The Development of a Rule-based Asthma System

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Abstract— Asthma is a very common disease that may become lethal if remained untreated. An asthma patient must always be alert with their body condition, especially their respiratory and the surroundings they are in. This paper proposes a development of a rule-based asthma system. This system provides advice for patients who would like to know the chances of getting an asthma attack are based on the patient's current asthma condition and surrounding environment. To do so, the patients will answer questions to enable the system to understand their current health condition and the environment they are living in. It will then provide suggestions to avoid the attack, or to hasten asthma recovery, which includes environmental factors. Data regarding asthma was gathered through an interview with doctors and online medical resources. A rule-based algorithm was developed based on the data gathered. With this program, it allows patient's self-management to lead a healthy, asthma-free lifestyle.

Keywords-component; Asthma, rule-based, expert system, patient's self-management.

I. INTRODUCTION

Severity of asthma may worsen due to many reasons, including self doings and the environment the patient is in. To avoid their asthmatic condition to worsen, they must first know what they should do both personally, and also changes they must make around them, on the things that may affect their health.

When it comes to personal changes, they will need to know their current stage of asthma, as different stages of asthma are countered with different methods. From there, only can they start changing their environment for the better. Although clinical experts are available to guide them for this purpose, many patients are unable to opt for this option due to cost and time constraints. This results in putting aside their health condition.

Globally, a host of technologies have been developed for asthma management. In the Malaysia context however, this is rarely the case. Many works have been done to develop technologies for children [1], [2] and [3] but little work has been done on other age groups for example teenagers or even working adults are also at risk within their environment. The reason behind the initiation of this project is to develop a system that accesses their asthma level to know its severity and recommends medical advices to the patient to avoid their asthmatic condition to get worse, where these advices includes in terms of asthma control and also environment-wise recommendations. It is known that many chronic illnesses like diabetes, asthma and cardiovascular disease can be prevented if there are substantial amount of patient's self-management [4]. Since different patients encounters different stages of asthma and comes from different backgrounds, the system is able to process different inputs from patients and produce feedbacks based on their inputs. The rest of the paper is organized as follows. In Section II, we review several related studies. In Section III, we described the rule-based algorithm and the program that was developed based on the algorithm. Finally, the conclusion and future work are given in Section IV.

II. RELATED WORKS

Rule-based expert system (ES) is the simplest form of artificial intelligence and it is being used in many fields, for example military, industrial and in medical practices. Human processes information internally, and it is too complex to be represented in an algorithm. Hence, by using rule-based, we represent that knowledge embedded in the expert, for example doctors, in the form of rules for problem solving [5].

Research done by [6] shows that access to an asthma specialist improves asthma outcomes of children. The author developed a telemedicine link which involves real-time video and audio conferencing between the students and school nurse with the asthma specialist at the hospital. This is a huge effort done by the authors to educate the remote parts where access to specialist is difficult and to empower them with the liberty to manage their health.

As for [2], the author designed a computerized system for childhood asthma exacerbations. It follows a set of national clinical guidelines with the knowledge extracted from the physicians, verified and incorporated into the system. This is done so it may influence the physicians' behavior to facilitate and adhere to the guidelines given. This allows better coherence in terms of medical practices as it is incorporated into their clinical practices after consulting a clinician.

Research work by [3] was done to gather data of child patients in the emergency ward. Parents act as the medium to

report their children's asthmatic condition, historical data, medication and others, so that doctors can act accordingly to the emergency situation. A rule-based approached is also used to link data captured in the system with the best practice guideline recommendation in pediatric asthma for the clinicians to act accordingly.

Another system is an integrated data mining system for patient monitoring with applications on asthma care in the hospital. This system is proposed by [7] where the system can predict the chances of asthma attacks and provide patients with the proper medical instructions or health messages based on the patient's daily bio-signal records, environmental data and integrated data mining system. Based on the experimental evaluation results, it is proven that the proposed mechanism is effective and reliable in asthma attack prediction. This application convinced the authors that asthma casualties can be predicted, and extension of this system should be done to become a home-care system for other kinds of healthcare applications.

Another attempt made to improve asthma treatment is Asthmaexpert [8], an ES, which was developed to better understand the clinical experts making medical decisions in order to manage asthmatic patient by assessing their severity. Different experts have different interpretation of severity, and it is hoped that Asthmaexpert can close this gap of interpretation. It is specifically tailored for hospitals which results in various design of the ES layout. Asthmaexpert will gather data from the patient and assesses the severity of the asthma attack, identifies the trigger factors involved, suggests any further investigations that may be required and offers a treatment strategy. However this system mainly focuses on the decisions made clinically, and does not elaborate on the changes to be done to the patient's environment.

Besides asthma, there have also been efforts done to improve medical care through artificial intelligence. For example, Harvard School of Public Health initiated a website, Your Disease Risk, which hosts a system called Disease Risk Index [9]. Initially, Disease Risk Index is an educational web site created by the Harvard Center for Cancer Prevention for informational purposes only and does not provide medical advice or services. With collaboration with Washington University at St. Louis, the system was further developed to become a system that predicts the chances and calculates the risk of a person to be infected with a disease. However, this development does not concern lung diseases like asthma, and mainly focuses on cancer related diseases. Figure 1 below shows an example of the system in evaluating heart cancer disease.

Figure 1. Disease Risk Index application

Therefore, the authors felt that it is important to provide an ESs to assist asthmatic patients. One of the real benefits of ESs is the ability to deliver real expertise to people who need it even though they are in different locations or only need the expertise occasionally and it is also inexpensive as compared to hiring a human expert. We can see the importance of ES and how it can intervene in our lives to help in assisting us, whether in our working environment or even in homes.

Authors in [4] felt that prevention of diabetes mellitus can be done if primary care physicians are there to address the preventive issues. However, that is not the case and there exist a gap between primary care physicians and patients in this matter. Thus, the researchers found a great potential in developing a computer-assisted program that might help close the gap. This program is able to tailor and personalized the feedback to the patients. A favorable outcome regarding this program was found although a more extensive intervention contact would be more ideal.

In Malaysia, there is a website [10] which was sponsored and funded by Merck Sharp & Dohme (MSD) Malaysia. It is a research-driven pharmaceutical company that researches different kinds of healthcare products. On this website, there are questionnaires that will be asked to know the severity of one's asthma. An advantage of this website is that it allows a person to input their demographic data to better gauge their asthmatic level. However, it covers minimally about a person's physical surrounding and how it might trigger an asthma attack.

III. DESIGN AND DEVELOPMENT

This proposed system is catered for people within the age group of 25-40 years of age, where the system can be used at various locations for example, at home, or even be placed in hospital as kiosks. It is developed using rule-based artificial intelligence that manipulates patient's inputs to produce corresponding suggestions accordingly. Data about asthma was gathered by interviewing medical doctors and medical sources from [11] and [12].

The system is divided into two parts: 1) to access a person's asthma level and 2) to see how the current environment that they are in can trigger their asthma attack (Figure 2). Most systems developed are used for clinicians to help categorize the severity of a patient before entering the clinic. This system however, could be an alternative method to provide authority and liberty to the patients themselves to access their asthma severity level and their environment at their own convenience. The system has a front-end mechanism that captures patient's input so that the system will correspond according to the patients needs. The system is designed to be simple, straight-forward and does not use medical jargons. It also embeds error-checking strategy to ensure maximum accuracy and patients are not able to skip vital questions.

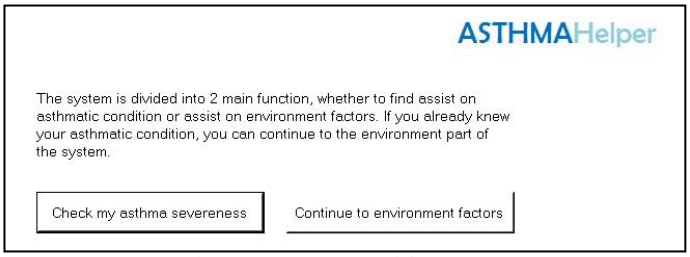

Figure 2. Two parts of the system

A set of asthmatic level clarity questions is asked to the patient to access their current health condition. These questions are then manipulated by the system to produce outputs which are suggestions to help patient's asthmatic problem. After knowing their current asthma level, they are able to continue answering questions regarding their surrounding environment, which is discussed later in this paper. An example of asthmatic level clarity questions are listed below:

Q1: Are you able to take part in ALL your normal physical activity?

Q2: Did you wheezed, coughed and have chest tightness at night, on waking or during the day for these pass four weeks?

Q3: Did you use your reliever inhaler this pass four weeks? (Except if it is used before exercise)

Q4: Do you have cold or flu?

Q5: What is your peak flow level?

A color-coded algorithm was then developed based on the analysis of interview results and medical sources to represent the different stages of asthma. These colors mimic the traffic light signals, as there is a global understanding on the meaning of these colors. The stages of asthma are divided into:

- Green
  This indicates mild cases or safe zone. For a mild asthma patient, they will feel fine and have no worries about their asthmatic condition but will continuously have their intake of medication which their doctors have prescribed to them.

- Yellow
  For second degree of asthma, the patient has some difficulties in breathing and cannot perform their routine activities, which will eventually affect their life. At this stage, the patient has to be more careful in controlling their asthma to avoid it from worsening.

- Red
  In severe cases, if the symptoms occurs more frequent, when the patient is not able to control their asthma and it is causing them to take more reliever, they would have to call their doctor to tell them their asthmatic has worsen. Else, they can immediately go to the hospital for a more thorough checkup.

Based on the data acquired, an if-else knowledge representation was developed, in order to categorize the different stages of asthma. Numbers 1), 2), 3) shows a sample of the representation.

1) IF (red) OR (yellow)

   THEN (asthma not well controlled)

2) IF (take part all activity)

   THEN (green)

   ELSE IF (take part certain activity)

   THEN (yellow)

   ELSE IF (not take part all activity)

   THEN (red)

3) IF (wheeze) OR (cough) OR (chest tightness)

   THEN (asthma not well controlled)

As a sample case to demonstrate the flow of the system, Figure 3 below shows a tree-flow diagram for a green level asthma patient using the system as a sample case. In other words, it displays the options a green asthma patient would have.

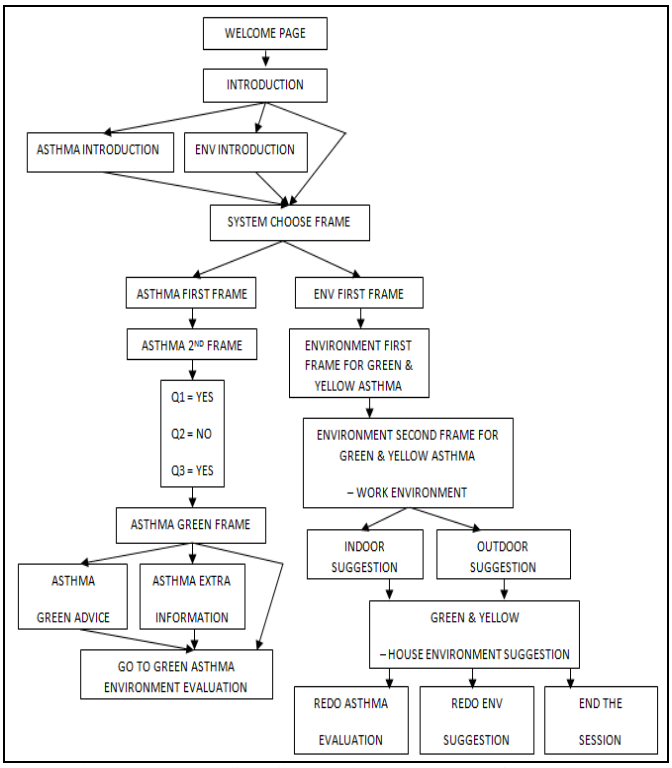

Figure 3. Tree – flow diagram for green stage asthma patient

Figure 4 shows a sample screenshot of questions where the system will ask the patient before accessing his/her level of asthma. The pop-up help dialog boxes are the result of clicking the question mark button beside the questions to get further information or clarification of that question. There is one help button for every question. The interface design is simple and uncluttered to cater its usage to all age group with different technical background.

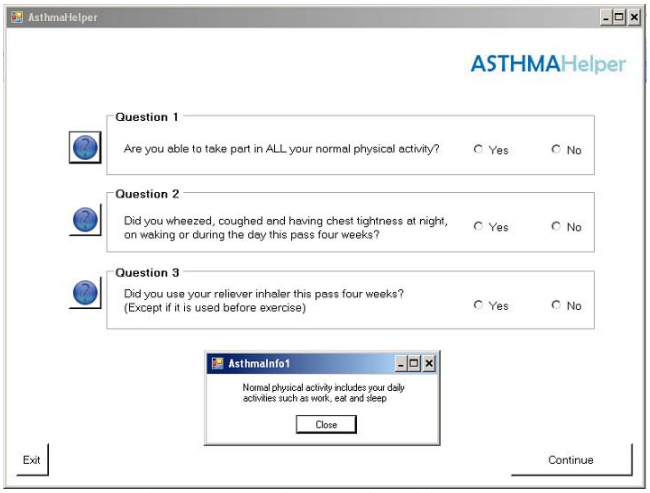

Figure 4. Sample screenshot of the system

Figure 5 is one of the possible outputs when the patient has completed the asthma questionnaire. For every output there will be suggestions on how to improve your asthmatic condition.

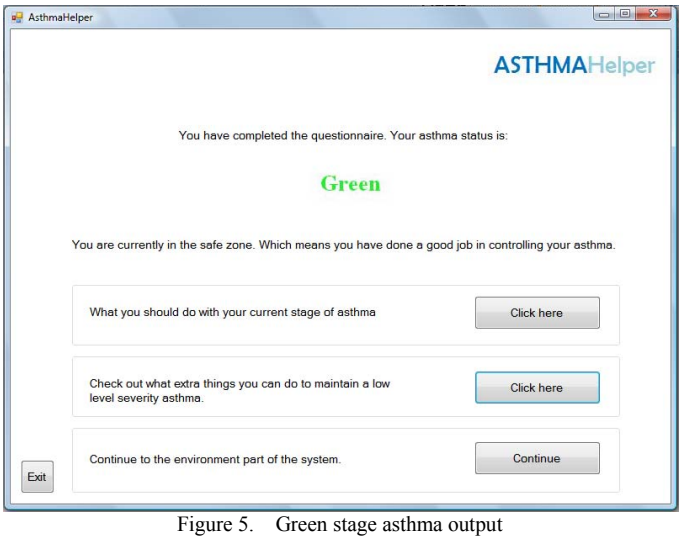

Figure 5. Green stage asthma output

Referring to Figure 5, if the patient chooses to know how the environment will affect his/her asthma condition, the patient can click the third 'Continue' button. A set of question regarding their environment will be asked for patients who would like to know how it will affect their asthma condition. A sample of questions is as below:

Q1: Does your work involve indoor or outdoor activities?

Q2: If you work indoor, what is temperature of the air conditioner, if you have one?

Q3: If you work indoor, how is the air flow in your workplace?

Q4: If you work outdoor, is it open to chemicals and dangerous substances or small substances (i.e.: quarry)?

Figure 6 below is the result of 'Indoor' for Q1. The system will explain issues concerning indoor working place and the things that the patient should take into account.

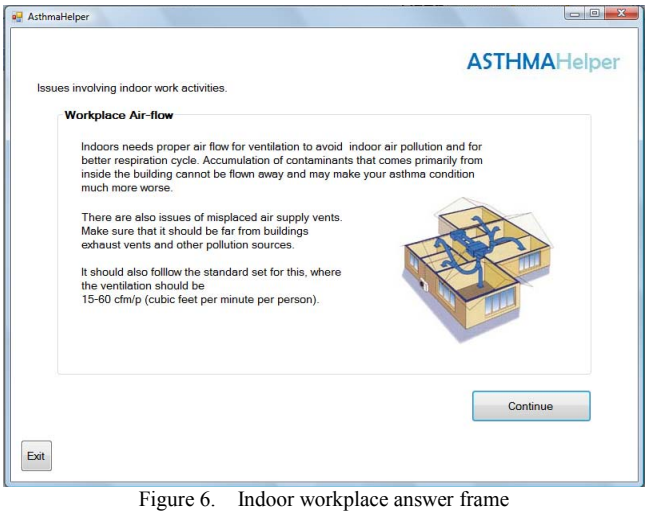

Figure 6. Indoor workplace answer frame

Figure 7 shows the sample for the environment part within the house environment.

Figure 7. House environment recommendation

IV. CONCLUSION

This expert system was developed using rule-based that helps asthmatic patients to be more aware of their current asthmatic condition and surroundings. This system is meant to prevent them from getting an asthma attack where their input to the system will be used to suggest changes or modifications needed to be done to the patient's lifestyle or the environment. This system can be enhanced by broadening the age group of patients, to cater to a larger group of people. Developing this system to be used on mobile phones will be ideal as patients can use the system wherever they are for example in a train or at the shopping complex while shopping. Also, adding demographic questions into the system will more accurately produce and personalize the feedback given by the system. Through it, the patients are able to change their environment to be better suited to their asthma level where they can lead a better lifestyle and prevent from an asthma attack.

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