A Comprehensive Study Health and Fitness Related Mobile Applications

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***Abstract* -- In the recent years, with the rapid growth of mobile and sensor technology, wearable mobile equipment has been gradually integrated into daily life, and played the key role in monitoring human daily activity and tracking health record. The emergence of mobile health has offered unique and varied opportunities to address some of the most difficult problems in healthcare, such as up-to-date and accurate information, and real-time communication with the healthcare facility. Wearable technologies empower consumers the ability to conveniently track state of health and fitness efforts. Online healthcare platform provides the personalized data-driven services. Data collected from this platform are extracted, shared, re-used and distributed in many ways for the studies of technology, sociology of health and illness, and even political economy. Privacy concern and governance policies are also important topics in mobile healthcare: who should own user-generated health data and who should get to benefit. The main purpose of this paper is to overview the current state of mobile healthcare technology in the iOS mobile app market. The paper surveys multiple toolkits and SDKs supported on iOS to monitor daily routine and health-related factors.**

I. INTRODUCTION

Mobile Health platform is gaining popularity because its various functionalities, its capability to track and notify most up-to-date data, and for its potential diverse and numerous amount of collected data that could be meaningful for sociology and health-related research. There exists a good amount of health and fitness mobile applications in the current mobile market, which cover a wide range of human's health-related factors such as weight, height, daily activity, heart rate, temperature, blood pressure, glucose level, sleeping patterns… However, most of these data are currently collected separately, and the metrics are frequently not used up to their potential. The quality of mobile health system also needs to be improved, especially in collaborative and monitoring and sending real-time notification efforts between patients and their own physicians. Privacy and governance of data is one of the main concern in data sharing: the industry needs to define which kind of data should be collected, and should be agreed upon through terms and conditions upon signing up for mobile services. The process of collecting and benchmarking data involves sharing information from individual to individual, from individual to organization, from organization to organization [4]. Data sharing is important as it provides the valuable information for analysis of quality of care

data; additionally, vast data could also be used to address disparities in a broader geographic context such as regional, state and national care card.

II. EMERGING OF DIGITAL TOOLS IN HEALTH CARE

A. Limitations with traditional usage of digital tools on health data collection

Medical organizations have started to collect health-related for a long time, and with the help of digital tools such as computers and mobiles, it has been a lot faster and easier to capture and store data in more reliable and secure way. However, the sharing of collected data is not performed in an efficient way, which limits the availabilities of resources for medical research organizations. (1) For example, when a person travelled abroad and had an emergent illness, if the local hospital could retrieve his health profile and medical records immediately, as well as his normal daily routine that might be factors affecting the treatment process, the doctors would be able to decide healing solution and reduce the risks. (2) There's currently no unified standard on how medical data should be categorized and stored: races, ethnicity, age, sex, language, membership, respondents are few in many attributes could differentiate a person's health evaluation.

The common challenges in collecting health-related data include:

- How to collect information about race, ethnicity, language or communication needed
- How to train medical staff to elicit this information in a respectful and efficient manner.
- How to address the potential patient on health issue and push back respectfully.
- How to address system-level issues, such as changes in patient registration, health screening and data flow.

In September 2014, Apple released its new iPhone 6 and 6 plus, with iOS 8 operating system, which contains the health-tracking app. In 2015, Apple first created HealthKit platform for third-party health-related mobile app developer. The company also introduced the long-awaited smart wearable Apple Watch.

B. Core Characteristics in mobile health care

Topic	Mobile Healthcare
Penetration into populations	Unprecedented communication access to population and subgroups, possible differential access by subgroups, differential mobile phone capability or dependence by subgroups.
Availability of apps	General purpose computational capabilities of increasing sophistication of functionality and data acquisition, reporting, local analysis; ease of access to apps;

	increasing number of health-related devices connected to mobile phones.
Wireless broadband access to the Internet	Access to full Internet resources; increasing sophistication, amount, and speed of communication in general, and data communication in particular; external device connectivity; Internet of things (devices) capable of direct Internet communications
Tethered to individuals	Decreasing delays in communication with specific individuals; tailoring to, and data captured by and about, individuals; location, physiological and psychology states, behavioral, and context awareness

Table 1: Mobile Health Core Characteristics [3]

C. iOS8 System Health Application

The Health App system on iOS8 provides the following features:

- *Medical network connection*: Users can create their own medical ID and enter medical data through the Health App. Users can also use third-party applications for automatically importing matching data fields into Health App. With the amount of data being imported, health charts are created to monitor health or daily routine.
- *Automatic health data collection*: Iphone has built-in motion sensors, which collect data on users' daily routine such as steps count, walking distance, pattern of activity and inactivity per day, sleep patterns… If the app is enabled, device will daily collect data and store in the health-app system for tracking purposes.
- *Health data presentation*: Apple Health App provides a health dashboard, where users can view their measurements, such as body weight, blood pressure, physical activities and other data. The dashboard also generates intuitive and easy-to-read graph by aggregating data based on different time range, such as by day, week, month or year.

Figure 1: Example of Health App usage on iOS8

D. HealthKit

Figure 2: Permission from mobile devices to HealthKit

HealthKit is a platform for third-party iOS application developers to get and dynamically store health-related data from Health App. HealthKit include six main features to access activities and health-related data: (1) Fitness, (2) Body Measurements, (3) Reproductive Health, (4) Sleep, (5) Nutrition, (6) Vitals [Figure 3]

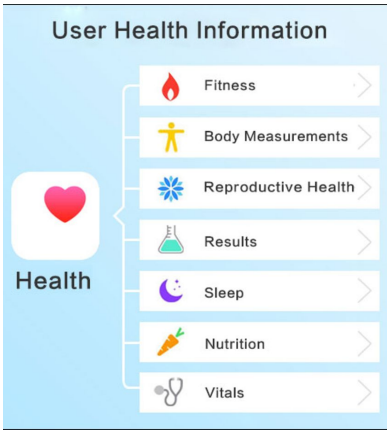

Figure 3: HealthKit main data access

According to recent survey, the following mobile applications have already integrated with HealthKit [15]:

- *American Well*: Patients in telemedicine can share their own generated data through this application. The application enables the communication on health-related data between consumers and their physicians over video. It will potentially increase the access to care for people and provide better care for patients with chronic conditions.
- *Humana*: Consumers are granted the rights to share health-related data such as steps count in particular, and earn reward points to mark the progress.
- *Patient IO*: This application uses PGHD from the HealthKit platform to update the personalized treatment plans that the consumer has created [4].

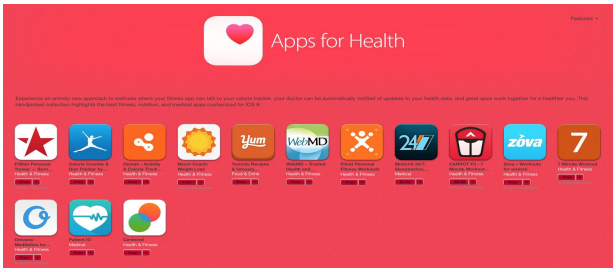

Figure 4: Example of Health App usage on iOS8

E. Apple Watch

The device includes the accelerometer for movement detection and measurements, the pedometer linked to GPS, the heart rate sensor, and the operating system with the similar health app system on iPhone to present the visualization of health data.

Figure 5: Health App on Apple Watch [15]

F. CareKit

CareKit is an open source framework developed by Apple that leverages customizable modules to the users. This kit will regularly track daily routine activities and monitor the care progress and also let users share their insights with the care teams. Apple founded this kit with a motive that care is not limited to doctor's office / at hospitals. Since CareKit is open source, developers can build upon existing modules and contribute new code to help other users. It is very easy to use and has six modules out of them two manages data and four provides user interfaces. [Figure 6] Care Card, System and measurement tracker, Insights, connect, document exporter and care plan data store are the six modules that CareKit provides. Aside from the benefits of the apps and the ability they give you to monitor and measure the progress of your medical care, CareKit also benefit on health data research fields.

Figure 6: CareKit built-in UI

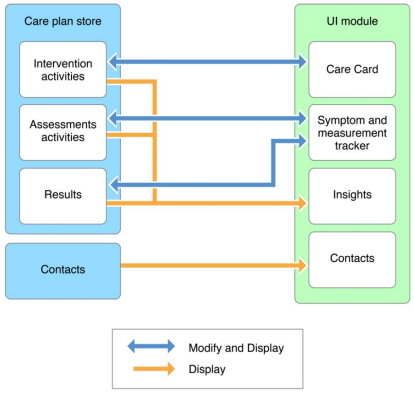

Figure 7: Relationship of items in the CareKit framework.

G. ResearchKit

In order to do medical research, Apple an open source framework called ResearchKit. It is used to create consent flows and provides customizable modules, which can also be shared with other users. It works well with HealthKit, which can be used to track the steps count, calorie burn and heart rate of the patients and study about those vitals. In ResearchKit, each application comes with a relatively standard setup process, with only minor differences between the apps. Users will first be prompted with a series of simple questions that determines if they are eligible for the study. Once users have established the consent to participate in the study, they can choose whether they would like data to be shared with just the institution behind the app, or with a wider field of researchers. [16]

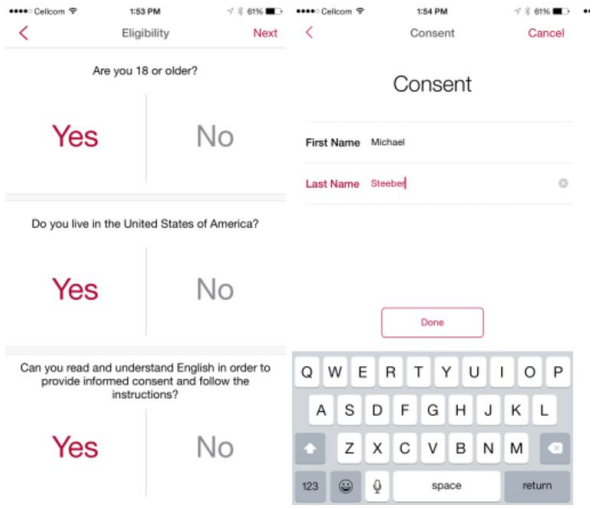

Figure 8: ResearchKit example, asking for users' consents for data access permission

III. PRIVACY OF HEALTH AND FITNESS RELATED ON MOBILE APPLICATION

As data sharing is the main feature in mobile health platform, security is considered the most concern issue that needs to be solved. In order to assure that sensitive data related to personal health information being shared in a reliable and secure manner, most mobile apps will ask for users' permissions to access health data on their personal phone.

On iOS, in order to obtain and update health and fitness data to mobile system, HealthKit requires users' manual permissions to access and manipulate data. This means HealthKit won't authorize automatic access to data without users knowing. Data is secured in HealthKit in two different ways: (1) Data is protected by a mechanism called Complete Protection, which require users' authentication (Eg: Touch ID or Password) while accessing data. (2) All data is encrypted.

For third-party application, accessing HealthKit data requires the following restrictions:

- Application must obey the constraints such as health data are not allowed for advertising purpose.
- Users control data access through privacy settings. Only after users' permissions, the application is able to access health data.
- Users could limit read and write permissions for certain health data property or attribute.

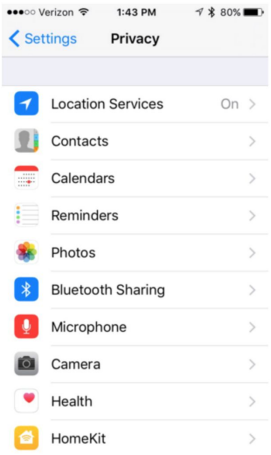

Figure 9: iOS User Privacy settings

IV. RESEARCH METHODOLOGY

This report examines and evaluates the accuracy and credibility of the Apple HealthKit application. The approach is divided into three steps:

1. Analyze users' daily behavioral characteristics within one week.
2. Get one week of recorded data to analyze.
3. The app compares behavioral data, validates results and reports.

The user is assumingly has daily activities as the pattern below:

- User rarely participates in sports activities.
- User rarely travels, and spends most time at home.

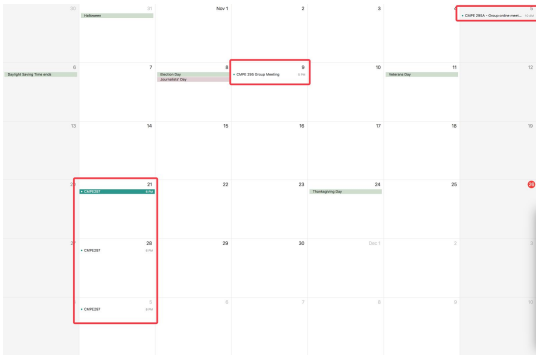

Fig 10: User Schedules

Expected outcome

According to the user's actual schedule, the user's travel record is not very rich. The user should obtain a relatively negative test result. At the same time, the user should get a recommendation to increase the health index.

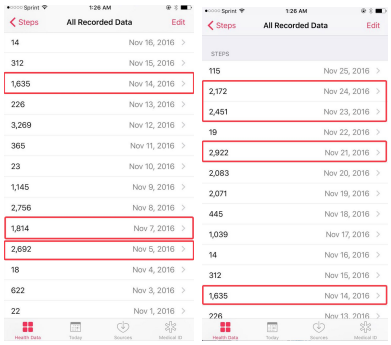

Fig 11: Application walking statistics

Depending on the data record, the application provides a set of behavioral data that closely matches the user's actual schedule. (user will have more steps for days he/she spends more time walking)

Result

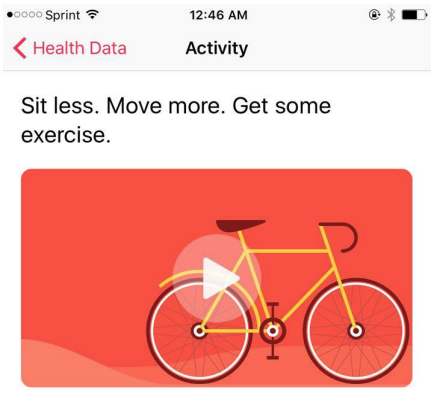

Fig 11: Application analysis results and recommendations

From the reference results provided by the program can be intuitive to judge, the application has been determined that the user does not love the results of sports while providing a recommendation to encourage users to go out sports. Through the statistical process, we can directly determine that the existing phase of the health application has been related to the sensor can accurately measure the user's daily behavior characteristics, while the user's behavior based on relevant data analysis and judgments, and give the user accurate suggest. This allows healthcare organizations to remotely access user behavioral data as well as health indicators while providing real-time health guidance and health assistance.

V. BIG DATA ANALYSIS IN HEALTH CARE

A. Health Care Data

Big data in healthcare refers to complex and large data, which is electronically captured and stored using modern tools and platforms. The traditional database management models are not effective to manage such big data. Also, when it comes to capturing real time vitals of patients like heart rate, blood pressure, step counts and temperature from wearable devices or sensors, it is often required to retrieve and analyze them in real time. Which in turn has to be fast and efficient. Health care data can be in different forms such as genomic data, clinical data, clinical notes, health publication data, behavioral data, patients' sentiment data and so on.

B. Big Data Analytics

The quickly growing area of big data analytics has initiated to play a significant role in the advancement of healthcare practices and findings. It has not only provided ways to capture, maintain, analyze huge amount of structured and unstructured data that is generated by many health care sources and systems but also helped to predict the future occurrence based on the present scenarios. The way big data is described is constantly changing. But overall, it revolves around the subject that it is a giant bulk of data whose speed, size and type needs one to discover new hardware and software tactics in order to correctly store, analyze and display the extracted data. Healthcare data has innate characteristics of the big data: volume, velocity and variety. Variety in healthcare data refers to the multiple sources of data including different types of data generated from medical systems, health researchers, health insurers, and so. The healthcare data generated from sensors, wearable devices, prescriptions given to patients, health data stored electronically on the hardware and other data sources adds up to the volume of healthcare data. The application of analytics in the context of healthcare data is the way to examine the large amount of data from numerous sources also in many different formats. In order to visualize the health-related data, various analytics based concepts are developed such as data mining, machine learning, artificial intelligence (AI), natural language processing and so on. The predictive analytics is used to analyze and visualize the data. Health data volume is growing dramatically in past few years and is expected to grow exponentially in upcoming years. Therefore, researchers are finding all the ways to store such huge amount of data and ways to analyze, represent them in order to bring out useful information from it.

For Big Data healthcare, MapReduce, (Hadoop framework) is uniquely capable to store a unique range of healthcare data types that includes EHR (electronic medical records), genomic data, financial and claims data etc. They offer scalable, reliable and availability features which were not offered by conventional database management systems. They also provide platform to build image recognition, diagnosis, surveillance to build as a part of specialized machine learning.

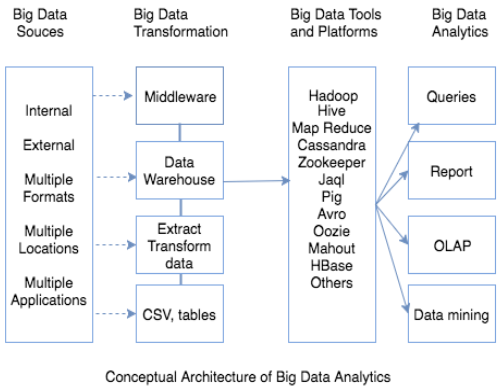

Figure 10: Architecture of BDA

C. Opportunities of Big Data in Medical Application and Health Care

Big data has all the potentials to serve applications in the field of healthcare. It has gained momentum in the direction of genomics, clinical researches, fraud prevention and detection, pharmaceuticals and medical services.

- *Clinical Researches*

In order to carry out the analytics in clinical area; operational data, financial data and other clinical data can be combined to get better outcome of analytics. There are various examples that has proved that by unifying all different types of clinical based information, the cost of care can be reduced at certain level also prediction of health related risks can be done at early stage.

- *Fraud Prevention*

To identify, prevent and lessen the number of frauds occurring can be executed by using advanced analytics to check the accuracy of the claims. There are ways to prevent the frauds one of them is using the big data predictive models. Doing so, the payers will know how to predict and prevent the fraud.

D. Challenges of Big Data Analytics in Health Care

- *Torrent of healthcare data*

According to the Institute for Health Technology Transformation, the amount of health data reached up to 1 billion gigabyte in mid 2012. An estimate has been done which states that this data will double in next 9 to 10 years. This deluge amount of data is a big challenge in healthcare.

- *Data Scientists scarcity*

According to McKinsey Global Institute, by 2020 there will be shortage of approximately 100k analytic talents. With this shortage it also means that about 50-60% data scientists position will be vacant. The reason behind this is not enough knowledge for the data analytics, less communication and collaboration, leadership issues and much more. This is one of the critical challenges of big data analytics in healthcare.

- Data chaos

Healthcare big data is not static. The data sources are continuously evolving and becoming more complex every single day. Also, they are variable which results in duplication, negligible consistency, imprecise in people's reducing trust from the data validity. All these challenges are very crucial to be taken care of if not it will get even worse in near future.

VI. CONCLUSION

In this research paper we went through all the emerging tools and platforms in big data analytics area, privacy in healthcare & fitness analytics and at last discussed all the aspects of

BDA in healthcare. All the tools and platforms that are listed in this paper are useful to do data mining and analytics in healthcare. It will also help to improve performance related to healthcare in future and will benefit in making decisions. Big Data analytics (BDA) does predictive modeling to check who are most likely to benefit from a care management plan. To prevent diseases, to decrease medical errors, right care at right time method to get effective medical outputs are few of the benefits that can come from big data analytics. Improvement in Research and development because of big data analytics in healthcare is also very significant.

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