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A SIMULATED WIRELESS MONITORING DEVICE FOR ASTHMATIC PATIENTS IN NIGERIA

Abiola Oluwatoyin B[1]
Department of Computer Science
Afe-Babalola University
Ado-Ekiti, Ekiti State, Nigeria
abiolatoyinbunmi@gmail.com

Adeyemo Oluwaseyi. A[2]
Department of Computer Science
Afe-Babalola University
Ado-Ekiti, Ekiti State,Nigeria
befittingcrown@gmail.com

Olatunji Kehinde. A[3]
Department of Computer Science
Afe-Babalola University
Ado-Ekiti, Ekiti State, Nigeria
odekunlekenny@yahoo.com

***Abstract*—Asthma is a common and potentially serious chronic disease that imposes a substantial burden on patients, their families and community. It causes respiratory symptoms, limitation of activity and flare-ups attacks that sometimes require urgent health care and may be fatal. This ailment has been identified as a threat to human existence, killing millions of people annually. Shortages of medical experts, hospitals and necessary equipment have been adjudged some of the prominent factors for the very high number of deaths associated with this ailment annually. This paper proposed a prototype monitoring system for managing asthma in Nigeria with a view to reduce poor communication gap between health-care providers and patients. The simulation describes hardware device which will be developed in a way to accept vital signs and symptoms. Once these signs are collated, they will be sent to the hospital centralized server and eventually to health-care givers for necessary attention. A set of patients and clinical sensors will be used to monitor patients. The simulated design was carried out using tools such as Microsoft visual studio, Dot Net framework 2010. If this simulated wireless monitoring device is implemented in real time, the rate of asthma attacks will reduce thereby reducing the rate of death resulting from the ailment, there will also be reduction in regular visits to the hospitals by patients.**

Keywords—Wireless Sensor network, Asthma, Monitoring Device, Patients, Clinic.

I. INTRODUCTION

The invention of patients monitoring system has been very important even to the fitness industry and as well as an aid to living a healthy lifestyle. Today, many treadmills and elliptical machines often have these monitors built in them to check the rate of heartbeat at any given time. These monitoring devices are also very important to cyclists and athletes because it prevent them from over training or under training. Health care systems have vastly improved in recent years with the introduction of devices compatible with digital signal processing; better image processing techniques and the introduction of sensors facilitating diagnosis of various diseases.

Wireless sensor networks (WSNs) and smart phone technologies have opened up new opportunities in health monitoring system. The integration of the existing specialized medical technologies with cell phone and wireless sensor networks is a very promising application in home monitoring, medical care, emergency care and disaster response [7].

Wireless Sensor Network (WSN) has paved the way for advancements in various aspects of sensing. These advancements have been possible with arrival of smart sensing techniques, smaller transceiver and sensing modules as well as stronger processing units.

Applications of WSNs range from military applications to global climate monitoring applications and from applications in underwater networks to applications in structural health monitoring and beyond. An important aspect of WSN has been the design of health monitoring systems centering on wearable sensor modules for patients [6].

A. *Definition of Asthma*

Asthma is a disease affecting the airways that carry air to and from the lungs. It is characterized by wide variations over short periods of time in resistance to flow in intrapulmonary airways. A common and potentially serious chronic disease that imposes a substantial burden on patients, their families and the community. It causes respiratory symptoms, limitation of activity and flare-ups attacks that sometimes require urgent health care and may be fatal. It causes symptoms such as: wheezing, shortness of breath, chest tightness and cough that vary over time in their occurrence, frequency and intensity. These symptoms are associated with variable expiratory airflow: difficult breathing air out of the lungs due to airway narrowing, airway wall thickening and increased mucus. It is one of the most chronic lung diseases that affect over 400 million people worldwide [4].

Factors that may trigger or worsen asthma symptoms include: viral infections, domestic or occupational allergens (e.g house dust mite, pollens, cockroach), tobacco smoke, exercise and stress. It is a common condition affecting all levels of society which may include: Olympic, athletes, famous leaders and even celebrities [1].

According to [3], asthma is also defined as a condition in which the airways narrow, swell and produce extra mucus thereby making breathing difficult and trigger coughing, wheezing and shortness of breath. For some people the disease can be a minor nuisance while for others, it can be a major problem that interferes with daily activities and may lead to a life-threatening asthma attack. Although, the disease cannot be cured, but its symptoms can be controlled. However, it is important for patients to work with doctors to track its signs and symptoms because asthma signs and symptoms change over a period of time. Symptoms of asthma are also identified as: shortness of breath, chest tightness or pain, trouble sleeping caused by shortness of breath, coughing or wheezing, a whistling or wheezing sound when exhaling. Symptoms of asthma often occur or are worse at night or on waking, they are often triggered by exercise, laughter, allergens or cold air and symptoms often occur with or worsen with viral infections. Asthma has two key defining features the first one is a history of respiratory symptoms such as wheeze, shortness of breath, chest tightness and cough that vary over time and in intensity and the second feature is variable expiratory airflow limitation.

B. *Asthma in Nigeria*

In Nigeria, about 15 million of the country's populations are suffering from asthma. According to the President of Nigerian Thoracic Society (NTS) Prof. Etete Peters in an address with journalist to mark 2016 Asthma Day, he said that in 2025 the number of people that are likely to suffer from asthma will be over 100 million of the total population stressing that it is the most common chronic disease in children. Despite the availability of different asthma drugs, a significant number of asthmatic patients are still suffering from the ailment while a sizeable number still dies from the disease. Many illustrious sons and daughters have been lost to premature death in Nigeria as a result of asthmatic attacks.

In recent times, the Nigeria government embarked on the use of e-health to meet the requirements of its remote and rural dwellers. The government had some challenges and hindrance such as inadequate resources, inadequate management of information amongst other. Countries such as the United States of America (USA), Canada, Spain, France and other countries involve in a wireless monitoring device for treatment of their patients.

Many people with asthma have very sensitive airways which react to cigarette smoke, allergies, infections, or cold air. Doctors may order some tests such as breathing, chest X-ray tests among others to know if a patient is suffering from asthma. Poor control of asthma may lead to continuous visit to the hospital, which can eventually lead to death.

Symptoms of severe asthma attack increase gradually and tend to become serious within 6-48 hours. Signs that indicate worsening severity of asthma attack include the following among others, increased heart rate, increased respiration rate, decreased saturated oxygen and increased cough rates and its duration. Therefore, detection of asthma attack and quick medical intervention requires monitoring and processing of these signs in patients in a real time where decisions can be made about the occurrence of its attacks.

II. MOTIVATION

Inadequate attention given to the management of asthma control in Nigeria could be an important factor for the rising morbidity and mortality rate from asthma despite major advances in our understanding of the disease process. Treatment challenges include poor communication gap between the health-care providers and the patients, high-cost and unavailability of essential asthma medications. Poor technique use of medication devices, especially the inhalational drugs and lack of National or hospital protocol or guidelines for treating asthma.

This review was aimed at highlighting the challenges facing asthma management in Nigeria and to discuss a more reliable way of improving its treatments. As a matter of urgency, there is need to reduce the number of people suffering from asthma in the country and help them to live normal lives. One of the ways in which this can be achieve is by implementing a wireless monitoring device whose application will be useful and powerful to reduce poor communication gap between health-care providers and patients thereby helping patients to seek medical treatment without regular visit to the hospitals. This research work is aimed at simulating architecture based on smart devices and wireless sensor networks to monitor the health of asthma patients in various scenarios. If implemented, patients will be monitored using portable and mobile devices which will accumulate and process data from an array of

wearable sensors. It is also aimed at instilling a sense of security in patients at all times by providing instantaneous attention for emergencies.

A patient will be able to use smart phone application which will automatically connect to the database with location information of doctor used by such patient. If this simulated wireless monitoring device is implemented in real time, the rate of asthma attacks will reduce thereby reducing the rate of death resulting from the ailment, there will also be reduction in regular visits to hospitals by patients except if critical cases occur as health-care providers will be available on time in most cases to attend to emergency, the system will also enhance better relationships between patients and doctors by reducing communication gap. If implemented, this device technology will help in monitoring asthmatic patients by collecting periodic and continuous data from patients and transmitting such information to the centralized server at the hospital. With this device patients' information will be accessed by hospital physicians remotely.

III. METHODOLOGY

The method of study that was adopted in this work include: the review of relevant literatures on the subject matter and the distribution of questionnaires to some medical personnel and asthmatic patients in some hospitals in Ekiti State to know their views about the current methods for the treatment of asthma patients and how they will respond if a wireless monitoring device is implemented to improve the treatment of the ailment. The simulation describes hardware device which will be developed in a way to accept vital signs and symptoms. Once these signs are collated, they will be sent to the hospital centralized server and eventually to the doctors in charge.

The goal of the proposed system is to help doctors and family members to keep track of vital signs in patients suffering from asthma and to direct information to appropriate quarters for quick intervention. This system is also aimed at developing a set of modules which can facilitate diagnosis for the doctors through tele-monitoring of patients. It will also facilitate continuous investigation of the patient for emergencies looked over by health-care providers. A set of patients and clinical sensors will be used to monitor patients. The sensor data will then relayed to the server using a smart device or a base station in close proximity. Health-care givers and doctors will then monitor patients in real time through received data from the server. This simulated system is designed in such a way that it can be implemented on any windows platform such as Windows XP or higher versions for faster processing. The simulated design was carried out using tools such as Microsoft visual studio, Dot Net framework 2010.

IV. SYSTEM DESIGN

The proposed system will be based on wireless technology device. It will consist of monitoring sensors and physiological sensors which will be embedded into the device. The system will collate vital asthmatic signs and these signs will be sent to the clinical workstation via the internet, a Wi-Fi or 3G architecture.

The two main parts of the system design will be the detection module and the radio frequency (RF) communication module. The detection module will be built in such a way that it will be placed on the patient's hand, while the radio frequency (RF) communication module will always be with the medical personnel. All the activities in the proposed system will be done remotely through wireless technology. The block diagram of the proposed system is showed in figure 1 below:

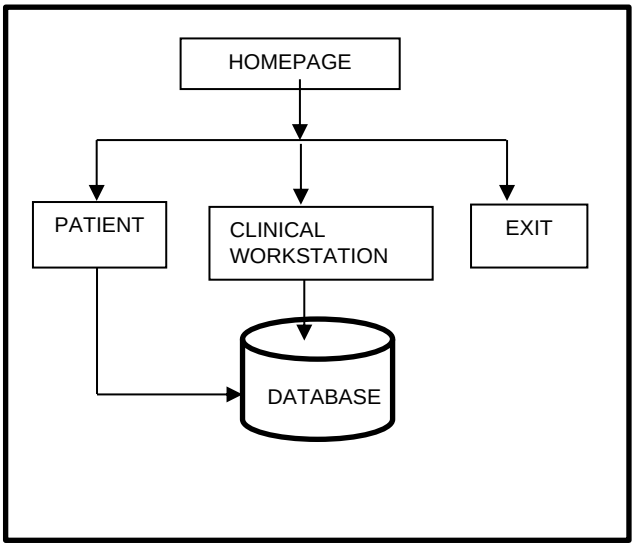

Fig 1: The Device Block Diagram

The block diagram consists of two main modules and the database as illustrated in figure 1 above: they are patients' workstation and clinical workstation. The description of the design of each module in the block is further explained below:

A. Patients Workstation

This block describes the various activities that can be performed on the patient's monitoring device which will include the following among others: sending of signals, delivery of messages and sending of responses to medical personnel. We simulated the design of the patient monitoring device based on asthma common symptoms. We used eight buttons comprising of letters and numbers which are: **A, B, C, D, 1, 2, 3, 4**. We assigned common asthmatic symptoms to each button on the patient's device as follows: for alphabet letters **A** to **D**: **A** is assigned to be chest tightness, **B** to be nasal flaring, **C** to be difficulties talking, and **D** to be throat itches. Also for the numbers **1** to **4**: **1** is assigned to be wheezing, **2** is assigned to be coughing, **3** is assigned to be shortness of breath and **4** for is assigned to be

headache. Also on this device and platform, the simulation buttons will provide details about a patient automatically. It will indicate if patient symptoms are in a critical, steady or overdose level. The simulated buttons simulates between the Signal buttons and send reports to the clinical workstation. In this case, the patient is required to click on the simulation button since this work is based on simulation.

B. Clinical workstation:

The clinical workstation is simulated to acts like a server where all signals and responses will be collated and grouped. From the workstation, prescriptions in form of messages can be sent to patients. Patient's status and other information will also be displayed here. The clinical workstation performs the following operation: sending messages and prescriptions to patients, receiving and classifying status codes, keeping track of patient's information, messages sent with the corresponding date and time by using **Patient ID.**

C. Database

All patient's device ID and health records are stored in the database from which vital information can be gathered at any particular point in time. The operations of the system is further explained in the conceptual model of the system in figure 2, the process model in figure 3 as well as in the operational flow diagrams of the system in figure 4.

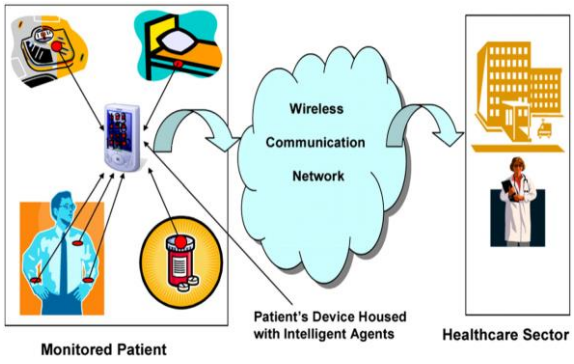

Fig. 2: Conceptual Model of the Proposed System

If the proposed system is fully implemented as a real time wireless monitoring device, Patients can receive information from medical personnel through the device. Communication can also be in form chatting from doctor to patient and vice-versa thereby reducing communication gap and improving the treatment of the ailment. Patients can also simulate signs to know whether they are in danger or not. The simulated signals are sent to the clinical workstation where records are kept and processed. Information exchange between patients' device and the clinical workstation will be done via the remote host that is the Internet. Also, at the clinical workstation, the first operation that will be performed is that signals sent from patients' workstation will be processed and for emergency cases an emergency team will be sent to attend to patient immediately. Also, if detected signs of the patient requires pertinent medical attention of the doctor, then the doctor sends the prescription needed directly to the patient through chatting.

The second operation is that at the clinical workstation, records of patients are sent to the medical server where the records of various patients with asthma are classified into different categories of top most priority. Medical doctors can access records of patients, as well as making inquiries on treatments giving to the patients in past times

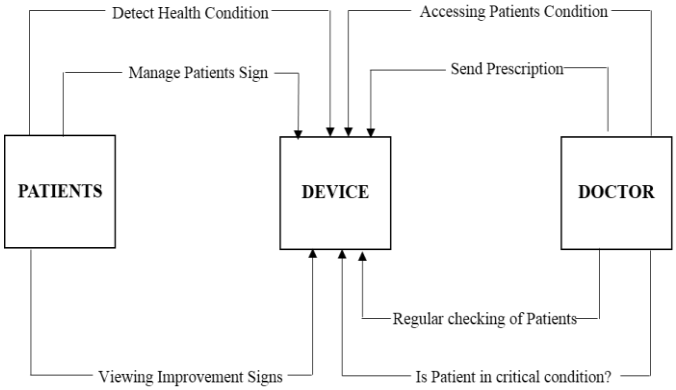

Figure 3: Process Model of the Proposed System

VI. SYSTEM SIMULATION

A. Home Page

The most important feature of the simulated system is that the interface is **User Friendly**. Anyone using the software for the first time will be able to navigate his or her way through and out of the software. From the home page to the patient device and to the clinical workstation, the software provides flexibility to navigate around.

Figure 5: shows a pictorial view of the home page of our simulated system. The patient workstation and the clinical workstation are to be located on different devices but since our work is a simulated work, both servers are showed on the main screen. By clicking the **Patient>>** button from the home page, the patient section will be displayed instantly, also by clicking the **Clinic>>** button, the clinical workstation will be displayed as well.

Fig. 5: Simulated Homepage of the system.

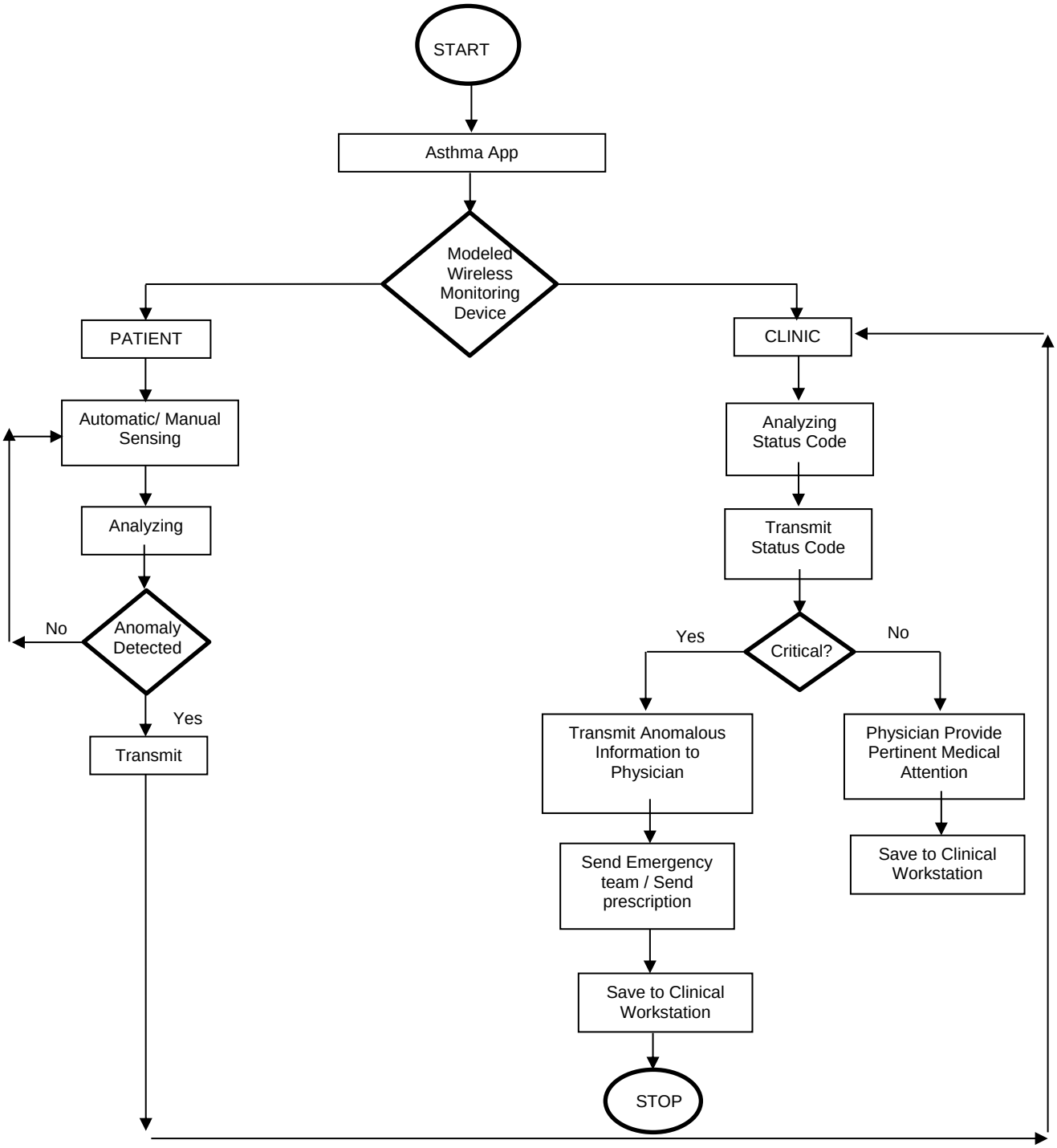

Fig. 4: Operational flow diagram of the system

B. The Patient Device

From the home page as displayed in figure 5, If **Patient>>** button is clicked, it automatically moves to the patient 'interface where the eight buttons **A, B, C, D, 1, 2, 3, 4** which were used to simulate common asthma symptoms as described above are showed. If a patient clicks any of the buttons on the device, an alert pops-up telling the patient that the signal has been sent to the clinical workstation. After which the patient awaits the clinic for prescription or a message. Figures 6 shows the simulated patient' device interface and figure 7 shows what happens when a button, is clicked from the device. Once a button say **A** meaning chest tightness is clicked a message pop-up in form of notification telling the patient that signal has been sent and the message is immediately received at the clinical workstation for necessary processing.

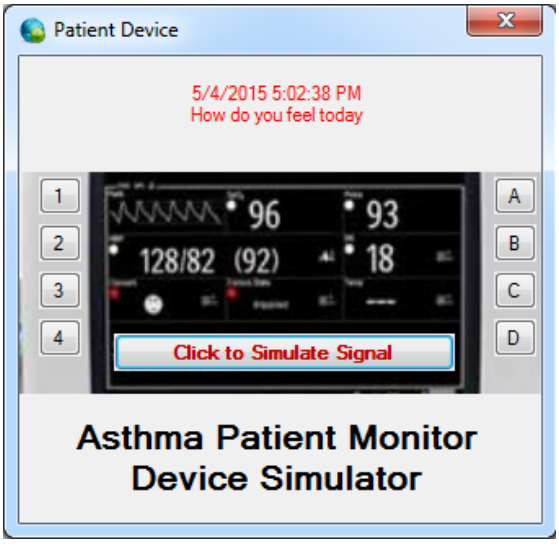

Fig. 6: Simulated Patient Device Interface

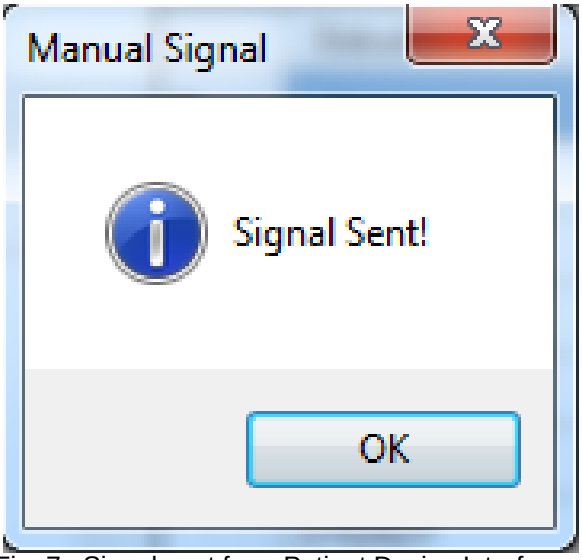

Fig. 7: Signal sent from Patient Device Interface

C. The Simulation Button

The simulation button provides details about the patient automatically. It tells may be the patient signs are in a Critical, Steady or Overdose level. Also, the simulation button simulates between Signals buttons (**A, B, C, D 1, 2, 3, 4**) and sends the symptoms at that time to the clinical workstation.

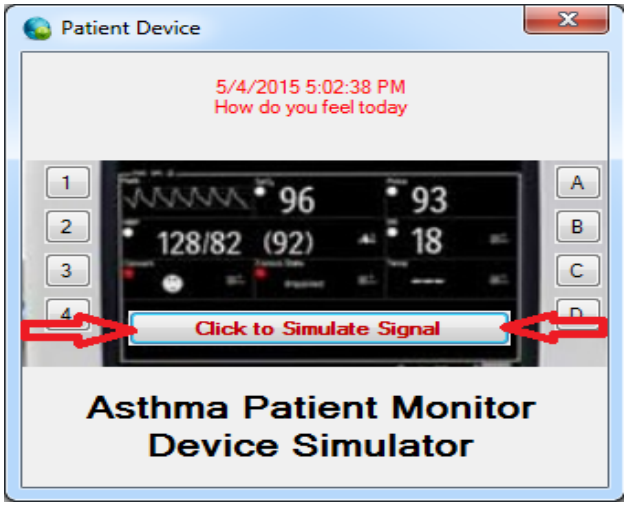

Fig.8: The Simulation Interface

From the simulation interface the various statuses are showed as: under-dose, steady and critical. **UNDER-DOSE** status explains that the patient is below the said prescription and also, that the signs are below the said standards. The **STEADY** status explains that the patient signs are normal and should not stop taking prescriptions. The **CRITICAL** status explains that the patient signs are abnormal and can lead to a serious damage. This simulated data is sent to the clinic for patient data management. The Interface of the critical status is displayed in figures 9 below and it has the same view with the remaining two statuses which are not displayed in this paper.

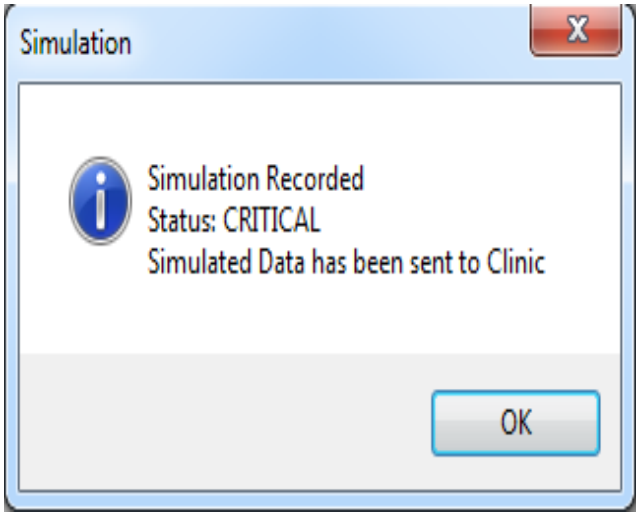

Fig.9: Critical Status

At the message receive box interface, patients can view a message from the clinic and its corresponding time of delivery. This box cannot be edited by patients and messages viewed by patients can be in form of drug prescriptions or the doctor checking on his or her patient

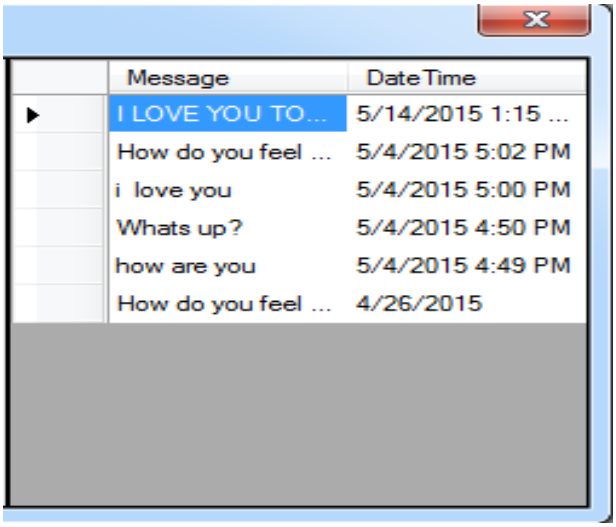

Fig. 10: Message Receiving Interface

D. *The Clinical Device*

From the home page, if **Clinic >>** button is clicked the clinical workstation is displayed from which patients' status is given. The clinical workstation performs the following operation: sending messages and prescriptions to patients, receiving and classifying status codes, keeping track of all patients 'device using a **Patient ID** and also the messages sent with the corresponding date and time are grouped on this platform. If implemented, the device for each asthmatic patient should have its own unique identifier. This will be necessary to track patients and their various locations more easily for quick responses from health-care givers.

Figure 11 below shows the **Patient ID** on the clinical workstation as well as the message box on the clinical workstation that allows doctors or health-care givers to send messages to patients at a particular time. Take for example, once the message written in figure 11 below on the interface is sent, it goes directly to the patient's device with ID number **P0001-ABCD45.**

E. *The Status Code Section*

The section keeps records of patient status code whenever a patient clicks on any button on his or her device. The status code section also ensures that the date and time a particular sign is received at the clinical workstation is recorded. The reason for this is that, when the doctor is not within the range, the date and time can be a notification which will help the doctor to know what can be done immediately.

F. *Message Record*

The message record section keeps copies of all messages sent to a patient with their corresponding date and time. The reason for the message record bar is to check on the improvement of the patient over time. Improvements are in terms of better health or normal health. During analysis, the message record bar can help tell may be a patient does not respond to the treatments given so far and they will be able to know what to be done to enhance a better health for such patient.

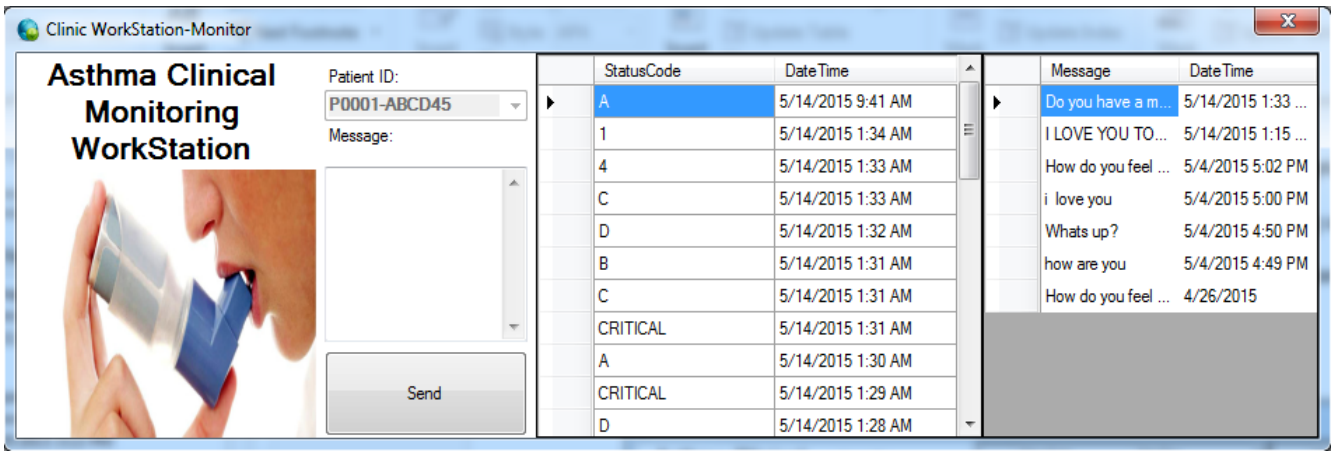

Fig. 11: Patient ID/message on clinical Workstation

VII. CONCLUSION

Inadequate attention given to the management of asthma control could be an important factor for the rising morbidity and mortality from asthma despite major advances in our understanding of the disease in Nigeria. In this work, we have been able to propose a prototype wireless monitoring device for asthma. This system has been simulated successfully for asthmatic patients and their caregivers for proper monitoring and to reduce communication gap between health-caregiver and their patients. If Implemented in Nigeria, it will go a long way at reducing the earlier proposed estimates of over 100millions of the total population likely to suffer from the ailment in 2025.

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