



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

# IJIRSET

International Journal of Innovative Research in  
**SCIENCE | ENGINEERING | TECHNOLOGY**

# INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 10, Issue 12, December 2021

**ISSN** INTERNATIONAL  
STANDARD  
SERIAL  
NUMBER  
INDIA

Impact Factor: 7.569

9940 572 462

6381 907 438

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# Non Invasive Device to Measure and Monitor Lung Capacity

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**ABSTRACT-** In this current scenario during the pandemic like asthma, copd (chronic obstacle pulmonary disease) and the current viral disease like covid-19 has been growing rapidly across the world, this disease directly affect the lungs. During this scenario we use spirometer which measures the lung function to diagnose various respiratory illness by injecting the mouthpiece into our mouth which brings abdominal pain for patients, facial exacerbated by a mouth and stress incontinence for the patients [1]. The goal of our project is to design a low cost device based on pulmonary lung function analyzer by FEV/FVC ratio wrt non invasive method that the patients can take the test with less efforts where they need not put the mouth piece in their mouth and accurate results are obtained that are in agreement between the measurement result and actual value. In this device the flow meter is connected to BMP280 sensor, which detects the pressure with which we are blowing. After the data is taken from bmp pressure sensor, It is sent to Node MCU ESP8266 which is a wifimodule, built along with microcontroller unit that is interfaced with android app known as BLYNK(legacy), through the embedded C programming language. These values are sent via wifi module to the mobile app as mentioned in the block diagram (given below). Finally the result is obtained at Blynk app that displays your percentage of our lungs. This work in faster response and any number of test can be taken by not going to doctor, by using this device. This process of application was tested for several people as shown in the diagram, so this project encourages easy and reassuring use and to design a low cost device that are used for routine respiratory health checkups.

**KEYWORDS:** Node MCU, BMP280 PressureSensor, Blynk(legacy)

## 1. INTRODUCTION

This pandemic COVID-19 has made us realize that we not only have to take care of the external parts but also the internal organs too. One of the internal organs, the lungs play the most vital role and needs to be given special attention specially in these hard times. The main role of lungs is to bring in air from the atmosphere and pass oxygen into the bloodstream. From there, it circulates to the rest of the body. Help is required from structures outside of the lungs in order to breathe properly. To breathe, we use the muscle of the diaphragm, the intercostal muscles (between the ribs), the muscles of the abdomen, and sometimes even muscles in the neck. The diaphragm is a muscle that is domed at the top and sits below the lungs. It powers most of the work involved in breathing. As it contracts, it moves down, allowing more space in the chest cavity and increasing the lungs' capacity to expand. As the chest cavity volume increases, the pressure inside goes down, and air is sucked in through the nose or mouth and down into the lungs. As the diaphragm relaxes and returns to its resting position, the lung volume decreases because the pressure inside the chest cavity goes up, and the lungs expel the air. COVID-19 is a respiratory disease, one that especially reaches into your respiratory tract, which includes your lungs. COVID-19 can cause a range of breathing problems, from mild to critical. Older adults and people who have other health conditions like heart disease, cancer, and diabetes may have more serious symptoms. A major issue with COVID-19 is with gas exchange in the alveolus. There is a very tight connection between the alveolar epithelium (type-1 cells) and the capillary. COVID-19 infects AT2 cells, kills them and floods the alveolus. In addition, there is evidence for micro thrombosis, which may block the vascular side. Clinically, this may appear as several conditions: severe bronchopneumonia, acute respiratory distress syndrome (ARDS) or sepsis. Pneumonia is inflammation and fluid in the lungs, making it difficult to breathe. Patients can experience shortness of breath, fevers and cough, which can be productive. More severe inflammation can lead to ARDS, which can require significant treatment including the use of oxygen therapies,

including mechanical ventilation or even extracorporeal membrane oxygenation (ECMO), which is a lung bypass machine that oxygenates the blood. If a patient develops this severe of a syndrome, this can lead to longer-lasting effects on the lungs, such as fibrosis (scarring of the lung). Sepsis is a syndrome of abnormal inflammation that usually results from infection. It can lead to multiple organs not working in a coordinated fashion. This syndrome can require support for failing organs, and thereafter, have a lasting impact on their long-term functionality.

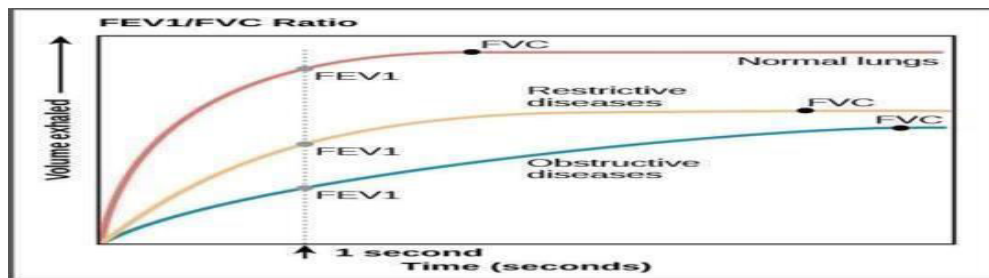


Fig. 1 Average value for FVC and FEV1

According to studies and reports from medical centers, for a normal healthy adult, the desired lung capacity is 6 liters. At rest, a man can hold up to 1.5 pint of air which is nearly equal to 750CC (cubic centimeter), while woman can hold up to 0.8 pint which is nearly 400CC (cubic centimeter), which means, most of us do not use full lung capacity. The normal ratio value of FEV (forced expiratory volume) / FVC (forced vital capacity) is 70% for an adult and 65% for people aged above 65 years (as shown in above graph)[2].

## II. OBJECTIVE

To study lung capacity in subject with the respiratory disorder by building an affordable device with sensors. To use Arduino to detect the lung capacity and to alert the concerned about it. To provide real-on-time analysis and to provide medical opportunities in remote areas and device can be used in patient's home for routine respiratory health checkups.

## III. PROBLEM WITH EXISTING SYSTEM

There are devices like Spirometer to check the lung capacity of a person, but the results are not much accurate and need several trails, where the Individual will have to attend to a doctor's presence. Not can everybody afford a Spirometer for themselves to stay back at home and test for themselves. A Spirometer has a blower to which we need to put our mouth around it in order to blow for the test, which is not advised for we can be infected by germs or even viruses since many people take the test with the same device. Spirometer test asks individual to blow as harder as they can, whereas those with active tuberculosis and history of syncope or increased risk of pneumothorax can cough blood (hemoptysis), hence should avoid testing using spirometer.

## IV. SOLUTION FOR THE PROBLEM

SMART BREATH (NON-INVASIVE DEVICE TO MEASURE & MONITOR LUNG CAPACITY) is to be developed based to efficiently monitor the lung capacity and compare the data via LTE (long term evolution) in real time and also which allows us to download and save information much faster for early diagnosis. The device will be provided with a pressure sensor onto which the individual will blow air. He/she will first need to take in a deep breath and later gently exhale onto pressure sensor. The pressure sensor will take in the necessary readings and will forward it to the processor which will calculate based on the readings and will compare with the ideal readings and will provide with the output onto an LCD/LED display. The device will enable any individual to detect his/her lung capacity and the sensors in the device will alert them in case if the data shows warning signs. If the FEV/FVC is 50%, the device will alert the individual about it and if it shows much lesser percentage i.e., below 33% the device will send warning alerts to him and his concerned. The device can also be integrated with android since most of the people have android phones and devices to which alerting text messages can be sent using wifi module.

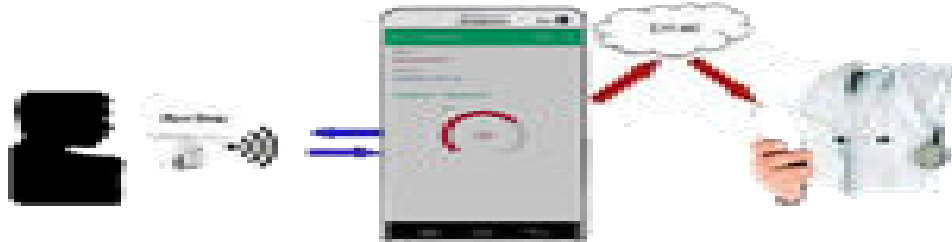


Fig 2 Non-Invasive Device to Measure & Monitor Lung Capacity

### V. DESIGN AND IMPLEMENTATION

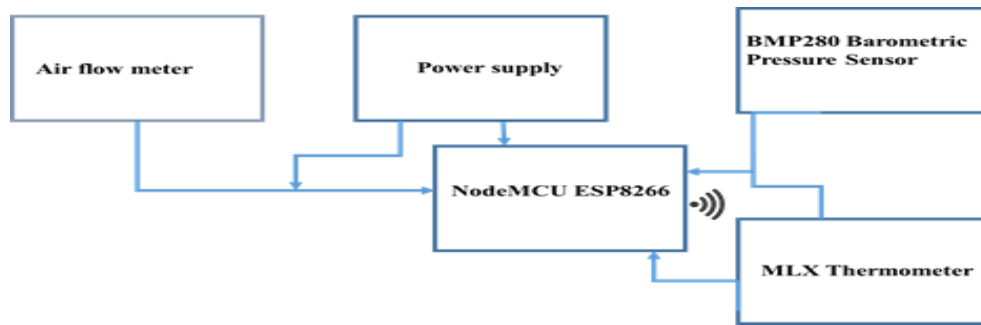


Fig 3:Block Diagram Of Smart Breadth

Microcontroller based non invasive electronic device, interfaced with android app known as BLYNK (legacy), through the embedded C programming language. The hardware part consists of the pressure sensor. Bluetooth module and NodeMCU ESP8266, MLX90614 Infrared Thermometer module, Air flow meter, Power adapter. In Android applications ("BLYNK") can be downloaded from the Google Play store, which features over 2.7 million apps as of February 2017. Android application is developed to receive the data and displays the results in terms of sensor values. The aspect of the android application involves wirelessly receiving data from the system. The Bluetooth transmitter module was programmed to transmit packets of data. The primary metrics used for diagnosing pulmonary illnesses are FVC (Forced Vital Capacity), representing the total volume of air exhaled, and FEV1 (Forced Expiratory Volume in 1 second), representing the amount of air that can be exhaled in the first second. The ratio FEV1/FVC is used to measure the obstruction in the airway. Based on regression equations stated in Hankinson et. al, 1999, the expected FVC and FEV1 values are calculated and compared to the actual values to distinguish between the illnesses. The Lung function Evaluation done using the Smartphone Application includes the parameters such as Name, age, gender, height in inches, Smoked years, Significant air pollution. The Chronic Obstructive Pulmonary Disease can be predicted based on the range. When the user blows through flow meter it detect the FEV valve by using air flow meter. From the flow meter it is connected to BMP280 sensor (Digital barometric pressure sensor), which detects the pressure with which we are blowing and the amount of air we are blowing. After the data is taken from bmp pressure sensor, it is sent to NodeMCU ESP8266 which is a wifi module, built along with microcontroller unit. This values are sent via wifi module to the mobile application (BLYNK). Apart from this, the function of infrared sensor is to detect the temperature of our body. Finally the result is obtained at Blynk app that displays your percentage of lung capacity and body temperature (as shown in Fig3).

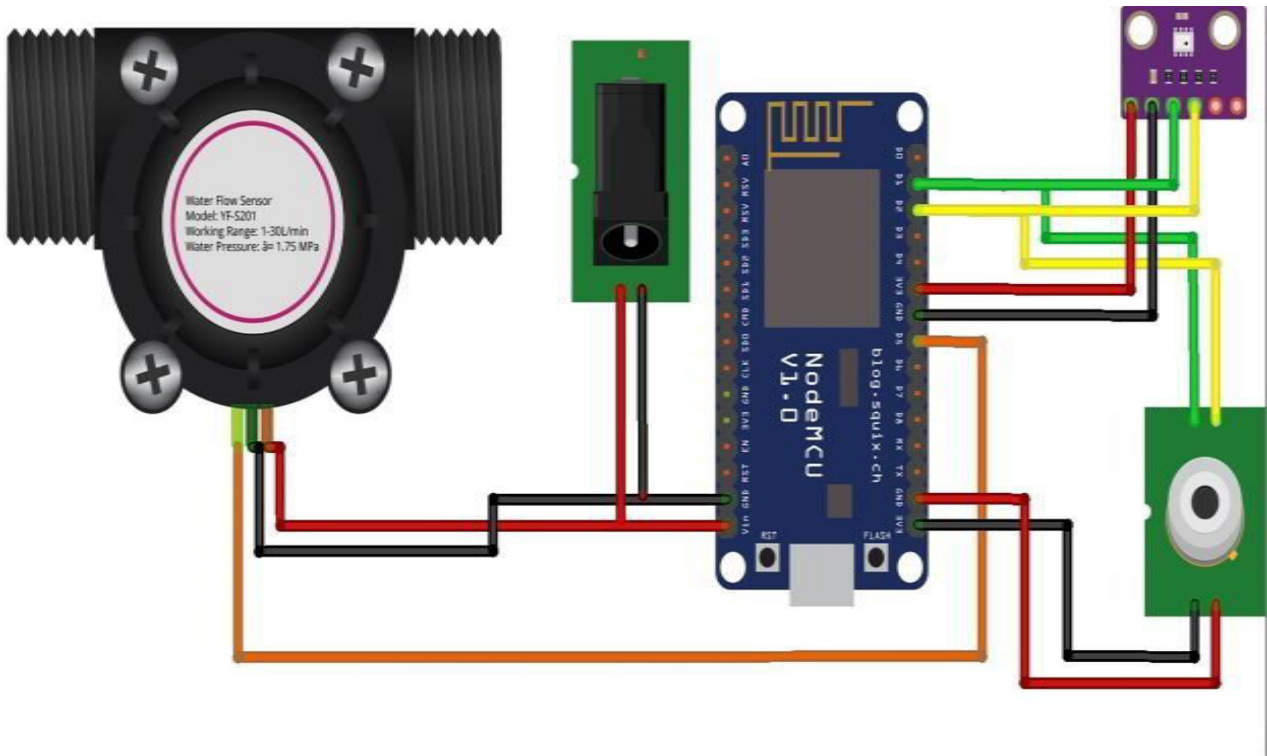


Fig 3a: Circuit Description

The Arduino Microcontroller (NODEMCU) works at 2 voltages 3.3V at 8 MHz and 5V at 16Mhz. 3.3Volts is supplied from the microcontroller to the VCC of the pressure sensor. The I2c communication lines of the sensor SDA and SCL are connected to the A4 and A5 pins of the microcontroller. XCLR and EOC pins are not used. The ground pins are connected. Then a voltage supply of 5V is fed to the Bluetooth module from the microcontroller. The TXD pin of the microcontroller is connected to the RXD pin of the Bluetooth module and RXD pin of the Microcontroller to TXD pin of Bluetooth module.

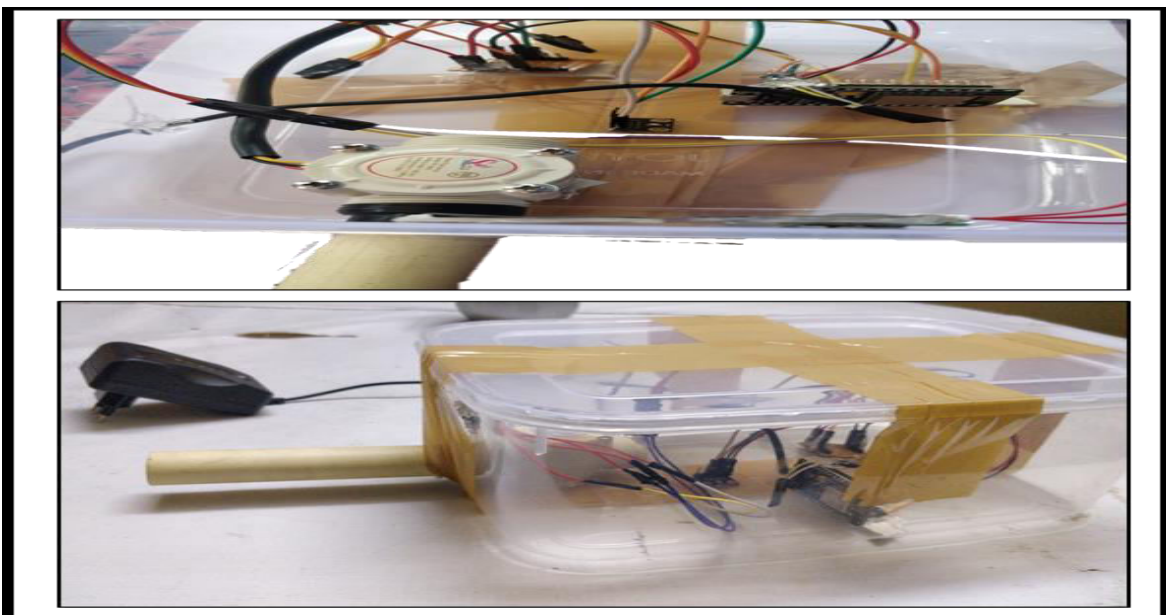
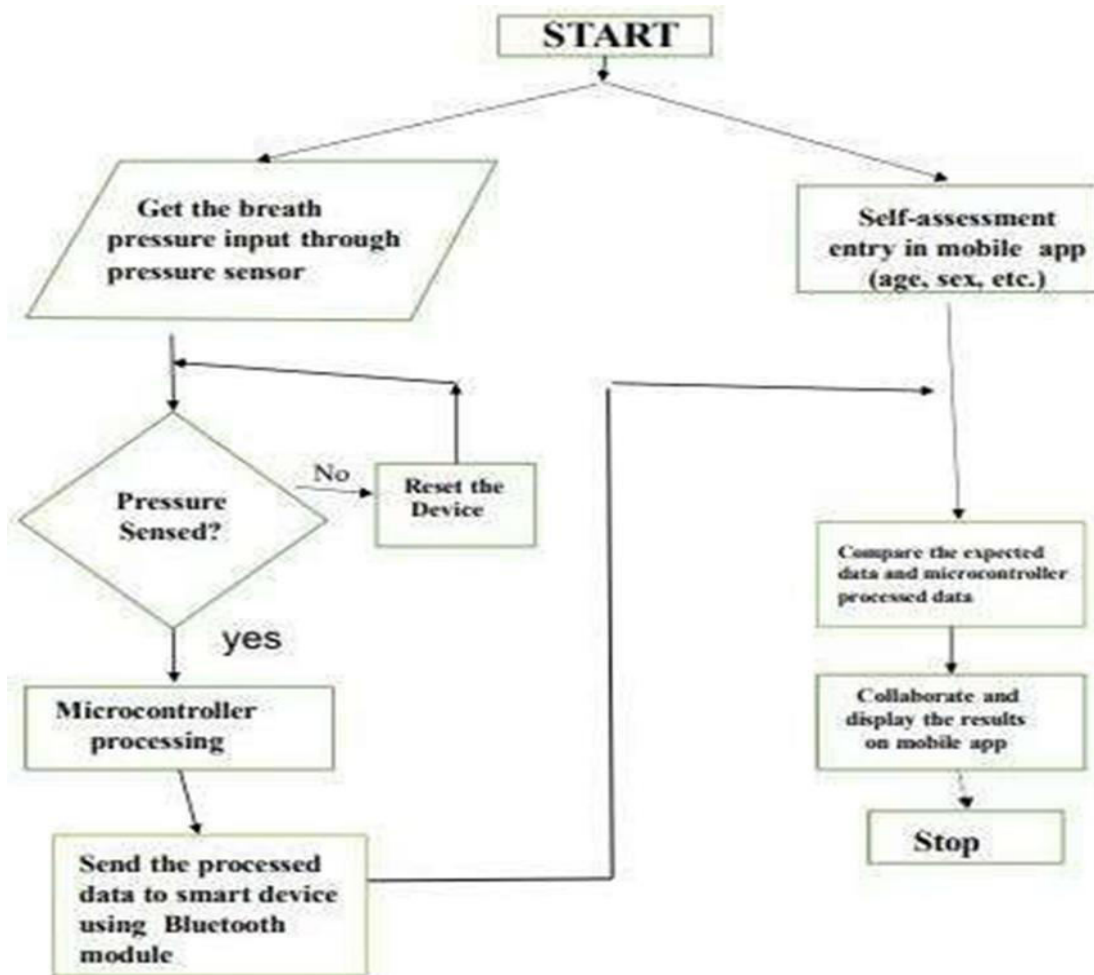


Fig 3b:Implementing the device

**VI. FLOW CHART OF THE SYSTEM**



**Flow Chart**

Fig 3c: Flow Chart of Smart Breath System

In the first step we need to enter the self-assessment of the person. After entering the database, the patient has to blow through the pressure sensor, the pressure sensor senses the air blown by the patient. This data is being fed to the system which is processed by the microcontroller. The data which is processed is transferred to the smart device which displays the data as graph. After this test the person has two options they are as follows:

If the person wants to update it to cloud then he can upload the same results to the domain specified, by creating his profile on the domain and save his data.

If the person wants it to be saved in his mobile then he can choose that option and save the results in his mobile.

**VII. RESULTS AND DISCUSSION**

This chapter depicts the technical outcome of the work. After design and implementation of proposed methodology, the implemented design has to be tested and verified. Hence, this chapter contains the results collected in response to the objectives. The steps involved in lung Function Evaluation

The breath pressure input is given to the 3D-printed Spirometer Shell and the digital pressure sensor (BMP085) is a self-converter and thus converts the Analog data to Digital data. The received data is fed to the Arduino microcontroller and further data is processed in the microcontroller and pairing the device by wifi module in Node MCU ESP8266 and



Begin the test.

Now compare the expected and actual values for FVC and FEV1 by using the ratio of FEV1/FVC.COPD prediction is done. Sensorvalues are displayed in the final step.

GOLD Criteria for COPD Severity (FEV <sub>1</sub> /FVC <0.7)	
Stage I: Mild	FEV <sub>1</sub> 80-100% predicted
Stage II: Moderate	FEV <sub>1</sub> 50-79% predicted
Stage III: Severe	FEV <sub>1</sub> 30-49% predicted
Stage IV: Very Severe	FEV <sub>1</sub> <30% or <50% with right heart failure

Fig 4: COPD Prediction by FEV1/FVC Ratio

Given below are the results obtained when an asthma patient blows into the mouthpiece that the patient’s condition . The same results are also obtained in other devices when the patient blows into the mouth piece and tells whether patients condition are normal or abnormal, if they are abnormal patients would be motivated to take next breathing more effectively. This leads to increase in the oxygen percentage in blood level[4].

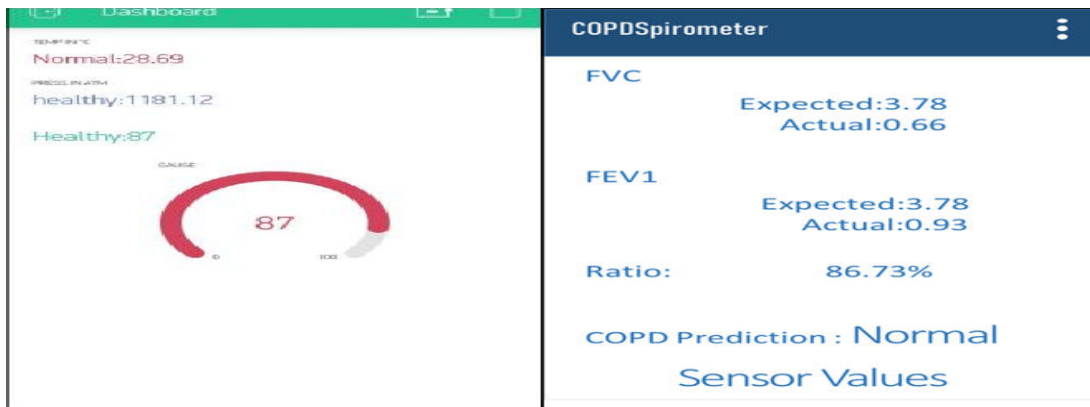


Fig 4a: Comparison of our device and existing device when the patient’s condition is healthy

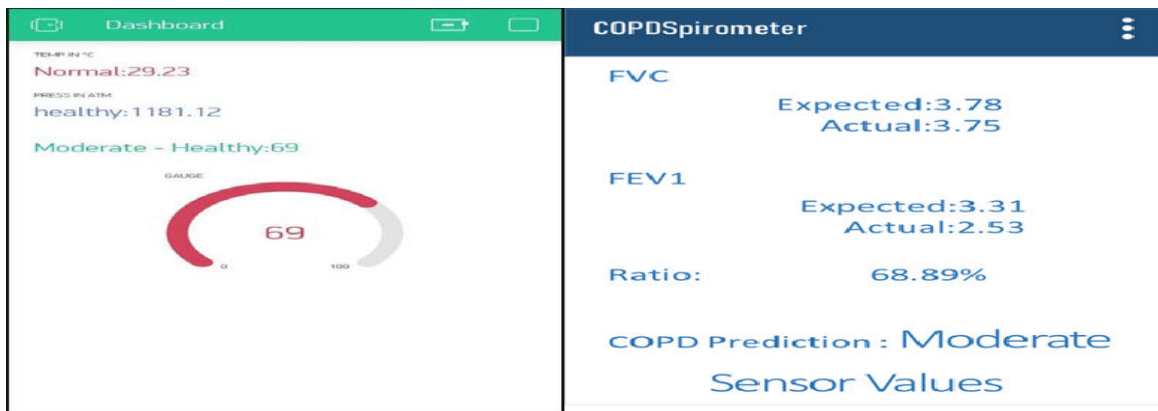


Fig 4b: Comparisons of our device and existing device when the patient’s condition is moderately healthy

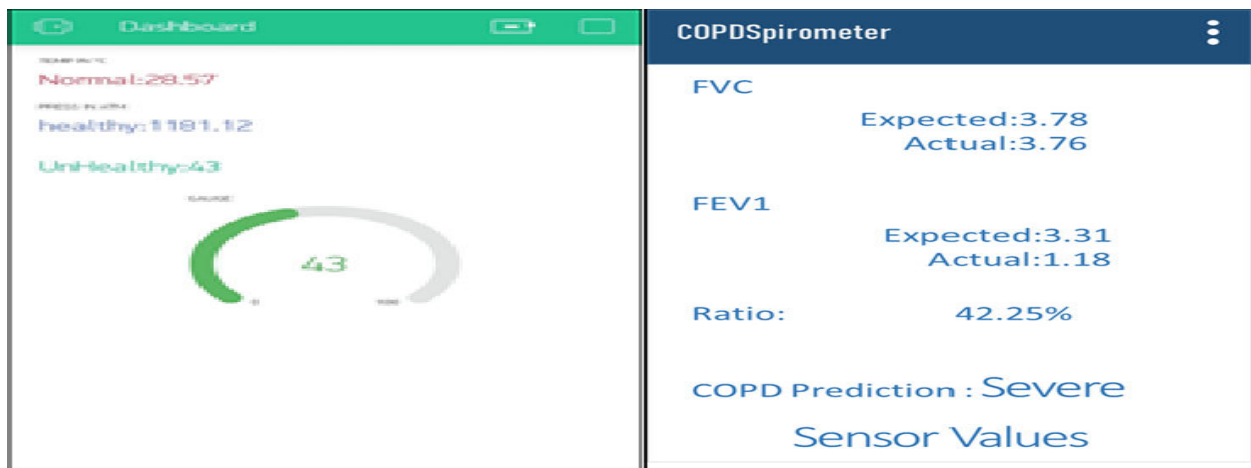


Fig 4c: Comparison of our device and existing device when the patient’s condition is severe

Now the tests are taken for the following 10 patients wrt to their age and height, meanwhile we compare the same test in existing device for the strong verification.

No.of patients	Age	Height(in inches)	Temperature( °c)	FEV1/FVC(%)	Status
1	22	69	33.65	69	Moderate healthy
2	24	68	28.69	87	Healthy
3	23	62	28.69	90	Healthy
4	23	65	28.47	91	Healthy
5	57	62	28.47	75	Moderate healthy
6	20	67	28.88	73	Moderate healthy
7	65	68	28.11	31	Unhealthy
8	21	67	28.59	96	Healthy
9	22	67	28.57	43	Unhealthy
10	63	68	28.71	68	Moderate healthy

Fig 4d: Test taken by our device



Sl.No	Age	Height (inches)	FVC	FEV1	FEV1/FVC (%)	Status
1	22	69	Ex:3.78 Ac:3.72	Ex:3.31 Ac:2.53	68.89	Moderate
2	24	68	Ex:3.78 Ac:0.66	Ex:3.78 Ac:0.93	86.73	Normal
3	23	62	Ex:3.78 Ac:3.75	Ex:3.31 Ac:2.12	91.33	Normal
4	23	65	Ex:3.78 Ac:3.60	Ex:3.31 Ac:1.53	89.99	Normal
5	57	62	Ex:3.78 Ac:3.77	Ex:3.31 Ac:1.55	74.56	Moderate
6	20	67	Ex:3.78 Ac:3.69	Ex:3.31 Ac:1.53	72.5	Moderate
7	65	68	Ex:3.78 Ac:3.75	Ex:3.31 Ac:1.92	33.1	Severe
8	21	67	Ex:3.78 Ac:3.76	Ex:3.31 Ac:1.18	95.55	Normal
9	22	67	Ex:3.78 Ac:3.75	Ex:3.31 Ac:2.45	42.25	Severe
10	63	68	Ex:3.78 Ac:3.77	Ex:3.31 Ac:2.56	67.09	Moderate

Fig 4d: Test taken by existing device by using expected and actual values.

### VIII. CONCLUSION

There are other methods that are employed in Hospitals to do the check-ups on respiratory diseases like Asthma and Chronic obstructive pulmonary disease (COPD) and current viral disease COVID-19. But they are very time consuming and costlier. When it comes to remote areas where the Doctors can't visit frequently, there exists the problem for the patients like this. They may not be able to go to the hospitals at the time when they have severe effects of these illnesses. Whenever the patient needs to check or whenever the doctors suggest for the test, they can make use of the simple and smart device that is designed for the check-up where they can send the data from wherever they are irrespective of time and place. Since the device is small in size, they can be carried with them [3].

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