HelpMeBreathe: A Web-Based System for Asthma Management

Alia Al Rayssi, Mahra Al Marar, Alyazia Alkhaili, Reem Al Dhaheri, Shayma Alkobaisi, Hoda Amer

***Abstract*—**We present in this paper a web-based system called "*HelpMeBreathe*" for managing asthma. The proposed system provides analytical tools, which allow better understanding of environmental triggers of asthma, hence better support of data-driven decision making. The developed system provides warning messages to a specific asthma patient if the weather in his/her area might cause any difficulty in breathing or could trigger an asthma attack. *HelpMeBreathe* collects, stores, and analyzes individuals' moving trajectories and health conditions as well as environmental data. It then processes and displays the patients' data through an analytical tool that leads to an effective decision making by physicians and other decision makers.

***Keywords*—**Asthma, environmental triggers, map interface, peak flow, web-based system.

I. Introduction

ASTHMA is a chronic lung disease that inflames and narrows the airways of the lungs. People with asthma frequently experience periods of wheezing, chest tightness, shortness of breath, and coughing [1]. Asthma affects more than 235 million people's lives globally [2]. It affects productivity in work, keeps students from their classes, and costs millions to treat. In 2014, it was estimated that about 105 million dirhams was spent on treating 139,092 asthmatics in the United Arab Emirates [3]. Patients sometimes think too little of the seriousness of their asthma and become less likely to pay attention to symptoms when they are not severe, which may lead afterward to serious asthma attacks.

People with asthma demand treatment guidelines and education on how they can properly control their symptoms and condition to reduce asthma attacks [4]. It is well known that asthma is affected by the environment, and asthma attacks have been linked to exposure to environmental factors such air pollution, temperature, and humidity. Furthermore, changes in weather, as people change their location has a severe effect on people suffering from asthma. It is estimated that 64 per cent of asthmatics in the UAE suffered sudden severe attacks in 2015 [2].

With *HelpMeBreathe*, patients are alerted as they travel around the country whenever they enter an area with high risk of asthma attacks. The alert informs a specific patient that an asthma attack may happen, and in turn prepares the patient for it beforehand. The proposed system also provides a data analysis tool for decision making. It generates important interactive information in an easy and useful way to help decision makers, such as physicians, know the state of the patients at any time in order to make better decisions that are data driven. *HelpMeBreathe* uses individuals' moving trajectories, environmental data from weather stations, and individuals' health conditions to better understand the relationship between environmental exposure and human health. It is built on top of the Smart Connected Health Alert System (SCHAS) [5], which is an on-going project that researchers and developers are currently working on. The proposed system's context view is displayed in Fig. 1.

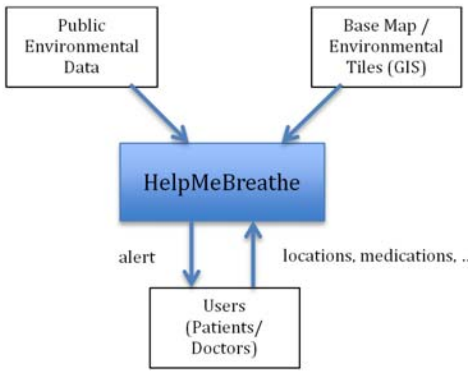

Fig. 1 A context view of HelpMeBreathe

The top three qualities that the developed system is designed to provide are:

1. Simplicity: simple to understand and use;
   a. The system choses to implement components simplicity and readability over the efficiency.
   b. It is simple to understand and it provides ability to add new components easily.
   c. The system uses simple frameworks including any third-party tools.
   d. The data are managed in a way that allows it to be used for many purposes.
   e. The system uses open source frameworks.
2. Exploratory: the system allows for exploratory activities such as visualization of location, movements, overlay of environmental factors, etc.
   a. This includes ability to view data in multiple ways (tabular, graphical, spatial, etc.).
   b. It also includes customizing the views (changing layers in GIS).
3. Maintainable: The system allows quick detection of any

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errors via tools and techniques to trouble shoot the system or subsystems.

a. This includes ability to move data/software from one subsystem to another.
b. The system includes just enough documentation to deploy and manage the working of it.

The above listed feature of our system makes it simple to adopt and to be deployed by decision makers. It also gives the opportunity to expand in the future to add more features such as managing other types of chronic diseases.

II. Background and Related Work

There are a few applications and systems that help in managing asthma, three of which are most relevant to our work, namely AsthmaSense, AsthmaMD, and Propeller. AsthmaSense is a smart phone application that was developed for tracking and monitoring asthma symptoms and medication usage [6]. It also provides medication reminders. The app allows patients to sync their data with the AsthmaSense Cloud, which provides an ongoing record of patient's symptoms and medication usage, so that concerned families or physicians can access this information. However, the app does not track the location of patients. The researchers are promoting that locations and weather functionalities will be added, but these functionalities are not available yet [6].

The second system is AsthmaMD, which is a free mobile application that is only available for iPhone users. It allows asthma users to easily log their asthma activity and medications in the form of diary [7]. These diaries can be texts or colored graph charts that can be shared easily with the user's physicians, or connected to their medical records.

Another work that is similar to ours is Propeller. Propeller has developed a mobile sensor that can be attached to patients' inhalers and linked to an iOS or Android mobile app and to an online platform. It records when and where the inhaler was used. The data gathered also provide information on the kind of environmental exposure that tends to cause asthma attacks for the patient wearing the mobile sensor. Using that data, the system minimizes the possibility of attacks. Geolocation is integrated into the app, thus medical practitioners have access to detailed information on how their patients are using their inhalers and can monitor how their treatments are working. The collected data indicate those areas where asthma attacks most often happen, which enables the medical personnel to warn their patients about any danger areas and send medical notifications and suggestions when needed. Although this system allows to efficiently report the inhaler usages associated with location and time, it does not track the individuals' locations when they are not using the inhaler [8]. Our work is unique in that it collects patients' data such as peak flow measurements, inhaler uses, as well as continuous trajectories, in addition to environmental data associated with locations. The analysis of such data allows for better understanding of the relationship between asthma attacks and environmental exposure at an individual level, thus providing better individualized asthma management.

III. System Design and Architecture

The two main goals of *HelpMeBreathe* are to warn the patient if he/she enters a "danger zone" that is likely to trigger an asthma attack and to provide the medical doctors with an interactive data analysis tool for better understanding of triggers of asthma and thus, better decision making. The overview and main functionalities of *HelpMeBreathe* are explained in this section. The proposed system has interactive web-based map that continuously collects the current location of an individual at a given time from a mobile app, stores it in a database, and allows the user to display it on a GIS interface on top of the United Arab Emirates map. In addition, the system uses the UAE weather stations to collect different environmental and air quality measurements continuously. It also uses the locations of the weather stations in order to develop an efficient spatial data structure called *Voronoi Maps*, which divides the area of the UAE into polygons by using Voronoi tessellation [9]. This structure allows for identifying and calculating the danger zones for asthma patients. A *danger zone* for a patient is an area in which there are weather conditions that may cause any difficulty in breathing or could trigger an asthma attack for that specific patient. When a patient enters a danger zone, the system detects it using computational geometry methods, and then sends an alert to warn the patient. A system overview of *HelpMeBreathe* is shown in Fig. 2.

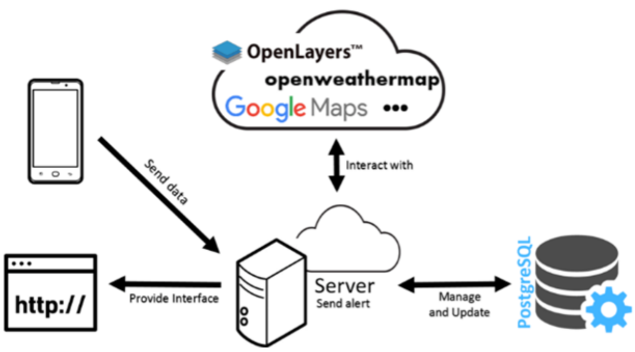
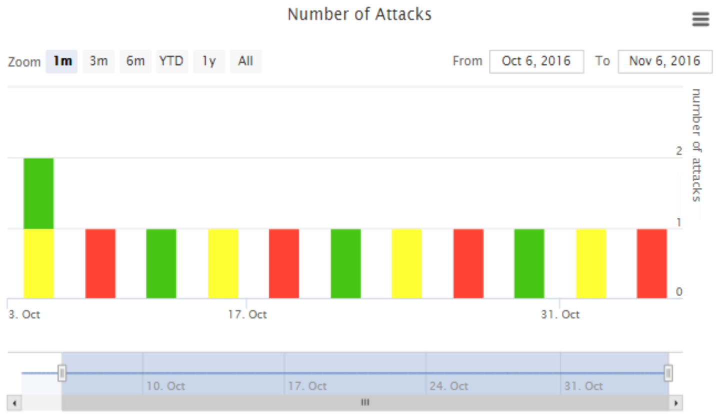


Fig. 2 System overview

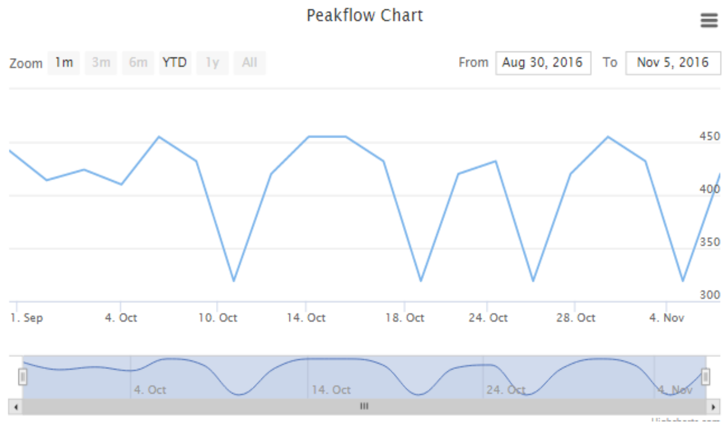
TABLE I
Patients List

Mobile ID	First Name	Last Name	User Name
18df4b616be90650	John	Smith	JS
c1fbfb0788c0d44ea	Mark	Wong	MW
5ad289032db8ffb01	Kim	Ray	KR
6b3ddb451ed7d9ct2	Mary	Branson	MB

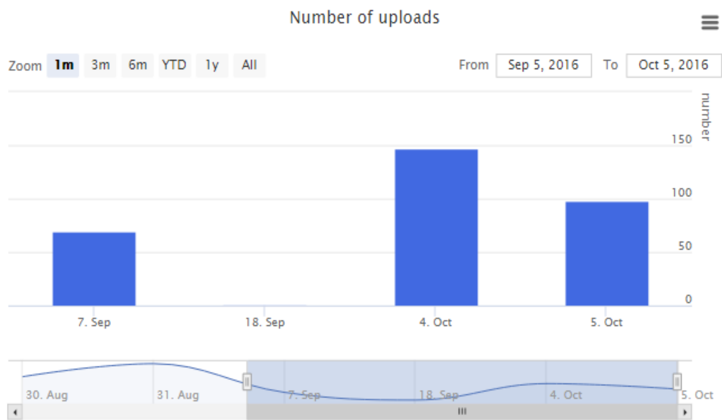
The system also provides a data analysis tool that can be used by physicians or decision makers to have a better insight into triggers of asthma and how different environmental factors play a role in triggering attacks. This is done at a granularity level of an individual and can also be simply aggregated to areas. The tool generates important information about patients and weather stations as online graphs and tables. It shows a list of participating patients (Table I) and generates data analysis charts if a patient was selected from the list as shown in Fig. 3. It also generates and displays a number of charts. The first chart (Fig. 3 (a)) displays number of attacks for the selected patient in a given period of time, indicating the severity of this attack, whether it is severe, medium, or mild. Another chart (Fig. 3-b) shows the peak flow readings for the selected patient. A *Peak flow reading* is an indicator for an asthma patient on how open his/her airways are, so he/she can better manage his/her asthma. Peak flows are measured by peak flow meters, which measures how fast the air comes out the lungs when the patient exhale forcefully after inhaling fully. A third chart (Fig. 3 (c)) shows the number of data uploads received by the selected patient.



(a) Number of Attacks

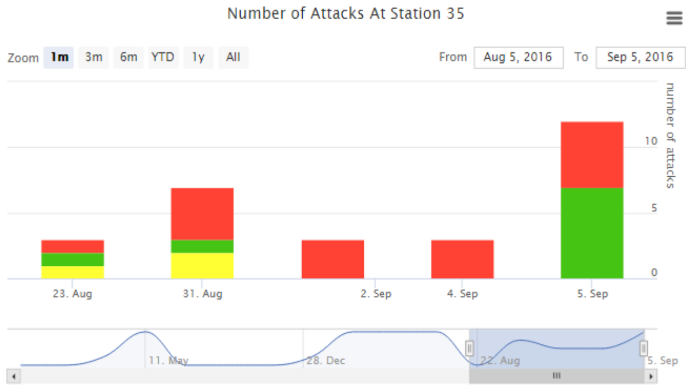


(b) Peak Flow Chart

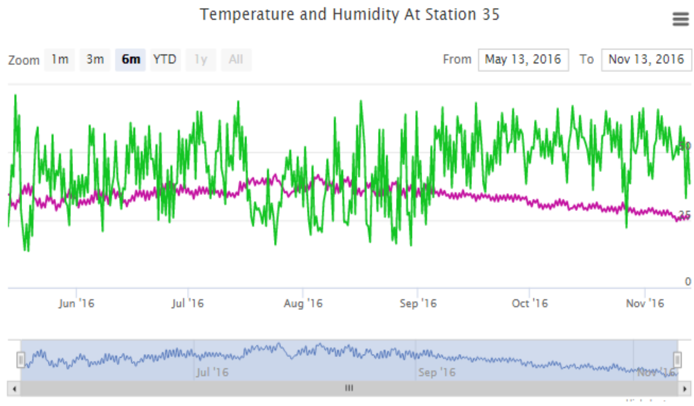


(c) Number of Uploads

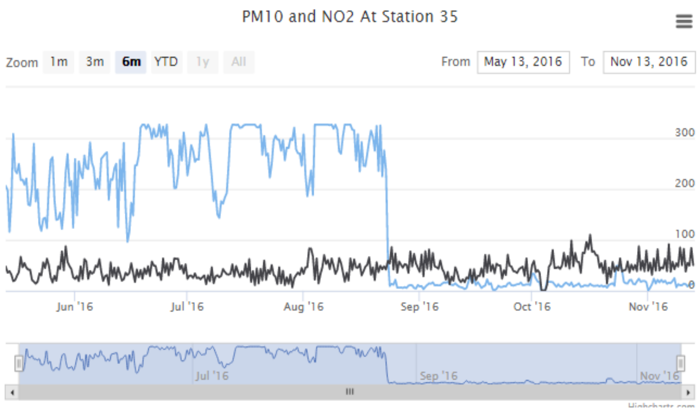
Fig. 3 Charts per patient



(a) Number of Attacks at Station 35



(b) Temperature and Humidity at Station 35



(c) Pm10 and NO2 at Station 35

Fig. 4 Charts per station

TABLE II
STATIONS LIST

Station ID	Station Name	City	State
35	UAEU	Al_Ain	Abu_Dhabi
18	Al Towya	Al_Ain	Abu_Dhabi
7	Al Ain Street	Al_Ain	Abu_Dhabi
19	Zakher	Al_Ain	Abu_Dhabi
6	Al_Ain_Islamic_Institute	Al_Ain	Abu_Dhabi

Moreover, the data analysis tool provides analysis for the data received from the weather stations in UAE. A station list (Table II) lists all stations from which we receive weather data around Al Ain city. A number of charts are then generated and displayed. One chart displays the number of attacks that happened within the region of each weather station for a specific period of time (Fig. 4 (a)). Another chart displays the temperature and humidity that were recorded by this station for a specific time period (Fig. 4 (b)). The third chart displays the levels of air quality measurement such as Pm10 and NO2 values for each station over time as shown in Fig. 4 (c).

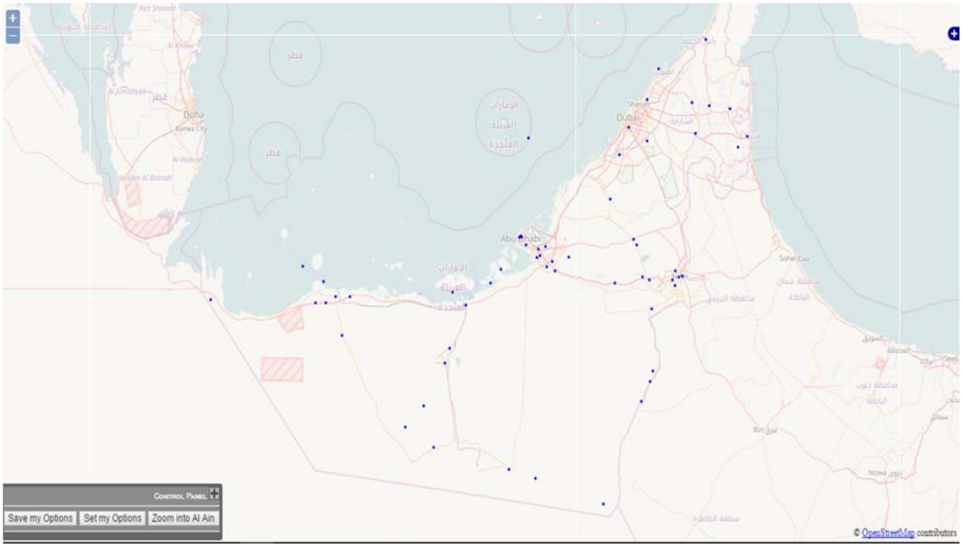
TABLE III
THE MODEL-VIEW-CONTROLLER ELEMENTS OF THE CODE

Model	View	Controller
• patients' information • patients' health profiles • patients' location • environmental data • UAE weather stations	• openlayers3.html • DataUAE.html	• layers.js • trackLayer.js • stationsLayer.js • uaeVoronoi.js • DataUAE scripts

HelpMeBreathe is a complex system with diverse aspects, so to clarify it, we use the Model-View-Controller architecture that simplifies and illustrates our system. The *Model* is the part that handles the logic for the system data. It handles and updates the PostgreSQL database of our system, and it consists mainly of the patients' data and trajectories. The *View* is the part that handles the display of HelpMeBreathe system, and the HTML files represent it. The main HTML file for the map part is *openlayers3.html,* and DataUAE.html is the main file to set up the structure of the data analysis tool web page. The *Controller* handles the user interaction, reading data, and controlling user input either in the map or the data analysis tool. The controller part is implemented in the many JavaScript files of our system. The summary of this architecture is depicted in Table III.

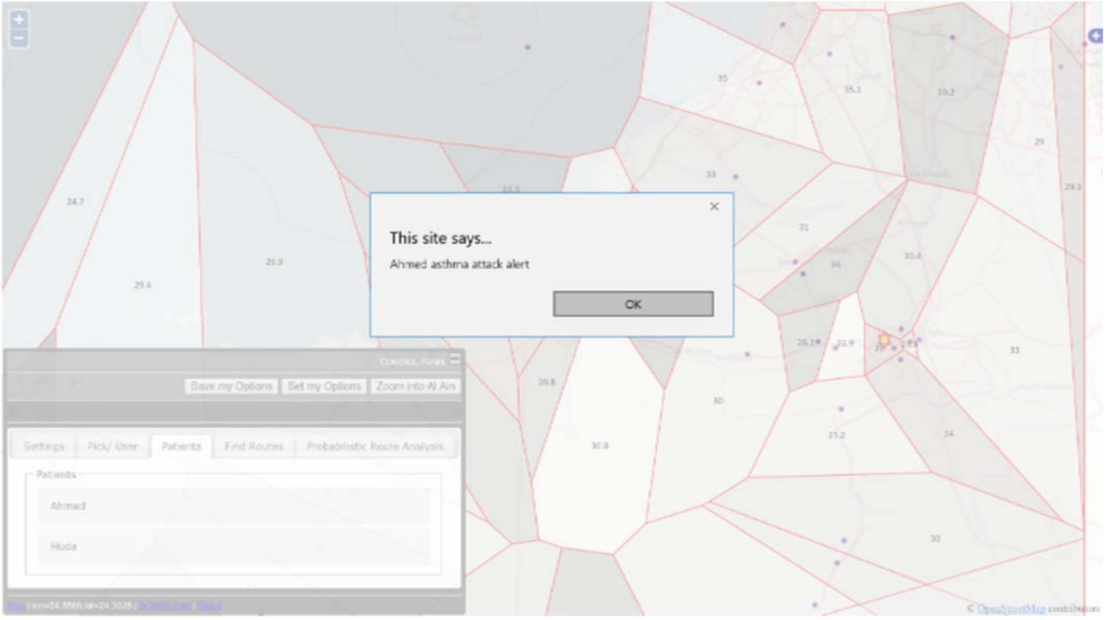
IV. IMPLEMENTATION AND TESTING

The system was developed using JavaScript, JQuery, AJAX, HTML and CSS. We used IntelliJ IDEA as our IDE. Moreover, open source libraries such as OpenLayers, OpenWeatherMap, and Highstocks were used to implement the system. The charts were developed using Highstocks, which is a charting library written in JavaScript that helps in visualizing large data sets, and we used jQuery to send and retrieve data from the PostgreSQL database, which is an object-relational spatial database.



(a) Weather Stations

(b) Voronoi Map



(c) Alert Event

Fig. 5 Map interface

A. The Map Interface

To implement the Map Interface part of the proposed system, we used the locations (latitudes and longitudes) of the weather stations from evCloudBrowser[1] and stored it in our database. The weather stations are then displayed on the UAE map as a GIS layer using OpenLayers as shown in Fig. 5 (a). We created the *Voronoi Map* on top of the UAE map using QGIS-software and uploaded it to the database using PostGIS. Using JavaScript, we added the UAE Voronoi layer to the map as shown in Fig. 5 (b). The weather station at the center of each polygon is the closest weather station to any point inside this polygon. Hence, that weather station is used to report the weather measurements whenever a patient is inside its polygon. Finally, we created a new marker layer named ‘Patients’, and added two synthetic patient records to this layer with a different health profile for each patient. The health profile is used to identify the attributes of the *danger zone* of each patient. This layer was added in order to demonstrate the case where a patient moves from one area to another and a *danger zone* is encountered, in which case the system generates an alert. Using the latitude and longitude of each patient, the system checks if the weather conditions in each polygon entered by the patient might trigger an attack based on his/her profile. If the conditions were met and the synthetic patient enters a danger zone, an alert is generated as shown in Fig. 5 (c).

B. The Data Analysis Tool

The Data Analysis tool was developed using JavaScript, HTML, and CSS. To create the charts, we used Highcharts JS and Highstocks JS, which are charting libraries written in JavaScript. In order to implement the data analysis part, first we collected and analyzed the data such as the weather information from UAE weather stations, trajectories and peak flow readings, as well as the inhaler usages of the patients. We stored all that data in the database using the PGAdmin III tool. We used IntelliJ IDEA 15 as a webpage editor to create the structure of the data analysis tool. The tool interface consists of two parts, charts per patient and charts per station.

The first part includes a user list and three charts, which are showing the peak flow readings, the number of asthma attacks, and uploads of a selected user. The second part includes a list of weather stations in Al Ain city and three charts. The first two charts display weather information, which are the temperature, humidity, pm10, and no2 values, and the last chart displays the number of attacks that happened in the area of the selected station for a specific period of time. For each chart, we retrieve the relevant data using an SQL query. Then, we refine the data and add them to the appropriate data structures. We then pass these data structures to the charting tools. A new SQL statement is generated, and information is re-displayed if a different patient is selected from the patient list (Table I), or a different station is selected from the stations list (Table II).

During the testing phase, we tried to detect as many defects as possible. We used mixed methodology of testing that combine black-box and white-box testing. In white-box testing, we reviewed and verified the code, whereas in black-box testing, the code was hidden and the system functionalities were examined without peering into the code. Each feature was tested to make sure that it works as expected. The user-friendliness and the navigation of our system were also tested.

[1] evCloudBrowser is a software that gives environmental data from 20 weather stations in the UAE, and it was developed by the National Center of Meteorology & Seismology.

V. Conclusion

In this paper, we presented a system called *HelpMeBreathe,* which helps in better understanding environmental triggers of asthma attacks at an individual level. The system is a useful tool for assisting decision makers, such as physicians, in making better decisions that are data driven in order to manage asthma in the UAE. Moreover, the system warns asthma patients if the weather in their area may cause any difficulty in breathing or could trigger an asthma attack, thus giving them the ability to move away and control their asthma.

Acknowledgment

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References

[1] What is Asthma. http://www.nhlbi.nih.gov/health/health-topics/topics/asthma. Accessed: 12 Dec 2016.

[2] N. Webster, "UAE survey shows the cost and impact of asthma", The National, 2015. (Online). Available: http://www.thenational.ae/uae/health/uae-survey-shows-the-cost-and-impact-of-asthma. Accessed: 19 March 2016.

[3] Alzaabi, M. Alseiari and B. Mahboub, "Economic burden of asthma in Abu Dhabi: a retrospective study", ClinicoEconomics and Outcomes Research, p. 445, 2014.

[4] A.Alizain, "One in eight adults in UAE is asthmatic", KhaleejTimes, 2012. (Online). Available: http://www.khaleejtimes.com/nation/uae-health/one-in-eight-adults-in-uae-is-asthmatic. Accessed: 19 March 2016.

[5] Shayma Alkobaisi, Wan D. Bae & Sada Narayanappa, “SCHAS: A Visual Evaluation Framework for Mobile Data Analysis of Individual Exposure to Environmental Risk Factors”, the 14th International Symposium on Spatial and Temporal Databases, 2015.

[6] AsthmaSense. http://asthmasense.com/. Accessed: 16 April 2016.

[7] AsthmaMD http://www.asthmamd.org/about/. Accessed: March 2016.

[8] Propeller. https://www.propellerhealth.com/. Accessed: March 2016.

[9] Wan D. Bae, Shayma Alkobaisi, Wade Meyers, Sada Narayanappa & Petr Vojtˇechovský ,”Voronoi Maps: An Approach to Individual-Based Environmental Exposure Estimation”, the 31st ACM Symposium on Applied Computing , 2016.