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Big Data Analysis: Why Not an Asthma APP?

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Abstract

Asthma and Chronic Obstructive Pulmonary Disease (COPD) is among the highest health diagnosis and therefore an economic drain, which puts substantial pressure on a huge number of patients, communities, and health systems. These chronic conditions are presently incurable but their symptoms can be controlled through quality health care, appropriate medications, and good self-management skills. Many asthma APPs have been developed to support asthma patients' self-management of the disease. Asthma APPs are still in the infancy stage of development. Literature review indicates satisfaction to be equivocal. Moreover, available APPs have many unresolved issues, such as the following: (1) No APP provides comprehensive asthma information while at the same time possessing the characteristics of an efficient tool for self-management of the disease; (2) No APP has the ability to integrate data from disparate formats; (3) Not many APPs provide for two way communication between patients and Health Care Providers (HCPs) and support the providers decision making process; (4) No APP targets older adults.

Different sources of data often imply data stored in inherently different formats. The integration of such data, culled from different databases requires use of Big Data (BD) techniques.

The proposed asthma mobile APP aims to promote elderly asthma patients' positive adjustment to this chronic disease by being an effective tool for patients to control their asthma triggers and support asthma self-management. Adjustment is a dynamic process and varies by individual. For that reason, a personalized asthma APP is necessary to control this chronic disease. The proposed asthma APP will allow patients to input their own asthma self-management data so the APP can identify patient personal triggers and will predict an asthma attack accordingly. Considering a patient's individual determinants and uniqueness is required to push the patient's positive adjustment to asthma since these elements affect the ability of individual to adapt to the illness.

The paper reports our effort to establish the desirable characteristics for the next generation asthma APP and for a population segment not presently well served.

Keywords: mHealth, smart-health, asthma, COPD, chronic disease, self-management, big data analysis.

Introduction

The US healthcare cost is estimated to reach $4.8 trillion in 2021, which will account for about 20% of the GDP (Centers for Medicare and Medicaid Services, 2011). Despite the high cost, the quality of healthcare services is quite low compared to other industrialized nations. The US ranks 11th in the world on many measures of health including outcomes, quality, and efficiency. The US also ranks 11th in access problems related to cost and equity (Davis, Stremikis, Squires, & Schoen, 2014). The US Health Insurance Coverage 2013 report by Census Bureau specifies that there are about 42 million Americans do not have health insurance in 2013, which is about 13.4% of population (Smith & Medalia, 2014).

According to the Centers for Disease Control and Prevention (CDC), chronic diseases such as heart disease, cancer, diabetes, and asthma are the leading causes of disability in the US and account for 70% of all deaths. Unsurprisingly, these chronic conditions are America's most expensive medical conditions. Specifically, asthma is among the top five expensive diseases in terms of direct medical spending in 1996 and 2006 (Lubkin & Larsen, 2013). Asthma is one of the world's most common long-term illnesses. This chronic condition puts substantial pressure on a huge number of patients, communities and health systems. In the US, asthma is one of highest health diagnosis and economic drain (Centers for Disease Control and Prevention, 2013).

Many international clinical guidelines indicate that the health outcomes can be improved by involving asthma patients in self-management programs. Recent expansions in mobile technology are expected to be a great help in developing a platform for the delivery of self-managed interventions that are highly customizable, low cost, and easily accessible (Huckvale, Car, Morrison, & Car, 2012).

Currently the use of self-management asthma apps by both HCPs and patients is at the beginning stages. Asthma apps for self-management are limited in their usefulness. However, the ability to develop quality and useful apps is promising. The research presented in this paper reports the design stage of the development of one such promising APP.

Background Information

The Use of mHealth to Address Healthcare Problems

The advent of health-care devices based on mobile technologies (mHealth) can improve the ability of HCPs to detect, monitor, and coordinate care for patients, especially patients with chronic conditions (American Academy of Allergy Asthma and Immunology, 2014). mHealth benefits are not limited to providing better information and communication between HCPs and patients but improving accessibility with flexible, asynchronous communication, and information exchange 24/7. mHealth allows patients to be involved in health care decisions, care management, and care prevention. The estimate of American adults' smartphone use in the US is at 64% in 2014 and the smartphone ownership is predicted to reach over 90% of the population within a few years (Pew Research Center, 2014). The popularity of smartphones promises increased accessibility and improved implementation of mHealth.

mHealth increases access to care by making remote diagnoses and treatments available (Boulos, Wheeler, Tavares, & Jones, 2011). More than that, mHealth is believed to reduce the cost by delivering quality healthcare in less time. A survey conducted by the Global mHealth Developer showed that 78% of respondents said that smart phones provide "the best business opportunities for mobile healthcare" in 2011 and 82% believed that it would dominate the industry for its usefulness and popularity by 2015 (Bottles, 2011). Smart phones improve the processes through which doctors, nurses, specialists, and other members of the healthcare team deliver healthcare.

Smart phones are performing a rising health-care role by supporting both HCPs and patients. Clearly, a smart phone does not only provide voice and text communication features; it also makes advanced computing and communication capability, such as Internet access and geo-position systems, available to its users. Researchers conclude that "portability, continuous uninterrupted data stream, and the capability through sufficient computing power to support multimedia software applications" are among the main aspects that give smart phones the advantage over other information and communication technologies (Boulos et al., 2011).

Some mobile applications and features that support the work of HCPs include alerts, diagnostic tools, medical education, medical references, appointment tools, e-prescriptions, messaging, and access to patient health records. Consumer-oriented applications include aiding and checking for medication compliance, mobile and home monitoring with portable devices (e.g., falls or emergencies), symptom or disease management (e.g., glucose or blood pressure monitoring), and monitoring of wellness/fitness. In addition, some apps make health records available to the patient. These apps involve patients in the process of treatment, get them "linked" to HCPs, and save them time and the cost of visiting health-care facilities. Thus, employing mobile communication in the provision of remote healthcare advice and telemedicine offers significant economic benefits.

Asthma and COPD

Asthma is a chronic disease of the lungs, which may occur at any age. Like other chronic diseases, asthma cannot currently be cured but its symptoms can be controlled through quality health care, appropriate medications, and good self-management skills (National Institute of Health, 2014). With asthma, the patient has an inflammation of the air passages that causes a short-term narrowing of the airways that carry oxygen to the lungs. As a result, patients with asthma experience difficulty breathing (American Academy of Allergy Asthma and Immunology, 2014). Asthma is a leading chronic childhood disease in the US, and studies indicate that there is "a direct correlation between the severity of asthma as a child and the incidence of COPD" (American Lung Association, 2012). Moreover, it is not uncommon for individuals to be diagnosed with asthma as adults.

COPD is also a chronic lung disease that may worsen over time, usually diagnosed in middle-aged or older adults. It is caused by smoking or prolonged exposure to irritants, such as coal dust, pollutants, and other industrial by-products. COPD also makes breathing difficult and, for that reason, asthma and COPD have similar symptoms, including coughing, wheezing, and shortness of breath. COPD causes the airways and air sacs to lose their natural elasticity. As a result, air may get trapped in the lungs (Smith & Medalia, 2014). COPD is the third leading cause of death in the US, and it is the second leading trigger of disability (American Lung Association, 2012).

Asthma triggers and COPD triggers may differ. For example, exposure to allergens and cold air may trigger asthma while exercise and upper respiratory infections, such as bronchitis or influenza, may trigger both asthma and COPD. However, environmental pollutants or irritants are more likely to trigger COPD, but they can trigger asthma as well. Furthermore, triggers are confounded in patients with both COPD and asthma, which means these triggers are associated with both asthma and COPD.

About 40% of COPD patients have asthma and this dual-diagnosis grows with age (National Heart, Lung and Blood Institute, 2013). Research supports that patients with both COPD and asthma suffer faster disease progression than patients with either disease alone (Hardin et al., 2011). Moreover, individuals with both asthma and COPD suffer more regular and severe respiratory exacerbations. Therefore, individuals with COPD and asthma characterize a significant

population at risk for poor health outcomes and decreased health-related quality of life (Hardin et al., 2011).

Although neither asthma nor COPD is currently curable, lifestyle changing and good management of the disease may improve quality of life and decrease disability. Complications of COPD include high blood pressure, heart problems, and lung cancer (Mayo Foundation for Medical Education and Research, 2014). Individuals with any chronic disease, including asthma and COPD, are also at risk for depression.

Asthma Prevalence Depends Mostly on Age, Gender, Income, and Race

According to the CDC, since 1980 the number of asthma patients is increasing at a rapid rate. The number of asthma population in 2010 (8.7%) is nearly triple the number of asthma patients in 1980 (3%). Asthma costs the US more than $56 billion each year, and there are approximately 25.9 million people currently suffering from asthma (Centers for Disease Control and Prevention, 2013).

Asthma prevalence is higher among children, females, and low-income populations, varying by race and ethnicity. Children have higher asthma prevalence (9.5%) compared to adults (7.7%). Females have higher asthma prevalence than males (9.2% compared with 7.0%). People of multiple races have the highest asthma prevalence (14.1%), while Asians have the lowest rates (5.2%). Blacks (11.2%) and American Indian or Alaska Natives (9.4%) have higher asthma prevalence than whites (7.7%). Among Hispanic groups, asthma prevalence is higher among people of Puerto Rican descent (16.1%) than those of Mexican descent (5.4%) (Akinbami et al., 2012).

The US Department of Health and Human Services Administration on Aging reports that more than two million Americans age 65 and older have asthma. Comparing the prevalence of asthma between different age groups of those of age 24-64 and those 65+, the higher age group has a higher prevalence. According to the American Academy of Allergy, Asthma and Immunology (2014), the senior age group represents the fastest growing segment of asthma sufferers in the US. Therefore, asthma is a disease of significant importance. The asthma mortality rate was 0.15 per 1,000 asthma patients for the period 2007–2009. Asthma patients over age 65 are at the highest death rate (0.58 per 1,000 patients) (Asthma and Allergy Foundation of America, 2014). Asthma may not be as dangerous a disease for younger patients as it is for older adults whose disease may be fatal. This statistical information indicates that although older adults have less asthma prevalence compared to children, the outcome of this asthma age group is worse.

Older Adults Are at Higher Risk and Treatment Is More Difficult

As mentioned previously, asthma affects patients at any age. However, older adults are more likely to experience asthma attacks. As people age, the bones of the ribcage become thinner and change shape leading to decreased ability to expand and tighten when breathing. Also, the diaphragm – the muscle that supports breathing – is weaker. As a result, less oxygen flows into the lungs and less carbon dioxide is removed from the body. In addition, some air may be entrapped in the lungs, which causes shortness of breath. Furthermore, with aging the muscles and tissues close to the airways lose elasticity and airways do not fully open. Alveoli may become baggy, which causes air to get trapped in the lungs and makes breathing hard (The U.S. National Library of Medicine, 2014).

With asthma patients, the airways are blocked temporarily and air is captured in the lungs; this creates irritation resulting in inflammation and increased mucus production. With COPD, the airways are also blocked which reduces airflow over the time and increases inflammation. There-

fore, the reduced elasticity of an older adult's airway makes asthma and COPD a common health problem (The U.S. National Library of Medicine, 2014).

As people age, the brain which controls the functioning of breathing may lose some of its function and the nerves in the airways are not as sensitive as before. Besides, the immune system of an older adult is weaker and less able to fight lung infections such as bronchitis or pneumonia, or chronic infections such as tuberculosis or chronic bronchitis (The U.S. National Library of Medicine, 2014).

All of these changes in the lungs make older adults with asthma or COPD susceptible to exacerbations. Asthma and COPD are considered a common disease in people over age 65. Due to some bad affects in the lung as a patient ages, asthma treatment for elderly patients is much more difficult. These patients are at higher risk since they are more likely to develop respiratory failure as a result of the asthma, even during mild episodes of symptoms. Older patients with mild asthma symptoms can have the same level of breathing difficulty as younger asthma patients experiencing a severe asthma episode. Beside, older patients usually have more difficulty using an inhaler without assistance. Asthma causes serious health problems for older patients if it is not treated properly. The airways remodeling may occur when a person with asthma is not treated properly to defeat chronic inflammation. Airway remodeling leads to COPD, which is a disease that currently can only be treated to reduce symptoms (American Lung Association, 2012).

Elderly patients are at higher rate of suffering from more than one chronic disease. For that reason, they are usually under multiple treatments and taking many prescriptions. Research concludes that about half of the total adults in the US have at least one chronic disease, and one out of four adults had multiple chronic health conditions in 2012 (Ward, Schiller, & Goodman, 2014). This problem together with the physiological changes, in general, causes more difficulties in self-management of their health.

Difficulty in diagnosis

Information from WebMD (2014) shows that most asthma symptoms are not obvious. Also, asthma symptoms develop slowly and some symptoms may disappear for a while and then come back. These subtle and gradual properties of asthma symptoms make asthma diagnosis very difficult and especially much harder to diagnose in elderly asthma patients. Even though older patients are at higher risk of having asthma and this chronic disease is more dangerous to elderly people compared to patients in other age groups, the diagnosis of asthma is more difficult for elders since symptoms of other illnesses which also are common such as chronic bronchitis or congestive heart failure are similar to asthma symptoms and may mask the specific symptoms. When the asthma symptoms are not recognized correctly, they may remain untreated, likely worsening and creating very serious health risks.

Difficulty in treatment

Since older adults have four times the risk of having more than one chronic condition, they have to take many medications during the treatment process. Some asthma medications react with treatments for concomitant conditions, which causes some side effects. Some medications may make asthma symptoms worse. Also, elders have difficulty in following treatment instructions, especially when they have to take multiple prescriptions.

Asthma Triggers and Four Components of Asthma Care

The 2007 Guidelines for the Diagnosis and Management of Asthma by the National Institutes of Health (2007) denote that causes of asthma are the interaction of multiple host factors such as innate immunity, genetics, and environmental exposures. Currently the asthma treatment is rec-

ommended to focus mostly on considering genetic factors and environmental triggers since the intervention to prevent innate immunity is still under study. For environmental triggers, the airborne allergens and the viral respiratory infections are the two most concerned factors. Tobacco smoke, air pollution, mold, medications, physical exercise, emotion, bad weather (thunderstorms or high humidity, cold, dry air), certain food, food additives, fragrances, and diet (obesity or low intake of antioxidants and omega-3 fatty acids) also are among the most common asthma triggers. The report also recommends four components of asthma care, which are "assessing and monitoring asthma severity and asthma control, education for a partnership in care, control of environmental factors and comorbid conditions that affect asthma, and medications" (National Institutes of Health, 2007).

Social Isolation and Adjustment to Illness

The chronic diseases and patients' psychological and/or physical distance, which leads to the feelings of tediousness, nonconformity, or exclusion, is defined as a patient's "social isolation." Social isolation can be intentional or involuntary. It does not only affect the patient's daily life but may also upset that patient's social support network such as family, co-workers, and friends. Social isolation causes alienating and unpleasantness and may progress to depression, loneliness, or other social and cognitive impairments. Patients with serious chronic illnesses perceive themselves as different from others and outside the mainstream of normal life. They know that they face a higher mortality rate than others. All of these negative thoughts and behaviors accordingly may stem from the patients' stigmatized disability. Social isolation, for that reason, is negative, is a social burden, and is one of the two most vital factors of chronic illness to be managed in the plan of care (Lubkin & Larsen, 2013).

Asthma patients, especially elder adults, have a higher risk of social isolation. Asthma triggers are many. It happens frequently and is unpredictable to patients. Asthma symptoms are sometimes out of a patient's control. Asthma symptoms usually prevent patients from normal life activities. Asthma patients may develop social isolation by-thinking that they are different from others and trying to avoid being a problem for others. More than that, asthma attacks elders at a higher rate. The losses of physical and psychological health, social roles, mobility, economic status, and physical living arrangement of elders prevent them from having many social networks and that is one of the main causes of developing social isolation. Social isolation is connected to functional disability since it prevents older adults from finding engagement with others (Lubkin & Larsen, 2013).

Coping with a disability requires adjustment to one's life style. Adjustments can be negative or positive. While many patients with a chronic-disease react negatively to their state and develop social isolation, others develop the inner strength and daily habits to live with their disability. Positive adjustment to illness can be considered as a set of multiple positive attitudes of the patient towards his/her illness such as an acceptable quality of life, vitality, life satisfaction, and self-esteem. On the other hand, negative adjustment often leads to inner stress, which manifests itself in the syndrome known as Adjustment Disorder (Lubkin & Larsen, 2013).

BD in Healthcare

What is BD?

One of the most common definitions of BD (Big Data) is "large volumes of high velocity, complex, and variable data that require advanced techniques and technologies to enable the capture, storage, distribution, management, and analysis of the information" (Institute for Health Technol-

ogy Transformation, 2013). However, a functional definition of BD in terms of determinants, attributes, and characteristics is presented, as follows:

Volume: the amount of data that is stored or analyzed is very huge (normally above a Tera-byte, often Peta-, or Exa-, or even Zetta-bytes).

Variety: multiple types such as structure data (metadata is well defined, e.g., tables, objects), unstructured data (binary data such as document, graph, and video), and semi structure data (metadata is contained internally, e.g., XML).

Velocity: the data is produced at high rates and operating on 'stale' data is not valuable.

Value: the data has perceived or quantifiable benefit to the users.

Validation: where the correctness of data can be accessed.

Stated above is a short list. In usage, some authorities may add to the above list, since the subject area is, as yet, not fully defined.

The type of technological support underpinning BD is:

1. Storage of colossal amounts of data, in formats that can easily be modified, if possible in application run mode.
2. Linkage of datasets stored in different formats.
3. Analytical models, which require and rely on large data for their working.
4. Human decision-makers who make the final decision on the possible utility of the patterns discerned by the analytical models using mega-data, possibly stored in different formats.

Thus, the BD idea is not confined simply to the use of databases, whether Relational or non-Relational – whether SQL and NoSQL.

Healthcare BD

Healthcare BD is the electronic health datasets that are produced at a very high speed and getting bigger and bigger over-time, which makes it very difficult (even impossible) to manage by using traditional software, data management tools, methods, and hardware. The current popular method of storing electronic healthcare data is using Relational Database Management Systems (RDBMSs) such as MySQL, PostgreSQL, Oracle, and SQL Server. In RDBMSs, data is stored as rows in tables. These tables are linked together by a defined relationship. In order to retrieve the needed data, many tables are joined together and specific data of each table is selected and combined to produce a result dataset. RDBMSs do not scale out (using more processors working together to improve performance) when joins are required. This makes the process of joining tables to get data out of the database time consuming, especially when the volume of data is large. Healthcare BD is so large that it cannot be easily managed using a single processor. When data grows big, it can be broken into chunks by spreading the chunks across multiple distributed database servers. In DBMSs, this sharing can be done but it requires an advanced maintenance process that is very costly and time-consuming which leads to operational inefficiency especially when the processes have to be repeated often (McCreary& Kelly, 2014). The speed at which the data must be managed is one of the key requirements when dealing with healthcare BD, which makes DBMS an inadequate fix.

Healthcare BD comes from many sources such as web and social media data (Twitter, blogs, health plan websites, smartphone apps), machine to machine data (streaming from sensors, meters, and other vital sign devices), big transaction data (claims and other billing records), bio-

metric data (finger prints, genetics, handwriting, retinal scans, x-ray, blood pressure, pulse and pulse-oximetry readings), and human-generated data (unstructured and semi-structured data such as EHRs, physicians' notes, email, and paper documents). The nature of RDMSs is storing data in predefined data type columns, which makes storing high-variability data in tables difficult (McCreary& Kelly, 2014).

Healthcare data is heterogeneous and complex. Inducing a meaningful use out of this data leads to great challenges in analyses and subsequent applications in practical clinical environment. The main problem of this huge data is its complexity, which makes it very easy to break, and when it breaks it is extremely hard and costly to fix (Berman, 2013).

BD technology includes the technology to store and to analyze the data. Healthcare BD analytics provide the possibilities of improving care, reducing medical errors, and lowering costs by detecting associations and understanding patterns and trends within the data. Healthcare BD analytics applications take the explosion in data for granted to extract insights for making better-informed decisions by supporting HCPs to foster more thorough and insightful diagnoses and recognize the most clinically and cost effective treatments (McCreary& Kelly, 2014).

Stories are key to persuasion. A dataset can tell thousands of stories. Patients are more convinced when the data is available to them. The use of self-management applications supported with evidence based data analysis, for that reason, are recommended for patients with chronic diseases. The really great advantage of big dataset is that it is very good at detecting correlations, especially subtle correlations that an analysis of smaller data sets might miss. In a BD resource, it is the relationship among data objects that are the keys to knowledge. Data by itself, even in large quantities, tells only part of a story. In addition, a study with larger data is more trusted, but this does not mean that the study result cannot be wrong.

Healthcare BD Analysis

Data by itself is just facts. It must be transformed into meaningful information to generate knowledge. The healthcare environment is generally perceived as being 'information rich' yet 'knowledge poor.' BD analysis is the process of data selection and exploration and building models using vast data stores to uncover previously unknown patterns. BD analysis can produce information that is very useful to HCPs such as supporting decision making processes, identifying or evaluating effective treatments and best practices, and identifying successful standardized treatments for specific diseases.

Some reasons for the popularity and acceptance of healthcare BD analysis include:

The huge amounts of data generated by healthcare transactions: information too complex and voluminous to be processed and analyzed by traditional methods.

Medical insurance fraud and abuse: using data analysis tools to find and track offenders.

Improving decision-making: discovering patterns and trends in large amounts of complex data.

Healthcare management or prevention: identifying and tracking chronic disease states and high-risk patients.

Customer relationship management: determining the preferences, usage patterns, and current and future needs of individuals to improve level of satisfaction.

Clinical operations: recommending more clinically-relevant and cost-effective diagnosing and treatment methods.

Research and development: developing statistical tools and algorithms to improve clinical trial design and determine adverse effects.

BD analytics "has the potential to transform the way HCPs use sophisticated technologies to gain insight from their clinical and other data repositories and make informed decisions" (Raghupathi & Raghupathi, 2014).

Previous Work

Many types of asthma APPs have been proposed. A number of characteristics for evaluating their effectiveness in providing patient-control of condition have been discussed and some have been implemented. Characteristic types, culled from the literature, that facilitate self-management will now be presented. These characteristics play a role in providing comprehensive asthma information, enhancing patient and HCPs communication, supporting self-management, and monitoring.

Supporting Communication

In the paper "Building Patient Relationships: A Smartphone Application Supporting Communication Between Teenagers With Asthma and the RN Care Coordinator" (Kimberly & Jillian, 2013) a pilot study using a smartphone application to not only share, at the point of living, health information such as health assessments, personalized health plans, and disease information, but also to provide a communication channel between the teenage asthma patients and his/her HCPs via text messaging has been conducted. Eighty five percent of patients specified that there is a positive change in the nurse-patient relationship since they could ask more questions together with having improved access and quicker response times. On the HCPs' side, they also indicated that the application offered an effective method to contact patients and improved accuracy of assessment data. Although the study pointed out that the lack of data integration feature with the Electronic Medicine Record (EMR) system is one of the most notable limitations of this implementation, the authors concluded that the smartphone technology and text messaging enhanced communication and enhanced the nurse-patient relationship which in turn went a long way towards good healthcare outcomes.

HCPs' Decision Supporting

Computer Decision Support System (CDSS) is defined as an active knowledge system, which provides case-specific advice based on considering a patient's health data (Wyatt & Spiegelhalter, 1991). In the article "Computer decision support systems for asthma: A systematic review," (Matui, Wyatt, Pinnock, Sheikh, & McLean, 2014) eight studies, with six at risk of bias, passed the inclusion criteria and were selected for assessing the outcomes of using CDSSs for asthma by HCPs. There was only one CDSS as a stand-alone system. Others were integrated (one is partly) with Electronic Health Record (EHR) system. The study results specified that CDSSs could help improving clinical outcomes for asthma patients if they are trustily used and with higher recommendations to improve compliance. Specifically, CDSSs support the work of HCPs in creating a proper guideline adherence such as enhancing investigating, prescribing, and issuing of action plans. Three out of eight studies reported that asthma daytime symptoms were decreased profoundly among patients in the intervention group. Three studies indicated a better asthma control in improving asthma-related quality of life. Two studies showed significantly lower exacerbations rate as manifested by fewer visits to the general practitioner and hospitalizations among the intervention group. The authors pointed out that "the next generation of CDSSs for asthma need to be designed to be able to go along with the HCPs' workflows for a more timely and easier access to advice" (Matui et al., 2014).

Asthma Self-Management

Recently, research was conducted to evaluate the effectiveness of 103 selected Android, Apple, Blackberry, and Windows Phone asthma apps as a tool to support asthma diagnosis or asthma management. The research indicated that within two years, the number of asthma apps doubled. However, the newer apps were not providing more comprehensive information such as the use of action plans or support guidance consistent with evidence. There are just a few apps that offer consistent guidelines and evidence-based instructions. About 50% of asthma apps offer only basic asthma information. Only three out of 56 apps in this category meet the standard of comprehensiveness of information about asthma. Half of the apps provide tools for asthma self-management. However, there are very few apps that effectively provide the complete features of an asthma self-management tool such as diaries and tracker, pollen status, pollution status, and allergen database. None of the apps propose comprehensive guidance for lay management of acute asthma with information about a suitable reliever medication use. Also, there is no APP that targets older adults (Matui et al., 2014).

Limitations of Current Asthma APPs

Most of all, the comprehensiveness of asthma information and the accuracy of evidence-based recommendations remain one of the largest concerns of an asthma app. New apps should overcome this limitation in order to encourage the implementation of an asthma APP in the treatment process. Firstly, the proposed asthma APP should also provide both features of offering reliable and comprehensive information about asthma conditions with supportive tools for self-management. Secondly, there should be a method of integrating an asthma APP data with the EMR system. System fragmentation is one of top reasons that prevent the implementation of a new APP. Thirdly, currently there are not many asthma APPs that support communication of HCPs and patients. As "asthma is common, globally-relevant, managed substantially in primary care and amenable to self-management" (Matui et al., 2014), getting patients involved in the treatment process is crucial and the communication between HCPs and patients is essential. Fourthly, there are currently very few asthma apps that support the HCPs decision-making process. The potential of this possibility in an asthma APP is pretty promising. And finally, there should be an asthma APP targeting older adults. As mentioned earlier, the mortality rate of asthma is higher among elderly patients and the treatment is more difficult. Because older adults also have more difficulty performing asthma self-management, they could use the help of a gadget in the absence of immediate availability of a caregiver. The US elder population has tripled since 1900 and is predicted to reach 72.1 million older adults by 2030, which is about 19% of the US population (Lubkin & Larsen, 2013). Thus, the need for the development of an asthma APP that targets older adults is vital.

Having discussed the nature of the disease, the desirable characteristics of asthma app, the possible user base for the app, and the limitations of currently available apps, next is the outline of the proposed project.

Proposed Asthma APP

Outlines of the Universal Asthma APP

Up until a few years ago, many people still believed that with a really large computer fed with a huge amount of data, almost any question could be answered (Berman, 2013). This statement is only half right. The right part in this idea is the crucial role of data, its information, and the knowledge that people get from it. Over time, the data that is collected and analyzed becomes bigger and bigger. This BD has an inestimable value, but it is very complex and difficult to build

and easy to break. For that reason, the idea of developing an expensive supercomputer facility to work with increasing qualities of biological data, or streaming data, at higher and higher levels of complexity appears to be impractical and unnecessary. BD technology helps to solve this problem. Specifically, it helps with Preparing, Sharing, and Analyzing Complex Information (Berman, 2013). The main purpose of BD is to produce small data (e.g., answer a question – like what is the nearest best reviewed restaurant in this location – based on the analysis of BD) and invaluable knowledge (Berman, 2013).

Tracking a patient's signs and symptoms is required for treatment. By analyzing environmental data of where a person lives, considering the genetic factors, and a patient's triggers information, the probability of that person having an asthma attack can be detected early. Also, analyzing this data can help patients in self-management of the diseases and can help procure timely intervention from medical practitioners.

An asthma APP can be developed to help with monitoring by suggesting tips and triggering an early warning based on BD analysis and stream reasoning. Recent research indicates that logical reasoning in real time on multiple, heterogeneous, gigantic, and inevitably noisy data streams can be used to support the decision making process of extremely large numbers of concurrent users (McCreary & Kelly, 2014). The main purpose of the proposed asthma APP is to avoid the triggers that can cause attacks. It is based on BD analysis of patient health information as well as geographic information. The APP will be a knowledge base provider to patients in order to provide better information and instruction for their asthma management and to HCPs in order to support their decision making process.

The great possibility of BD identifying correlations is explained in the following statement: "Whenever sufficient information can be quantified, modern statistical methods will outperform an individual or small group of people every time." from a Harvard Magazine article (Shaw, 2014). However, it also carries the hidden danger of "finding correlations in very large linked datasets without understanding the causation" (Shaw, 2014). As a result, the correlations that are detected are actually spurious correlations because of the missing of real understanding of what is actually happening. For that reason, after a hypothesis is created, a reasonable test should be designed to confirm the validity of the hypothesis based on the analysis of the data. "This ability to gather and link self-reported information to larger datasets has proven a powerful tool" (Shaw, 2014). In this case, the APP will detect an impending asthma attack by linking the tracked personal asthma triggers of a patient with the environmental information and analyze the combined data to predict if a patient may get an asthma attack in the near future. The sensor that plays a role in streaming a patient's oxygen level, heart rate, and breath data will provide evidence-based data for another analysis to approve or disapprove the hypothesis.

The three main steps of predicting an asthma attack are described as below:

1. The APP will keep track of the patient's asthma management information by allowing patients to create an asthma diary. This self-management feature requires the patient to input information on his/her daily medications; rescue medications; emotional state; if unwell, type and severity of un-wellness; if there is an Asthma attack onset, the activity the person was performing at the time of onset; and finally, if onset was experienced by some person-specific trigger, which one? The asthma self-management feature provides data that can be analyzed for identifying the patient's personal asthma triggers.

2. The data of individual triggers is then compared with the environmental data, which is automatically integrated in the APP. The APP is able to detect the patient's location and searches for that location's environmental data such as humidity, pollen, mold, dust mites, and air pollution. This data integration feature supports environmental information that can be analyzed together with the patient's individual triggers to predict an asthma

attack. A sensor is used in the APP to read the oxygen level, heart rate, and breath data of a patient. The streaming sensor information plays an important role as a screening test to confirm if an asthma attack could occur.

3. If the analysis process indicates that there will be an asthma attack in the near future, the APP will trigger an alert to both the patient and the health provider and suggest some tips to possibly prevent an asthma attack.

The proposed APP, by providing a comprehensive tool for Asthma information and featuring self-management, is a tool which also promotes synchronous communication between patient and the HCPs; moreover, the proposed APP is a tool which supports the HCPs decision-making process; finally, the proposed APP is expected to boost asthma patients positive adjustment to this chronic condition. Figure 1 diagrams this proposed APP.

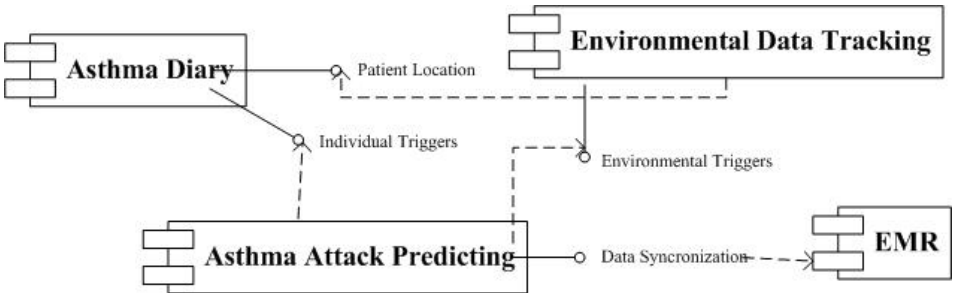

Figure 1. The Universal Asthma APP Component Diagram.

Experiment and Comparison

In healthcare, in order to evaluate the effectiveness of a new intervention with sufficient evidence, the differential clinical management of patients between the control and intervention groups should be as low as possible. Usually, a suitable randomized experimental design should be conducted for the evaluation purpose. For an asthma APP evaluation, "the seasonal nature of asthma and long-term adherence to self- management practices will be carefully considered and recorded" (Matui et al., 2014).

In any clinical study, the study participants' right must be protected. These include right to informed consent, shared decision making, and privacy for research participants. One of the authors of the study is a Registered Nurse and a committee will guide the trial protocol being developed. Complete compliance with the aforementioned rights of the participants, will be adhered to (Palmer & Rosenberger, 1991).

The Pilot Study

A controlled study of 5-10 people will be conducted through the clinical practice of one of the authors. The idea is to learn heuristically for tweaking the APP's parameters and testing the software before a full trial.

Sample Size Determination

As the study report will be presented in partial fulfillment of the PhD degree, the study will only be conducted to test the APP functionality in about 50 patients.

Randomize Selection of Patients between Control and Intervention Groups

Intervention group

As mentioned above, asthma prevalence varies based on some characteristics of patients such as age, gender, income, and race. To ensure the validity and reliability of the experiment, the subjects will be randomly selected by a computer program. Each study subject will be assigned with a unique identification number (ID) and the program will randomly pick up a specific number of subjects. This process will be done with careful consideration of the equal distribution of patient characteristics that may affect the disease prevalence that was mentioned in the section "Asthma Prevalence Depends Mostly on Age, Gender, Income, and Race." First, patients will be categorized in groups of patients that share the same characteristic such as age, gender, and race. Second, the software will randomly select an equal number of patients in each defined group. The results of these selections will be combined to form a random but equally distributed dataset of patients. Finally, the software will randomly select patients from this dataset.

The selected patients in this intervention group will be provided with the proposed asthma APP to manage their asthma. Patients who fail to follow up will be tracked and the result will be calculated with person-year units instead of number of subjects.

Control group

The seasonal nature of asthma is considered, for that reason, the patients who are selected randomly for the control group are the asthma patients that are under treatment for asthma during the same period of trial of the intervention group.

Conclusion

The proposed asthma mobile APP aims to promote elderly asthma patients' positive adjustment to this chronic disease by being an effective tool for patients to control their asthma triggers and support asthma self-management. Being informed about their illness status and provided with their asthma indicators, the asthma patients' involvement in treatment or monitoring is expected to increase. Patients are usually more persuaded and motivated by the health indicators that they can see. This will encourage patients toward a positive adjustment since the real information or numbers on the screen will be obvious to them. Adjustment is a dynamic process and varies by individual. For that reason, a personalized asthma application is necessary to control chronic disease. The proposed asthma application will allow patients to input their own asthma triggers and will predict an asthma attack accordingly. Considering a patient's individual determinants and uniqueness is required to push the patient's positive adjustment to asthma since these elements affect the ability of individual to adapt to the illness.

Recommendations

Any device or treatment meant for Aiding Management of a Condition will require more through extensive testing than could be undertaken in the present phase of developing and testing. In subsequent phases, the APP could be augmented and tested for the inclusion of more asthma triggers as well as different populations. In addition, issues such as security, privacy, standards, and governance should be carefully considered when developing an asthma app. These factors play a very important role in the implementation of any healthcare application.

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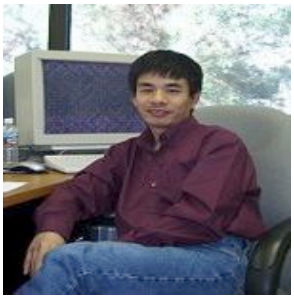
Biographies

Quan Do got her master degrees in Information Systems and Health Informatics. She is currently an Interdisciplinary PHD student in Computer Science – Nursing at New Mexico State University. Her research interests include database, big data analysis, health informatics, software engineering, information systems, and Epidemiology.

Dr. Kris Robinson's research interest focuses on health disparities that occur as a result of chronic illness experience, in particularly pain of Hispanics of Mexican American descent and their families, and ultimately the development of interventions to increase quality of life and optimum functioning in this population. Since moving to the Southwest in 2005, she has participated in several small research projects in the border area and presented at regional, state and national conferences with positive evaluation results. She received three years of funding from NINR under the R-15 mechanism to mentor future nurse and health science researchers. During this project, interprofessional research assistants assisted in translating and testing a psycho-educational intervention in cancer patients with pain. (NINR, #1R15NR0a2-190-01). Her latest funded research focuses on utilizing technology to enhance self-management of chronic illness symptoms (NIGMS, 2013-2014).



Dr. Son Tran received his Diplom Mathematiker degree in Mathematic Cybernetics and Comuting Technique in 1986 from the Technical University of Dresden, Germany, and his Master's and Ph.D. degrees in computer science from the Asian Institute of Technology, Thailand, and University of Texas at El Paso in 1993 and 2000, respectively. Before joining the Computer Science Department at New Mexico State University as an Assistant Professor in 2001, he was a post-doctoral at the Knowledge Systems Laboratory, Computer Science, Stanford University.