLUSIONS AND FUTURE WORK

Health care industry is data-intensive and data-driven industries. Massive amounts of data are generated from health care providers, public and private payers, ancillary service providers such as labs and pharmacies, and health care consumers alike. With the developments and new inventions in mobile devices, wearable devices, network, and social networks, even personal health data are accumulated and available. Storage and efficient access of those data have been primary concern and interests. The challenge is, however, not just in storage and access, but also in making this data usable.

As more and more data is being collected, there will be increasing demand for big data analytics which is in its infancy for the healthcare domain. Unraveling the “Big Data” related complexities can provide many insights about making the right decisions at the right time for the patients. Efficiently utilizing the colossal healthcare data repositories can yield some immediate returns in terms of patient outcomes and lowering care costs. A big data analytics platform in healthcare that support the key functions necessary for processing the data is on immediate demand. The criteria for platform evaluation may include availability, continuity, ease of use, scalability, ability to manipulate at different levels of granularity, privacy and security enablement, and quality assurance Real-time big data analytics is a key requirement in healthcare. The lag between data collection and processing has to be addressed and resolved. The numerous analytics algorithms, models and methods is also need to be dynamically available for large-scale adoption.

Ongoing investments and intensive efforts in the solutions, infrastructure and expert knowledge are needed to support and advance big data. This will broaden the opportunity to more positively impact outcomes. Such initiatives will cause us to look at data that have not been studied before or simply weren't available, thereby opening up a whole new set of analysis opportunities — opportunities to dramatically transform the various practices in health care industry

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