

# Physiological Monitoring for Childhood Asthma

National Science Foundation: REU Sensor, Signal and Information Processing Devices and Algorithms

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**Abstract**—Asthma is the leading chronic childhood disease that affects seven million children in the United States. Currently, there is not a simple scientific method of continuous monitoring of physiological or environmental conditions of asthma patients. The purpose of project is to create a wearable device to connect human patients and the environment. This will be done by creating a Human-in-the-loop Cyber Physical System. These COTS-sensors will be used to create a pilot system. The pilot device will provide valuable data that will help implement the goal of an integrated health care device that enables patients to identify stressors and manage treatment. The data collected by the device will enable correlation of symptoms with environmental markers. The device will enable patients to track and optimize treatment plan.

**Key Words:** Asthma, integrated healthcare device, environmental aggregates, ozone, particulates

## I. DESCRIPTION OF PROJECT

Asthma is a chronic disease that causes inflammation of the airways and increases the production of mucus in airways. Due to the inflammation and mucus, the airways are extremely constricted which leads to shortness of breath, wheezing, and in some cases mortality. [1] As of 2015, the current number of children who suffer from asthma in the U.S. is 6.2 million, which is approximately 8.4% of the total adolescent population [2]. Asthma is considered one of the most prevalent chronic diseases in children and is the cause of over 10 million missed school days per year [3]. Asthma also has a large financial cost to American families, who spend approximately 56 billion dollars per year. Currently there is no easy way for children to monitor physiological responds to the environmental stressors such as airborne particles and ozone. The purpose of the project is to design an integrated health care device that will enable patients to identify stressors and management treatment.

The wearable devices will ideally have six sensors [4]. Three of the proposed sensors will monitor the environmental condition, such as, temperature, particulate and ozone concentration. According to the Environmental Protection Agency (EPA) particulates of PM 2.5 and PM 10 such as dust and smoke are significant respiratory aggregates [5]. In order to detect particulates a dust sensor that uses physical size exclusion filters and optical sensing will be integrated into the device [4]. Ozone, which is also known as smog, has been classified as a pollutant that has significant affects asthma suffers. In order to detect the ozone concentration in an environment, the device will have a molecular sensor that will use Chemically-sensitive Field Effect Transistors (ChemFETs). The dust sensor and ozone sensor accuracy is dependent on temperature, therefore, a LM35 temperature sensor will be installed on the device. With the wearable environmental monitors, asthma sufferers will be able to determine, in real time, if a particular area is safe and what environmental aggregates trigger negative physiological response [4].

The device will have three physiological sensors that will help identify patient specific environmental stressors [4]. A pulse oxygen (SpO<sub>2</sub>) sensor, which will detect the level of oxygen in the blood by optical and flexible fluoroscopy, will be incorporated into the device [4]. The SpO<sub>2</sub> level is an important indication of lung health, if the level is low than this indicates an obstruction of the airways [6]. The patient's galvanic skin response (GSR) will be monitored using electrochemical impedance spectroscopy [7]. The GSR is important in determining that amount of physiological stress a patient is under [7]. A force expiratory volume (FEV) detection device will be installed in the wearable systems by using a flip straw, similar to a water bottle, and force sensors [4]. FEV measurements are important to evaluate because FEV measurement will help determine if the patient is experiencing respiratory distress [8]. The goal of all the sensors is to help identify patient specific stressors and give consumers the power to manage and optimize asthma treatment.

By the end of the nine-week REU session, six COTS-devices will be assembled and environmental data will be collected and interpreted in order to maximize device design.

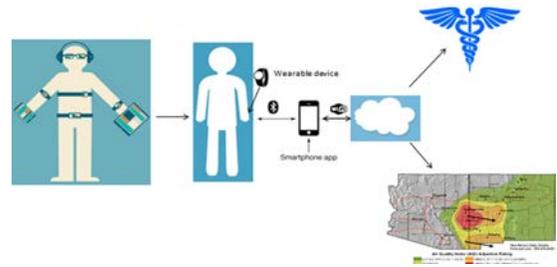


Figure 1: Diagram of how the wearable device will share data with patients, healthcare providers, and environmental maps.

## References

- [1] What is Asthma . (2014, August 4). Retrieved June 7, 2017, from [//www.nhlbi.nih.gov/health/health-topics/topics/asthma#](http://www.nhlbi.nih.gov/health/health-topics/topics/asthma#)
- [2] What is Asthma . (2014, August 4). Retrieved June 7, 2017, from [//www.nhlbi.nih.gov/health/health-topics/topics/asthma](http://www.nhlbi.nih.gov/health/health-topics/topics/asthma)
- [3] United States Environmental Protection Agency. Asthma Facts. March 2013. [http://www.epa.gov/asthma/pdfs/asthma\\_fact\\_sheet\\_en.pdf](http://www.epa.gov/asthma/pdfs/asthma_fact_sheet_en.pdf). (Retrieved April 7 2015)
- [4] Blain-Christen, J., Ross, H. M., & Ozev, S. (2017). CPS: Medium: Air Care - Environmental and Physiological Monitoring for Childhood Asthma NSF 17-529. Tempe, AZ.
- [5] . Particle Matter Basics. (2016, September 12). Retrieved June 7, 2017, from <https://www.epa.gov/pmpollution/particulate-matter-pm-basics#PM>
- [6] Patent Information Series. (2011). Pulse oximetry. Am J Respir Crit Care Med, 184, P1.
- [7] T. Luo, L. Li, V. Ghorband, Y. Zhan, H. Song, and J. B. Christen, "A portable impedance-based electrochemical measurement device," Proceeding of the 2016 International Symposium on Circuits and Systems, 2016
- [8] A. Baptist and G. Sanders, "Pulmonary Function Tests (PFTs)," Resident and Medical Student Online Syllabus, 05-Mar-2005. [Online]. Available: <https://www.med.umich.edu/intmed/allergy/edu/syllabus/TOPICS/PFTs/pft.htm>. [Accessed: 20-Jun-2017].

