Evaluation of User Interface of Computer Application Developed for Screening Pediatric Asthma

Maryam Zolnoori[1], Josette F. Jones[1], Mostafa Moin[2], Hassan Heidarnejad, Mohammad Reza Fazlollahi[2,3], and Masoud Hosseini[1]

[1] School of Informatics, IUPU University, Indianapolis, Indiana, USA
[2] Immunology, Asthma, and Allergy Research Institute, Tehran University of Medical Science, Tehran, Iran
[3] Masih Daneshvari Hospital, Shahid Beheshti University of Medical Science, Tehran, Iran
{mzolnoor,jofjones,hosseini}@iupui.edu,
{MMoin,fazlollahi}@sina.tums.ac.ir,
Heidarnazhad@ams.ac.ir

Abstract. Asthma is a chronic disease which has a negative effect on the quality of life of (1.4% to 27.4%) people around the world. Unfortunately in many countries, because of limited access to pulmonary physicians, and laboratory tests, asthma is usually under diagnosed especially at the first stages of this disease. The purpose of this study is to report a patient –centered computer application for diagnosing pediatric asthma. Techniques of semantic networks, production rules, fuzzy logic, and decision trees have been applied for representing evidence-based research knowledge. User-Interface of this system is evaluated by nurse practitioners. Result of this evaluation reinforces that this system meets requirements of user interaction satisfaction.

Keywords: Asthma, diagnosis, decision tree, semantic network, fuzzy logic, user interface evaluation.

1 Introduction

In 1984, asthma was defined as a chronic disease that remains under-diagnosed and undertreated [1]. Despite improvement in pathological and clinical knowledge for diagnosing asthma, in 2012, asthma is defined as a global health problem that economically and socially has a huge negative effect on families and societies[2]. Asthma under-diagnosing [3, 4] especially in children is accompanied by low quality of life. Sleep disturbance, activity limitation, and missing school days, and eventually emergency department visits, which may result in hospitalization[5].

However, evidence-based medicine proposes a systematic solution for diagnosing and treatment of disease [6, 7], and evidence-based guidelines developed for diagnosing diseases relevant to respiratory symptoms are heavily dependent on laboratory tests [8] which are not widely accessible to many primary care settings or physicians 'office. Patient-centered tools such as questionnaires which are provided to diagnose symptom-related asthma do not collect sufficient information about the patient's

C. Stephanidis and M. Antona (Eds.): UAHCI/HCII 2013, Part III, LNCS 8011, pp. 563–570, 2013.

respiratory symptoms [9, 10]. These questionnaires usually are applied in population-based studies to estimate the prevalence of asthma [11, 12].

Medical informatics is the intersection of medical practice, computer and cognitive science[13] providing solutions to deal with inconsistencies, insufficiencies, and uncertainties in medicine. Cognitive science [14] involves an in-depth analysis of a problem and its diagnostic in terms of identifying algorithm of decision making and principles of system usability.

As solution of this problem, we combined techniques of knowledge representation (computer science), process of medical judgment (cognitive science), and the patient's view to model empirical knowledge obtained from asthma evidence-based research (medical science). This model serves as patient-centered decision support system for diagnosing childhood asthma.

This paper is phase 2 of the project of developing decision support system for diagnosing (screening) pediatric asthma. In this paper, we present the results of evaluation of a user interface of this system. The rest of this paper is as follows: developing conceptual model (section 2), knowledge representation (section 3), system testing (section 4), user interface evaluation (section 5), and conclusion (section 6).

2 Developing Conceptual Model of the System

The conceptual model of this application is developed based on a framework of problem solving at different level of medical care [15]. This framework consists of four stages as follows:

1. Observation: observation is considered as variables that disturb daily activities of patients. Patients can recognize the variables and usually search for solutions to eliminate them.
2. Findings: Findings are a set of variables that patients have confirmed as having been observed. Findings have potential clinical significance.
3. Facet: Facet is a cluster of medical findings in every module to indicate underlying medical problem that can serve as part of the knowledge needed for decision making. Facets are used to divide information obtained from users into sets of manageable sub-problems.
4. Diagnosis: Diagnosis is the aggregation of obtained results in every module.

Epidemiological and pathological knowledge of asthma disease is represented based on this conceptual model.

3 Knowledge Representation

Techniques of knowledge representation used for modeling knowledge of asthma disease include semantic network, decision tree, and fuzzy logic.

3.1 Knowledge Representation Using Semantic Network

The epidemiological and pathological knowledge of asthma can be constructed as a casual relationship using semantic network serving to classify knowledge into manageable clusters of information. Knowledge collected from evidence-based research is reformed based upon the patient's view. Patient observations and findings are limited to symptoms and history. Therefore, for developing the semantic network based on the patient's view, we eliminate all variables that patients do not have access to (including laboratory and atopy tests). In this model, genetic factors, medical factors, environmental factors, associated disease, symptoms appearance and symptoms hyper-responsiveness are considered as main nodes representing cause and effect variables. This semantic network is depicted in figure 1.

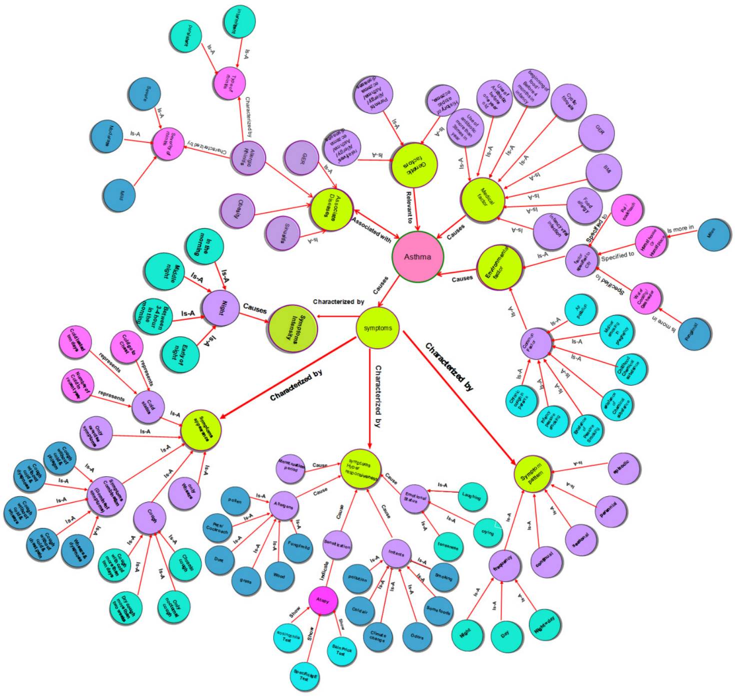

Fig. 1. semantic network based on patient view

Every main node in this module summarizes findings of patients for a class of variables such as medical history or associated diseases.

3.2 Developing Algorithm of Decision Making

Stages 3 and 4 of the conceptual model serve as a guiding framework for developing the algorithm for decision making. Every main node in semantic network consists of a facet of knowledge for diagnosing asthma. The possibility of asthma would be calculated from the aggregated results obtained from each module. Figure 2 depicts algorithm of decision making serves as inference engine of diagnosing asthma.

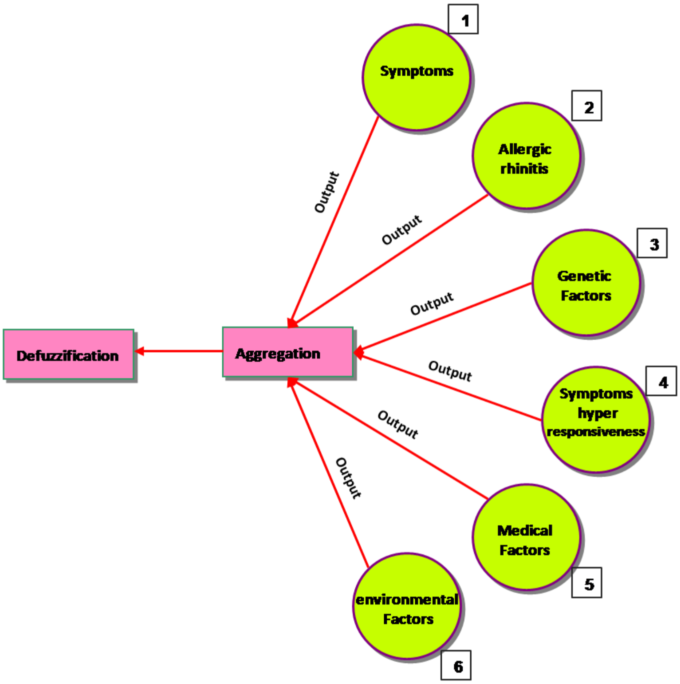

Fig. 2. A schematic view of Inference engine of application of pediatric asthma

3.3 Generating Decision Trees

To model the relationship between variables in every module (depicted in figure 2), the technique of decision trees is applied. Each variable is represented as a question in every node of the tree. The alternative response for every question split nodes into multiple branches. As a result, every path in the tree includes a facet of knowledge for decision making.

Rules which are used for developing decision trees of this application are as follows:

- Heuristic Meta rules: Heuristic Meta rules are used to determine the initial nodes in trees, and manage constraint on module and sub-module. For Example, in module of respiratory symptoms, seven decision trees are used to represent relationship between variables.
- Directive Meta Rules: Directive Meta rules determine the sequence of the variables in the branches of tree. For example, if someone has wheeze - then ask for seasonal variation of symptom.

- Statistical rules: Specificity and sensitivity of variables calculated in epidemiological research are used to estimate possibility of asthma for a set of medical finding in every path of trees. End nodes in each branch include possibility of asthma which is represented in linguistic statements in a continuum from very low to very high.
- Fuzzy logic: Fuzzy logic is used to represent the uncertainty of linguistic statements in a continuum (0-10).

4 Evaluation of System Result

This system has been tested on 139 asthmatic patients and 139 non-asthmatic patients who had respiratory symptoms and were referred to the immunology, Asthma, Allergy Research Institute of Iran. The specificity and sensitivity of this system, with a cut of value of 0.7 are 100% and 88% respectively.

5 Designing User Interface

One of the fundamental challenges with health information systems is to consider the human computer interaction [16, 17]. In fact, effectiveness of a piece of a software developed in medicine is not an internal attribute of the software, but is determined by the user's interpretation, and it depends on the user's specific context [18] . In medicine, user specific context can be considered in two ways: patient-centered view or health care providers' view. To design decision support for childhood asthma, interaction between this system and users is considered from the point of view of the parents who have direct relationship with the children having problematic respiratory symptoms.

The underlying premises which are considered for designing this interaction are: 1) People who are going to use this software have a little technical knowledge of computer systems, 2) they have minimal knowledge of medicine (They can recognize symptoms, and their pattern, and have a history of child).

To improve user-friendliness and intuitive data point of this system, we considered the following features in developing user interface:

1. To create the first interaction between the system and user, we give general information about the system and the type of questions that the user will be required to answer in the login page.
2. Modular base structure of this system helps user to concentrate on the specific type of questions
3. To start interaction with every module, a brief introduction of the module is provided before presenting questions in the screen.
4. To give users some information about the questions they are supposed to answer, semantic network and decision tree of every module is presented in the page of every module.

5. To prevent the system from appearing awkward or cumbersome, we used some colorful objects in every page related to the type of questions in every module.
6. To minimize the process of learning needed for working with this system, a part of every page is setup to guide users.

These features help users to feel confident (by getting probably sufficient information about this system) and keep him/her motivated to go through all the modules, answer questions, and finally see the possibility of asthma for a patients with respiratory symptoms.

To facilitate the process of data entry, multiple choice questions are considered. Users can read the questions and choose one of the options that highly match with the patients' background or current situation. However, this type of questions may limit interactions between the system and users, but will improve accuracy of entered data. Figure 3 presents some snapshots of user interface of this application.

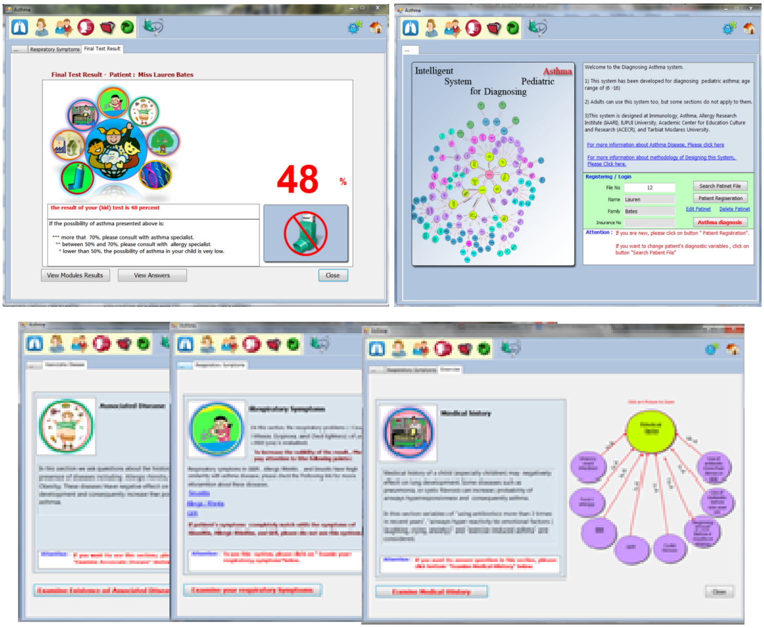

Fig. 3. Screen shots of user interface of application for diagnosing pediatric asthma

5.1 Evaluation of User –Interface

After obtaining IRB approval (#1302010660) five nurse practitioners who have had direct communication with asthmatic patients participated in this project.

Instrument. A modified version of QUIS (Questionnaire for User Interaction Satisfaction) [19] was used to evaluate user interface of this software. This questionnaire consists of five parts. Part 1 concerns general experience of working with this application. Part 2 concerns the windows layout of the system, Part 3 the terminology used, Part 4 the learnability of the interface (how easy it is to learn), and Part 5 system capabilities. Each part is evaluated by some relevant criteria. A 9-point Likert Scale (0-9) is applied to assess each criterion.

Result of the Evaluation. Five nurses were asked to run this application, register a patient and go through all the modules and answer questions appeared on the user interface. Then they filled in QUIS questionnaire regarding to their evaluation.

To analyze the results of the evaluation for each part, an average of marks given to each criterion by the nurses was calculated. This result for each part is as follows:

Part 1 (general experience): 7, part 2 (windows layout): 7, part 3 (terminology): 8, part 4 (learnability): 7, and part 5 (system capabilities): 7.

These values show that user interface of this application meet the requirement for user-interaction satisfaction.

6 Conclusion

In this paper, we evaluated user interaction satisfaction of an application developed for diagnosing pediatric asthma. Five nurse practitioners participated in this project. The overall results of this evaluation indicates that the system meets the requirement of user satisfaction, the criterion of "designed for all level of users" in the part of system capabilities received an average score of only 4. Feedback from the nurses indicates that patients need more medical information to answer the questions. Thus, this application should be upgraded to provide more medical knowledge related to the questions asked.

Acknowledgement. I would like to gratefully acknowledge Professor Linda Gilman who provided me with the opportunity to evaluate user interface of this application. I thank Sophia Kusch for reviewing this paper.

References

1. Rees, J.: ABC of asthma. Definition and diagnosis. British Medical Journal (Clinical research ed.) 288(6427), 1370 (1984)
2. Wahn, U., Matricardi, P.M.: Toward a definition of asthma phenotypes in childhood: Making a long way shorter? Journal of Allergy and Clinical Immunology 130(1), 111–112 (2012)
3. Annesi-Maesano, I., et al.: Factors related to under-diagnosis and under-treatment of childhood asthma in metropolitan France. Multidisciplinary Respiratory Medicine 7(1), 24 (2012)
4. Yeatts, K., et al.: Who gets diagnosed with asthma? Frequent wheeze among adolescents with and without a diagnosis of asthma. Pediatrics 111(5), 1046–1054 (2003)
5. Yeatts, K., et al.: Health consequences for children with undiagnosed asthma-like symptoms. Archives of Pediatrics & Adolescent Medicine 157(6), 540 (2003)

6. Sackett, D.L., et al.: Evidence based medicine: what it is and what it isn't. BMJ 312(7023), 71–72 (1996)
7. Satterfield, J.M., et al.: Toward a Transdisciplinary Model of Evidence-Based Practice. Milbank Quarterly 87(2), 368–390 (2009)
8. Dicpinigaitis, P.V.: Chronic cough due to asthma ACCP evidence-based clinical practice guidelines. CHEST Journal 129(suppl. 1), 75S-79S (2006)
9. Weiland, S., et al.: Phase II of the International Study of Asthma and Allergies in Childhood (ISAAC II): rationale and methods. European Respiratory Journal, 2004 24(3), 406–412 (2004)
10. Shin, B., et al.: A new symptom-based questionnaire for predicting the presence of asthma. J. Investig. Allergol. Clin. Immunol., 2010 20(1), 27–34 (2010)
11. Yang, C.L., et al.: Verifying a questionnaire diagnosis of asthma in children using health claims data. BMC Pulmonary Medicine 11(1), 52 (2011)
12. Hong, S.-J., et al.: The validity of the ISAAC written questionnaire and the ISAAC video questionnaire (AVQ 3.0) for predicting asthma associated with bronchial hyperreactivity in a group of 13-14 year old Korean schoolchildren. Journal of Korean Medical Science 18(1), 48–52 (2003)
13. Patel, V.L., Arocha, J.F., Kaufman, D.R.: A primer on aspects of cognition for medical informatics. Journal of the American Medical Informatics Association 8(4), 324–343 (2001)
14. Kaufman, D.R., et al.: Conceptual knowledge and decision strategies in relation to hypercholesterolemia and coronary heart disease. International Journal of Medical Informatics 55(3), 159–177 (1999)
15. Evans, D.A., Gadd, C.S.: Managing coherence and context in medical problem-solving discourse. In: Evans, D.A., Patel, V.L. (eds.) Cognitive Science in Medicine: Biomedical Modeling, pp. 211–255. MIT Press, Cambridge (1989)
16. Kuhn, K., Giuse, D.: From hospital information systems to health information systems. Methods of Information in Medicine 40(4), 275–287 (2001)
17. Coiera, E.: Interaction design theory. International Journal of Medical Informatics 69(2), 205–222 (2003)
18. Fieschi, M., et al.: Medical decision support systems: old dilemmas and new paradigms. Methods Inf. Med. 42(3), 190–198 (2003)
19. Chin, J.P., Diehl, V.A., Norman, K.L.: Development of an instrument measuring user satisfaction of the human-computer interface. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. ACM (1988)