A Non-invasive device and automated monitoring system using peak flow meter for asthma patients

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Abstract—

Our propose system is a Non-invasive device and automated monitoring system to assist patients and healthcare provider in tracking the patient condition. Asthma patients need to constantly perform self-monitoring at home using a device called "peak flow meter". The device results are recorded during a period to be reviewed later with a doctor. The application uses the collected PEF scores and determine the patient's status, then shows recommendations based on the action plan. The system also implements machine learning (ML) to predict if the patient will decline then sending him alerts, it also helps the patient adhere to his treatment plan by reminding him of his medications times and recording if he took it.

Keywords — Mobile Application •Asthma• Triggers• Symptoms • Peak Expiratory Flow • Peak Flow Meter• Action Plan.

I. INTRODUCTION

Asthma disease is affecting the lives of more than 300 million people worldwide, and by 2020 this number could go up to 400 million patients [8]. It is a common long-term reversible inflammatory disease that affects the lower respiratory tracks airways of the lungs by causing swelling in the airways which in return makes it hard for the patient to breath, and the causes of that vary, from triggers such as breathing cold air, extreme exercise, pets, air pollution to other causes such as genetics and the environment as well [2].

Asthma is a preventable disease and in order to do so, the patient needs to adhere to specific procedures and medication to help him in self-managing his condition.

In addition, for prescribed medication and procedures to be effective, the patient must do his part accordingly and stick to the doctor's orders,

because poor self-management will lead to severe asthma condition and an escalation in the disease condition. The proposed solution is a system that is connected to a hardware device called "peak flow meter" that is used to assess the pulmonary function of the patients to monitor their asthma from home. Based on the device scores, an action plan will be devised and a medication prescription. The system named "Breathe" will help the patient stick to his action plan, as the main purpose of the system is to deploy compliance and adherence to stop the patient's condition from escalating. Many other features will be added as well, such as making sure the patients are adhering to their daily treatment plan by reminding them of the medication time.

Moreover, to ensure the success of the study and the guaranteeing accurate results, the study participant sample will be of four categories which is based on asthma disease classification which are a healthy person, Intermittent asthma patient, Moderate asthma participant, and patient with severe asthma, with varying ages starting from 18 years old.

In conclusion, this system will use machine learning to predict the patient's condition periodically if his condition is declining and will display an alert message showing the possible reasons for his status and the importance of going to the hospital. This machine learning will be built by collecting information from the patient and based on this information the prediction of his status will appear, this helping the patient in maintaining his condition.

II.   LITERATURE REVIEW

A.   Monitoring

Asthma is a preventable disease and in order to do so, the patient needs to adhere to specific procedures and medication to help him in self-managing his condition. In addition, each patient is different in their asthma condition and will probably need different care and medication. However, the patient's capability to monitor their conditions at home lies with exploiting personal medical assistants and e-health technology, the latter it is a very important and promising trend in contemporary medicine. Chronic illnesses such as asthma requires permanent home monitoring over some period. Self-monitoring of lung function is the preferred action that helps physicians and asthma patients to control the disease jointly.

The doctor's diagnoses depend on his understanding of the patient's condition from what the patient is telling the doctor about his state and the doctor's observations of the patient's symptoms. But this may not be enough to provide a doctor with all the needed information to understand the patient's case because the patient may not remember all the occurring events that could have affected his health [10]. As a result, the need for remote monitoring systems is crucial to help doctors in understanding patient's conditions and progress to be able to correctly diagnose their patients before their symptoms get worse.

B.   Asthma Management Systems

This section focuses on looking through various asthma management systems in the market and listing the beneficial services they provide for asthma patients around the world.

- *Breath Count asthma system*

Breath Count is an application that available worldwide for people with asthma or COPD who are using a peak flow meter device to help them keep a record of their condition and manage it. The main process of this system is that a patient must enter Peak Expiratory Flow scores after using the peak flow meter device, and based on entered scores the system will identify a patient's condition. In this system there is no prediction feature for the patient's condition if it's declining in advance [6].

- *Kegan Air Application*

Kegan air is an interactive free application that's designed for asthma patients to keep track of their health condition. It offers the patients some questions to answer and based on the answers the application can give the patients the weather and the environmental factors around them that may cause asthma symptoms to manifest as a result, the patients will contain his condition and will avoid triggers easily. Regardless of these features, Kegan air has some unsupported features, for example, in case of measurement it doesn't take peak flow meter inputs, also in the management side it doesn't have an action plan, nor does it include emergency instructions for the patient [5] [9].

- *Smart peak flow meter system*

This system uses a smart Peak Flow device connected to the phone by the audio jack found in any smartphone model, it started in 2014 and developed over the years till 2017 it helps asthma patients by monitoring their condition on regular bases and it measures changes in the airflow and the result is categorized into a different zone. For each

zone, the patient is advised based on his condition with the appropriate medical advice. The scores are displayed in a chart to read easily and monitor changes in a better, understandable way. The charts could be shared with a medical physician as PDF file to get a recommendation. The patients are reminded to use the peak flow meter every day to make sure they are keeping up and improving [4]. In this system the doctor cannot monitor his patients periodically, and not enough to ensure the patient adherence to his recommendations.

- *Asthma Pal Application*

The Asthma Pal application is about predicting the risk of an asthma attack, which is the main purpose of it. The application offers a feature that gives information about the risk of the next asthma attack that may occur, also it provides a customized training plan for the patients that exercise this feature is a significant part of the application as the training improves the condition of the patient health in the long-term. This application does not provide an action plan that can assist patients in keeping track of their health and medication doses. Furthermore, it doesn't offer emergency instructions to the patients [3].

- *Wing Application*

Sparo's Wing is a smart modified device for asthma patients supported with an application that helps in measuring lung function. This application will specify the patient status in which zone (Reed/Green/Yellow) and give him appropriate instructions, this will enable the patient to detect his status declining earlier and help him to do the right action to prevent the asthma attack. [7]. The main drawback of this system is it's only sold and used in the United States.

- *FindAir Application*

Find Air system consists of small hardware that attaches to the patient's inhaler, this hardware contains a smart sensor that helps in collecting the data for each use of the inhaler. This hardware will be connected to the application via Bluetooth which will allow the patient to view and analyze the collected data. [11]. The application lacks some crucial features that could help patients such that, there is no record for the patient Peak expiratory flow value that could help the patient see the true progression of his condition

- *Asthma Storyline Application*

Asthma Storyline is one of the applications that help in self-monitoring asthma conditions, it's sponsored by the Allergy &Asthma Network. Asthma Storyline is free of cost and it allows the patient to monitor his health by storing the medication information and receiving alerts as a reminder for daily doses. in addition to recording his daily symptoms and mood, it also keeps tracks of PEF scores reading from the peak flow meter device and checking his action plan [1]. This application has some disadvantages, it doesn't send an alert to the patients in case of bad weather or about his declining condition it is used only in the United States and isn't available in other countries.

III. PROPOSED SYSTEM METHODOLOGY

A. The System Structure

"Breathe" system is connected to several applications and API's to reduce the user input in the system, thus improving the user experience. It's dependent on the weather and pollution API's. This system will help users in their day to day life. Figure 1 illustrates the overall architecture of the system.
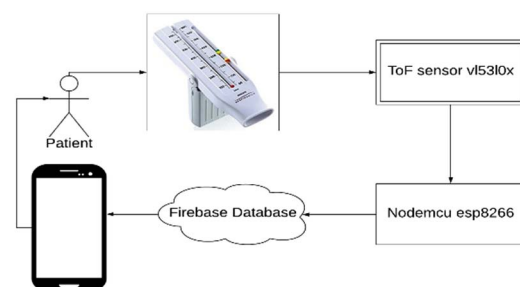

Figure 1 System Architecture

The user blows into the peak flow meter device, then the PEF score is picked up by the laser sensor and stored in the NodeMCU that uses the ESP 8266 chip to transfer data into the Cloud. Finally, the score is retrieved by the application and displayed to the user along with other features.

- Hardware

Breathe system is going to use peak flow meter device with a hardware that uses NodeMCU an open source IOT platform that contains an integrated ESP8266 chip that provides a Wi-Fi connection access points for the system to communicate with cloud. The platform is connected ToF (Time of Flight) distance sensor, that uses a laser to measure the distance. And a breadboard power supply module connected to a battery. The NodeMCU is programmed to send data to the database server is managed by the underlying cloud server "Firebase".
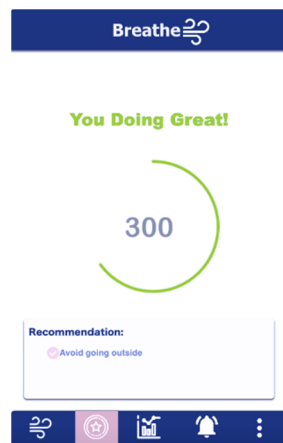
- Mobile Application

Figure 2 Score Interface

The plan for this system is to develop a mobile application for android platform. It's the interaction point between the system and the user that enables him to perform the functionalities of the system efficiently and effectively. Each interface is intended to be developed with the consistency, smooth navigation, and high security in mind. The application will collect the users PEFR scores, symptoms, and possible triggers to provide him his condition chart and provides information for the machine learning model inputs. In addition to providing the user daily reminders of his medications and appointments.

- Machine Learning Model

The system will contain a machine learning model that it's binary classification. The model is built using python integrated into the mobile application and it will periodically check the patient status based on the given indicators provided from user , and based on that it will make a prediction of the user's condition if it's is declining, then the system will display an alert message as a dialog showing the possible reasons for his declining condition and show them the importance of going to the hospital.

IV.   CONCLUSION

This paper was conducted to introduce the proposed idea of an asthma monitoring system (Breathe). The system purpose is to help asthma patient adhere to their medication and doctor's instruction, thus stabilizing their condition and minimizing the overall costs of disease. The system uses a non-invasive device and is designed to track and monitor the patient condition using a modified version of the Peak Flow Meter which measures the patient's PEF

scores to determine the airways degree of obstruction , these results are to be shared with healthcare providers and to be procced in the application.

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