TOBACCO SETTLEMENT REVENUE OVERSIGHT COMMITTEE

TOBACCO SETTLEMENT REVENUE (TSR) FUNDING REQUEST

Name of entity requesting TSR funds: New Mexico State University

Name(s) of each program for which TSR funds will be used: aMAP: Asthma Management Assistance and Prediction Using Mobile-Sensor Application

Description of each program, including its purpose:

Please see attached

Have you requested TSR funds prior to this request? ~~Yes~~ No

Have you received TSR funds prior to this request? ~~Yes~~ No

If yes, in what fiscal years?

What will you use the requested funds for? Please include goals and objectives.

Goal 1: Development of a program for predicting asthma attacks that learns to predict from data collected by the NIH by mining the associations between asthma triggers. This program will be used as the seed module for aMAP.
Goal 2: Development of miniature sensors for environment monitoring. These sensors will be used for collecting data needed for asthma prediction.
Goal 3: Development of an integrated system for predicting asthma attacks that combines the seed program and the information collected from the sensors and from the Internet.
Goal 4: Development of a self-management module for asthma patients for personalized data collection..
Goal 5: Integration of all modules to create the final product, aMAP.

Is this a change from previous years' use? ~~Yes~~ No

If yes, please describe the change and reason(s): Not applicable

Amount requested (Total amount, and amount for each program):

350,000 US$

What other sources of funding are applied to this purpose?

We have no other source of funding.

Name, title, telephone, email and mailing address of contact person:

Vicente Vargas, Office of Government Relations, 575-646-5190, v_vargas@ad.nmsu.edu, NMSU, PoBox 30001, Las Cruces, NM 88003

Date: 8/29/2016

COVER PAGE FOR NM TOBACCO SETTLEMENT GRANT APPLICATION

Project Title: **aMAP: Asthma Management Assistance and Prediction Using Mobile-Sensor Application**

Names	Affiliations
Principal Investigator: Son Cao Tran and Satyajayant Misra	Computer Science
Co-Principal Investigator: Jill McDonald	College of Health and Social Services

Total Budget Requested: US$ 350,000

Period of Performance Requested: Start___7/1/2017_____ End __6/30/2019_____

PROJECT SUMMARY:

The ultimate goal of this project is to create a mobile-sensor application that allows asthma patients to use their mobile phone or any device connected to the Internet to monitor and manage their asthma conditions. Tools for predicting asthma attacks and asthma self-management as well as enabling technologies that can utilize streams of data (e.g., weather, pollens, etc.) over the Internet will be needed to build such an application. Towards this end-goal we propose a six components research plan aimed at developing tools and enabling technologies. The six components will include: (*i*) identification of characteristics of asthma triggers; (*ii*) investigation of mechanisms for tracking and recording symptoms and medications of asthma patients; (*iii*) investigation of mechanisms for assessing the severity level of patients' asthma and predicting asthma attacks based on patient-specific triggers; (i*v*) research and development of sensors that will provide local environmental conditions feedback (e.g., air quality, humidity, etc.); (*v*) design and development of an integrated mobile-sensor application for asthma attack prediction and asthma management; and (*vi*) identification of functionalities that support communication with health care providers (HCPs) and allow asthma patients to effectively manage their asthma condition. The application will be the first of its kind in the domain and will result from a strong interdisciplinary collaboration between an asthma health policy expert and two computer scientists working on artificial intelligence, and learning and sensor technologies and Internet of Things. The holistic approach taken in the design and development phase will result in an application that will find broad-based use and appeal.

aMAP: Asthma Management Assistance and Prediction Using Mobile-Sensor Application

1. ***Specific Aims***

The main goal of the proposed research is to provide asthma patients with a mobile-sensor and personalized monitoring and management application that helps minimize the impacts of asthma attacks. To achieve this goal, we propose a six components research plan aimed at developing tools and enabling technologies for (*a*) assessing and monitoring asthma severity level and predicting asthma attacks; and (*b*) eliminating asthma triggers in combination with treatment of comorbidities that impact asthma. The six research components include: (*i*) identification of characteristics of asthma triggers; (*ii*) investigation of mechanisms for tracking and recording symptoms and medications of asthma patients; (*iii*) investigation of mechanisms for assessing the severity level of patients' asthma and predicting asthma attacks based on patient-specific triggers; (i*v*) research and development of sensors that will provide local environmental conditions feedback (e.g., air quality, humidity, etc.); (*v*) design and development of an integrated mobile-sensor application for asthma attack prediction and asthma management; and (*vi*) identification of functionalities that support communication with health care providers (HCPs) and allow asthma patients to effectively manage their asthma condition. The proposed mobile-sensor application will focus on identifying and predicting asthma triggers that precipitate an asthma episode or flare-up, or cause the flare-up to get worse. By correctly predicting asthma attacks and identifying asthma triggers that can affect a patient, the application can alert the individual about potential problems, thereby improving the quality of care and significantly reducing the treatment cost (e.g., reducing the number of hospital visits). The proposed system can greatly benefit asthma patients and directly impact the well-being of patients' families.

2. ***Research Strategy***

Significance: Asthma is a chronic disease of the lungs, which may occur at any age, and is one of the world's most common long-term illnesses. Studies show that asthma in children is strongly related to secondhand smoke. For example, secondhand smoke can trigger an asthma attack in a child; children with asthma who are around secondhand smoke have worse and frequent asthma attacks; and more than 40 percent of children who go to the emergency room for asthma live with smokers. According to the Center for Disease Control and Prevention (CDC), since 1980 the number of asthma patients has been increasing at a rapid rate: 8.7% of the population in 2010 vs. 3% in 1980 (the number is especially large when accounting for the increase in US population in the meantime). This chronic condition puts substantial economic pressure on a huge number of patients, communities, and health systems. It costs the United States (US) more than $56 billion each year with more than 25 million people currently suffering from asthma. *Asthma is also a public health priority in New Mexico, with 9.6% of adults and 9.0% of children suffering from asthma. According to the 2014 NM Epidemiology Report, US $30 million was spent in 2009 for hospitalizations with a primary diagnosis of asthma, which are mostly preventable!*

Like other chronic diseases, asthma is currently incurable, but its symptoms can be controlled through quality health care, appropriate medications, and good self-management. Accurately predicting asthma attacks and correctly identifying potential asthma triggers in the surrounding environment are two of the most effective preventive measures, yet challenging activities, in the care for asthma patients. This calls for the development of tools and enabling technologies for the prediction and prevention of asthma attacks. As asthma is highly individual dependent, such tools and technologies must be able to learn to adapt to individuals and readily available everywhere a patient goes. The proposed research rests on the hypothesis that the Internet of Things (IoT), Big Data analysis, availability of massive public information strongly related to asthma (e.g., weather, pollen, air quality), and mobile technologies (e.g., sensor

network, mini-sensor) can be leveraged to develop the necessary affordable tools and technologies for predicting asthma attacks and identifying asthma triggers at the individual level.

Innovation: Current guidelines for asthma treatment focus on providing health care providers with information on how to effectively control asthma. They also stress that patients need to play an active role in asthma self-management in order to control asthma symptoms and prevent asthma attacks. For example, asthma patients are advised to keep an asthma diary, which keeps track of their asthma symptoms, medications used, and Peak Expiration Flow (PEF) readings to enjoy an "asthma free" life, by recognizing asthma attacks before they happen and getting them under control. Yet, predicting an asthma attack remains a task that completely relies on a patient's awareness as well as experience. Indeed, to the best of our knowledge, there exists *no automated mechanism* for predicting asthma attacks at the personal level. Our proposed research aims to address this urgent need. It will result in an integrated mobile application for asthma attack prediction and asthma trigger identification. The system consists of two components: a mobile application for predicting asthma attacks and asthma management and a battery-powered sensor for monitoring asthma triggers in the environment.

Approach: We plan to achieve the goal of the project with the following intertwined tasks: (*i*) establishment of identifiable characteristics of asthma triggers; (*ii*) development of software tools and device(s) for tracking symptoms and medications of asthma patients; (*iii*) development of tools for assessing the severity level of patients' asthma and predict asthma attacks; (*iv*) development of tools to improve communication with health care providers (HCPs) and allow asthma patients to effectively manage their asthma condition; (*v*) development of a mobile application that will provide local environmental conditions feedback (e.g., air quality, humidity, etc.); and (*vi*) development of an integrated mobile phone application for asthma attack prediction and asthma management. The approach is schematically illustrated in Figure 2. Each user will be equipped with the mobile application (on the smartphone) and the sensor (represented by the antenna). The application will gather information from weather and allergy related websites on the Internet (e.g., weather.com, weatherunderground.com) and also get information from the local environment sensor. The application will create a knowledge-base to learn the patient-specific triggers and other information, which will significantly improve prediction and forecasting accuracy.

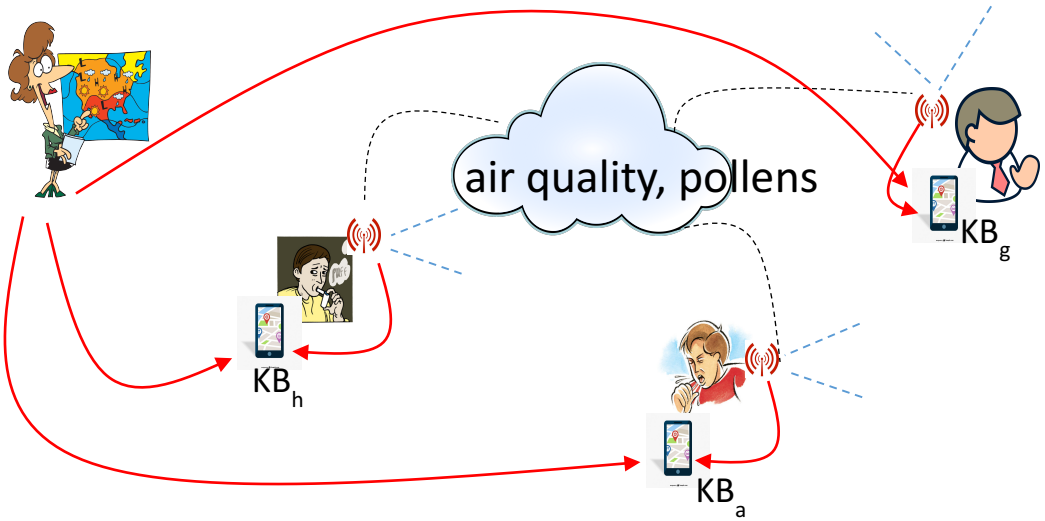

Figure 1 Schematic Diagram for use of the mobile-sensor platform.

We have published three research papers on the topic related to Tasks (*i*)-(*iii*). Specifically, a literature review on characteristics of asthma triggers has been completed and an initial research on the development of a tool for asthma attack prediction has been conducted. The current system is built using Deep Learning algorithm and Big Data analysis technologies and trained using data from the largest publicly available inpatient health care database (NIS 2012) and has an accuracy of 78%. Accuracy can be improved by training the system with data that contains location information. Funding provided by the grant will be used towards acquiring proprietary databases that contain such information.

To accomplish Tasks (*iv*)-(*vi*), we plan to build a miniature battery-powered sensor that is equipped to measure the air quality in the vicinity of the individual/patient (similar to the sensor developed by PI Misra shown in Figure 2). The sensor will be equipped to notify the patient through a built-in vibration alert that will be triggered by air quality values above tolerance threshold. It will also communicate with our mobile application on a mobile device using the Low-Energy Bluetooth technology. The application will provide more details, such as weather conditions, specifics on weather service allergy alerts in addition to alerts from the sensor. It will also provide historical location data along with allergen levels during the day or the last several days. This will result from coordination between the sensor and the application. The patient will be able to self-monitor the environment and correlate it with their asthma status. The PIs will work on developing the air quality measurement component of the sensor and the mobile phone application.

Figure 2: Miniature Sensor for Environment Monitoring

The research team includes Drs. Tran and Misra (CS) and Dr. McDonald (HSS) and is well-positioned for conducting the proposed research with expertise in Artificial Intelligence (Dr. Tran), sensor network (Dr. Misra), and epidemiology (Dr. McDonald). Dr. Tran is a leading expert in knowledge representation and reasoning, planning, and intelligent agents. He has published more than 130 papers in premier conferences and journals (e.g., AAAI, IJCAI, KRR, ICAPS, AIJ, JAIR). His publications have been cited more than 5500 times. His researches have been funded by NSF and DARPA. Dr. Misra's research interests include design and development of wireless sensors, anonymity, security, and survivability in networks and protocol design for these networks, the future Internet, and in supercomputing and smart grid architectures. He has over 50 peer-reviewed publications in several prestigious venues (e.g., ACM Transactions on Networking/Mobile Computing, INFOCOM, ACM Supercomputing). His research has garnered over 2300 international citations and has been funded by the NSF, DoD, and. Dr. Jill McDonald is the Stan Fulton Endowed Chair in Health Disparities Research and Director of the Southwest Institute for Health Disparities Research. She was also the assignee for the US-Mexico border region NCCDPHP. She has published over 50 peer-reviewed journal articles, which have been cited over 3100 times. Her research was funded by several federal agencies including the NIH.

The proposed work is for a duration of two years. We expect to continue with our preliminary research between now and the start of the project to continuously improve our asthma attack prediction component by investigating alternative machine learning algorithms. We expect to obtain a system with an accuracy of 85-90% and the initial prototype of the sensor by the end of the first year of the project. The development of the mobile application as an integrated system will be completed in the second year along with iterations to improve the hardware.

3. ***Budget***

The total budget requested is 350K. The funds will be used to support PI research during the summer (1 month) for PIs Tran and Misra and 0.5 academic calendar month for PI McDonald. The funding will also be used for supporting 2 graduate students for 20 hours/week and a post-doctoral scholar. Their duties will include: (1) assisting in the research activities associated with this project and (2) conducting graduate-level research to achieve the objectives. Funds are also requested to support the tuition fees of the graduate students.

Funds are also requested for the purchasing of laptop computers to run the tests, the sensor hardware and supplies for creating the sensors to measure local conditions, and servers for running the iterative learning algorithms and to store data. Funds are also requested for the acquisition of anonymized healthcare data for the development of the initial predictor and materials for building the sensors. Funds will be used to recruit participants for the project's evaluation.

Some of the funds will also be utilized to support trips by the students and the investigators to attend national and international conferences in healthcare informatics, data science, IoT and wireless technologies, and artificial intelligence.