Original research

Designing a Novel Clinical Decision Support System for Asthma Care, Control, and Education

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Running title: Making a novel CDSS (clinical decision support system) to bridge the gap between guideline and practice behaviour in asthma.

Abstract

Background: A significant gap prevails between the guideline preaching and the practice behavior across the globe for asthma despite an exponential development of the understanding of the disease with availability of good therapy.

Aims: The aim of the work is to frame a novel CDSS observing the principles of the GINA guidelines to bridge the gap between the guideline and the practice behavior for asthma and help the grass root practitioners, healthcare workers, and the patients.

Methods: A team of physicians and engineers worked together. They decided several decision algorithms for asthma on the diagnosis, determination of control status, identification of exacerbations, course of actions / treatment depending upon the level of control, and the status of exacerbation following the principles of the GINA guidelines. Each decision algorithm was encrypted in JAVA (open source) and the algorithms were connected on rational sequence to provide a series of inferences. Additionally, incorporations included a) a "know asthma hyperlink at each page to allow the user to learn about the disease in a simple way and b) hyperlink to all the medical terms used and finally, c) the knowledge of the common precipitants, and d) a small text about the CDSS.

Results: The CDSS was successfully prepared and tested in a single point clinical practice situation where it appears satisfactory.

Conclusion: The CDSS prepared following the principles of the GINA guideline may help to bridge the gap between the guidelines recommendations and the practice behaviour for asthma.

Ke words: Asthma, clinical decision support systems, guideline adherence, gap between guideline and practice behavior. (The Pulmo - Face; 14:2, 36-40)

ABBREVIATIONS:

CDSS: clinical decision support system

GINA: global initiative for asthma

INTRODUCTION:

Asthma is a global problem of huge dimension with its prevalence and incidence being on a rise.[1] While a patient of asthma can lead a normal life with the disease being controlled, there are millions of asthmatics suffering relentlessly due to the lack of proper education and treatment. Over last two decades asthma care has turned more and more evidence based with publication of several guidelines. [2, 3, 4, 5, 6, 7] But a gap persists between the given guideline recommendations and the prevailing practice across the globe. [8, 9, 10, 11, 12] Bridging this gap has become very important to cater to the suffering patients and it appears that the mere publication of guidelines is not enough to serve the purpose. Practice according to the guidelines should be made simple and accessible so that a grass root physician or even the patients can follow it. Electronic clinical decision support systems (CDSS) are new adjuncts to the educational and treatment armamentarium for better management of a disease. The use of a computerized decision support system at the place and time of care can help to reduce treatment error and improve the quality of care. [13, 14] We have prepared a CDSS on asthma following the GINA (2008) guidelines in order to make it easy to be accessed and used by educated patients and the grass root level health care workers as well.

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METHODS:

Understanding the problem:

Both the literature survey and clinical experience tally in our case. A simple prescription survey revealed a huge gap between the practice behaviour and the recommendations of the GINA guideline. [4] There has been an urgent demand to address the problem by developing some effective intervention. Hence, a decision to make a computerized CDSS was proposed in our group discussions amongst the members of the institute in collaboration with the School of Medical Science and Technology, Indian Institute of Technology, Kharagpur. A team was then formed to accomplish the job.

Steps of making

All the decisions and developments in making the CDSS were accomplished through several group meetings amongst the members of the team. GINA 2008, being a familiar guideline in India [7] was selected after reviewing several other guidelines. Some vital areas which were chosen from the GINA guideline are:

1. diagnosis from the questionnaire.
2. understanding the status of control from the questionnaire.
3. the triggers .
4. treatment recommendations according to the status of control .
5. understanding of an exacerbation with its assessment; making the best possible decision recommendations including the actions to be taken in an emergency situation.

Whenever possible, each of the issues such as the diagnosis, assessment of the status of control and finally the treatment as provided by GINA guidelines were addressed. The best algorithms on each issue, from amongst several decision making algorithms (in flow chart formats), was chosen in group meetings (see flow chart 1 for the diagnosis of asthma algorithm). Each flow chart is framed and prepared digitally while its display on the screen was prepared with the help of the JAVA. Here the GINA-principle guided set of questions are displayed with provisions to tick the right choice on a radio button (see figure 1). An interconnection has been made between the different sets of questions in a rational and logically acceptable algorithm as discussed. Hence, the user finds it easy and helpful to move from the issue of diagnosis, to the issue of status of control, to the identification of the triggers, understanding and availing the best available treatment for various situations including exacerbations. On each page, we provided hyperlinks to a simple description of the medical terminologies used by us to make the learning easy for the users. A decision is derived and displayed at each set of questions and a provision has been made to retrieve a decision series at the end so that the user is provided with a reasonably elaborate impression of his or her status. Finally, a small text has been added at the beginning to inform the user about the purpose of the CDSS. This is to impress upon him that a decision support system is not a substitute for proper medical attention and attendance. The software is made capable of detecting any wrong choice in replying to a set of questions. It also has the ability to provide immediate feedback regarding an inadvertent omission or error and also guide the user to correct the error/omission. In the identification and assessment area of the acute stage, a limited positive response has been given importance so as to direct the patients for optimum care as a benefit of doubt. In addition, a link, “know asthma”, is placed at each page to take a reader to a simple but effective text to understand the disease where we have placed real pictures demonstrating the use of different inhalation devices and the peak flow meter and kept provision for videos as hyperlinks to educate the user. The areas of education on asthma actually covered asthma as a) the basic knowledge about the disease with understanding of the basic physiology and terminology, b) the prospect of total control of the disease without much toxicities with proper education and regular use of inhalations in the right fashion, c) educating about the use of peak flow meter and keeping a good peak flow chart, d) educating to identify and avoid the circumstances that may trigger the asthma attack, e) educating about the necessity of monitoring the disease responding to a questionnaire that includes lung function tests (the home monitoring with peak flow meter), and finally f) educating to make the best the best possible action at a point of time according to the situation concerned (stable or exacerbation).

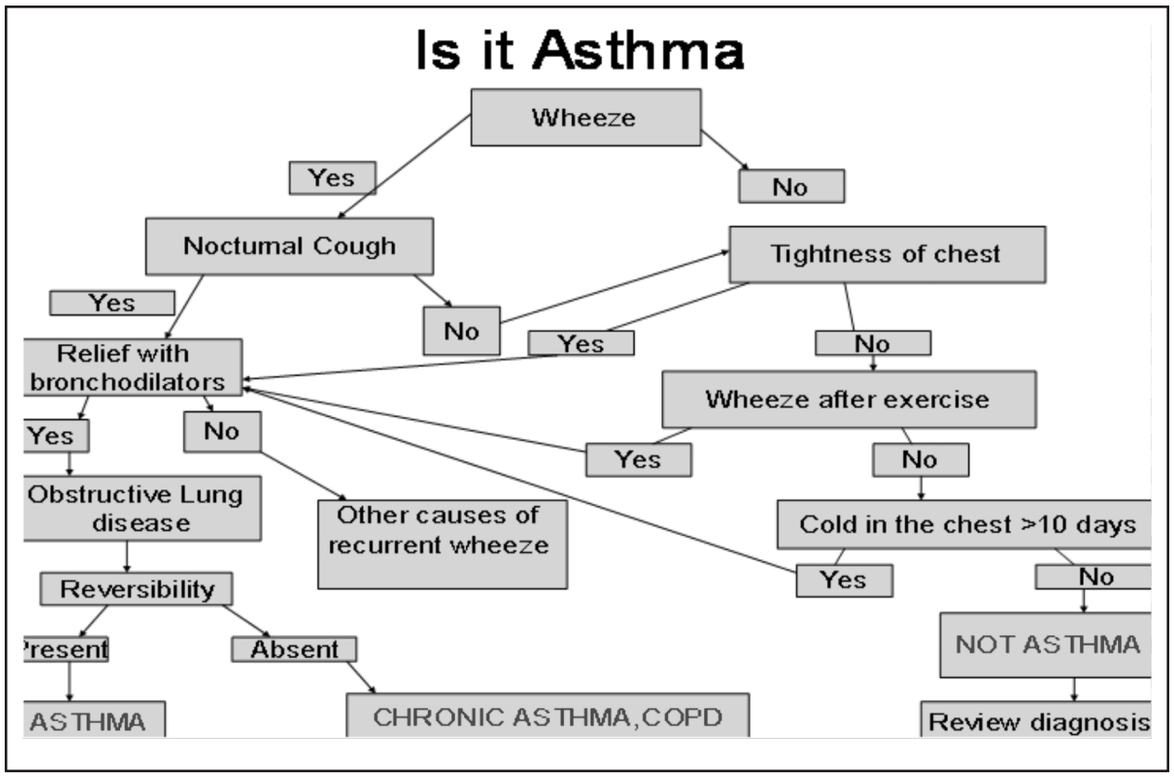
RESULTS:

A CDSS has been successfully developed following the decision algorithms as planned and named as ACCESS (Asthma Care, Control, and Education Software System). All these algorithms have been connected successfully to have an effective logistic regression of decisions regarding the diagnosis, status of control, avoidance of the precipitating factors, and finally making the best possible therapeutic decision or action as per the principles of GINA guidelines. The hyperlinks including the “know asthma' section has also been effectively incorporated. The display of a response collection format based on a decision algorithm is given in figure 1. We have displayed the product to several doctors and patients with good verbal feedback. The completed CDSS has been tried in practice on a small number of patients. Some modifications have been incorporated and it appears ready for use with provision for further improvisations.

DISCUSSION:

Asthma is an increasing global problem. With the tremendous progress in understanding the pathophysiology and with the revelation of the inhaled drugs, the management of asthma has become much easy and rewarding and today, the experts are even hopeful of making the total control of asthma. [15] Asthma guidelines available from the nineties have put forward evidence based information with an attempt to rationalize the practice habit and maintain uniformity in the diagnosis and management of the disease. [2, 3, 4, 5, 6, 7] GINA, formed in 2002, has been very active in preparing the guidelines and the latest, updated GINA 2008 guidelines, is accepted globally. [7]

Flow chart 1



Flow chart 1: The chart shows logistic algorithm (regression) to derive a likely diagnosis through serial reply to a set of questions.

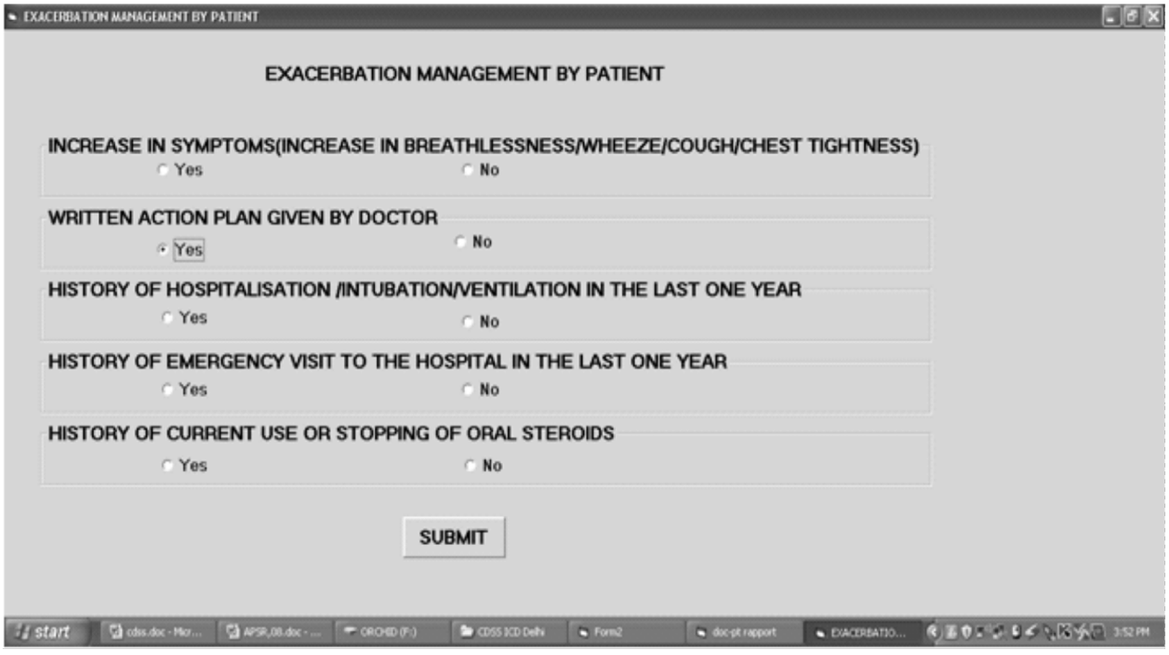


Figure 1: The figure elaborates the questions been displayed at the front end with provisions to tick the right choice on a radio button.

Despite the availability of such excellent guidelines as the GINA 2008 version, there has not been expected improvement in the practice behaviour of doctors globally. There has been a huge gap between the guideline recommendations and what is actually practiced on ground. [8, 9, 10, 11, 12] General practitioners miss the diagnosis in many an occasions. [16] The prescribing patterns of physicians also suggest that the use of anti-inflammatory asthma medication is not consistent with the guidelines' recommendation. [16]

Surveys amongst pediatricians report barriers to guideline adherence. [17, 18] They derive from lack of awareness, lack of agreement with specific recommendations, and even lack of agreement with the concept of guidelines in general. Regarding the NHLBI (National Heart Lung and Blood Institute) guidelines, barriers such as lack of familiarity [19] and lack of agreement [20] have been documented among internists. Additional hypothesized barriers include economic disincentives, patient noncompliance, and inadequate time or resources. [21, 22] Focus groups suggest that physicians encounter different barriers when using different components of asthma guidelines. [23] Thus it appears that bridging the gap between the guidelines and practice will probably be the most important intervention today to improve the quality of care of millions of asthmatics.

Improving the adherence of physicians to a particular guideline may not be possible from a generalized intervention as the barriers may differ from one setting to another. [24] To help the job, both paper and computer based decision support systems (DSS) has evolved over last two decades. It has been found that the computer based decision support systems (CDSS) improve the physicians' compliance with specific treatment guidelines. [25, 26] CDSS are interactive computer programs designed to assist physicians in decision making. The basic components include a dynamic knowledge (medical) base and an inferring mechanism (rules provided by experts or evidence based information). It is implemented through a medical logic module based on expert system or artificial neural networks or both. Decision support systems are not new but the addition of computerized DSS need more attention in today's world. Their application at the point of care is comfortable and involves the incorporation of adequate and detailed capture and storage of patient data in an electronic format. This allows the display of logistic regression with artificial neural network and on the spot recommendations according to the peculiarity of the case concerned. Thus, an explicit computerized protocol, driven by patient data, can produce patient specific output (instructions). Hence, an individualized treatment, based on standardized clinical decisions becomes possible. [12, 13] This is an important non-intuitive property that deserves emphasis among clinicians.

Clinical CDSS are more recent developments on our artificial intelligence. The potential benefits of CDSS fall into 3 broad categories as- a) improved patient safety, b) improved quality of care, and c) improved efficacy of health care delivery. Many CDSS improve practitioner performance. [27] Use of handheld computers that can provide the guideline based DSS was found to be associated with increased adherence by physician to guidelines' recommendations. [28] It has been observed that computerized DSS are also likely to reduce the rate of error and increase the compliance to evidence based recommendations. [29] A clinical decision error may be catastrophic in certain situations. An error rate of even 1% in the intensive care unit (ICU) can threaten patient safety in a significant manner. [30, 31] This is probably applicable to acute asthma settings and may also be true for other non-ICU situations as for stable asthma. Thus, it is important to standardize the clinical decisions with reduction of unnecessary variation in practice behaviour; A CDSS may be of tremendous help in such a situation. The adherence to a systematic approach based on an evidenced based protocol has potential to ameliorate the current problem of guideline – practice dissociation. Here, the use of computerized protocols at the time and place of delivery of patient-care appears as a reasonable way of improving treatment quality and reducing error. [12, 13, 14]

Meanwhile, over the last decade or so, computers are widely used and have become popular globally with the exponential growth of internet use. Hence, it is prudent and timely to intervene, to prepare and adopt an easy, effective, and internet friendly CDSS for asthma, based on the popular and globally accepted GINA guidelines (2008).

For a successful CDSS the following features are found necessary:- a) automatic provision of decision support as a part of clinician workflow ($p < 0.00001$), b) provisions of recommendations rather than just assessments ($p<0.0187$), c) provision of decision support at the time and location of decision making ($p<0.0263$), and d) computer based decision support ($p=0.0294$). [32] This has been inferred by analyzing 70 studies on 15 CDSSs of which 68% of cases showed significantly improved clinical practice with use of CDSS. [32] From this point of view, the CDSS model developed by us has been a successful one since it meets all the criteria mentioned above.

With all the advantages of a CDSS, there are few limitations too. Though the CDSS, covers the population in general, it has no special provision for the pediatric age group/recommendations. Also it has not been tested in field practice. Further, we are yet to ascertain the minimum educational qualification required for the patient or user that is necessary for its successful use. This needs further validation in actual field practice. There is room for further improvisation based on the feedback/opinion of experts and the users in general. We foresee that with translation into different languages, this CDSS model can be successfully used across various communities.

CONCLUSIONS:

An effective CDSS for asthma care, control, prevention has been developed. It, however, needs further validation in actual field practice.

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