INFORMATION AND COMMUNICATION TECHNOLOGY DEVELOPMENTS IN ASTHMA MANAGEMENT: A SYSTEMATIC REVIEW

VENKATA RAMA SATYA KUMAR DUVVURI, WU JIANHONG

ABSTRACT

This review aims to explain the progress of information and communication technology (ICT) applications in asthma management. Appropriate literature was printed out from the bibliographic databases and library source using relevant key phrases of ICT and asthma. The ICT developments from simple to complex modules to augment the conventional methods of asthma care with a caution of excessive reliance upon technology were discussed. However, it should be noted ICTs are for maximizing the human clinician’s own ability to receive and process information as well as providing unique opportunities for patients, physicians, pharmacists and researchers.

Key words: Asthma, communication, information, management, technology

BACKGROUND

Asthma is an inflammatory chronic public health problem throughout the world [Figure 1] affecting people of all ages, which can result in variable restriction in the physical, emotional and social aspects of a patient’s life.[1,2] It is estimated that around 300 million people in the world currently have asthma.[3] The prevalence of asthma increases as communities adopt modern lifestyles and become urbanized.[4] With the proportion of the world’s population living in urban areas projected to increase from 45 to 59% in 2025, there is likely to be a marked increase in the number of people with asthma worldwide over the next two decades. It is estimated that there may be an additional 100 million people with asthma by 2025.[5]

Effective management of chronic illness requires a close partnership between the patient and all health care providers.[6] Recent studies have shown that long-term monitoring of asthma severity can reduce asthma exacerbations, optimize drug therapy and decrease the cost of asthma management.[7] The management of a chronic patient is a collective and cooperative enterprise that may exploit Information Technologies to improve the overall quality of care.[8] Most consideration among them is given to Internet technologies and decision-support technologies.[9,10] Emerging at the beginning of the last decade, the world-wide web rapidly imposed itself as a new medium for interconnecting people throughout the world. Overstepping the initial publishing purpose, Web applications currently evolve towards the setting up of virtual working and communication spaces, intended to be used by specific communities of users.[11] The use of the web for telemedicine applications seems now-a-days a compulsory solution: the web has become a standardized infrastructure for giving access to sophisticated telemedicine applications from virtually any machine and operating system. Such standardized communication platform guarantees accessibility and usability advantages to both patients and physicians.[12,13]

The aim of this review is to emphasize the advancement of technological trends in asthma management that are significantly involved in every phase of telemangement/remote management of chronic disease. This paper is structured as sections: 1. Background; 2 Materials and Methods; 3. Results and Discussion and finally, 4. Conclusions.

MATERIALS AND METHODS

We developed a search strategy to find any publications about the computer, communication and information technology related to asthma and used these to search the MEDLINE (1966 to current update), CINAHL, DOAJ, PubMed databases using the key phrases telemedicine, teleconsultation, telepharmacy, patient education, database, decision support system (includes artificial intelligence, decision trees, neural networks, expert system), geographical information system and asthma. The appropriate literature was printed out from the online source and library (journal) source.

RESULTS AND DISCUSSION

From the review of literature, we found some important cornerstones, which can play their indispensable role in effective management of asthma [Table 1]. These were discussed in detail under the following sub-headings.

Telemonitoring (TM)

TM is defined as the use of information and communication technology (ICT) to monitor patients at a distance for or for remote monitoring of patients, including the use of audio, video and other telecommunication and electronic information processing technologies.[15] In 1905, Dr. Einthoven
Table 1: Information and communication technology developments for asthma management

<table>
<thead>
<tr>
<th>Author</th>
<th>Sample</th>
<th>Intervention</th>
<th>Outcome</th>
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<tr>
<td>Finkstein et al, 2000[20]</td>
<td>31 asthma patients</td>
<td>Home monitoring of portable spirometer and palm top computer</td>
<td>Validity of spirometry self-testing and acceptability of an internet-based home asthma telemonitoring system by asthma patients. All patients performed spirometry twice daily on their patients from their own home for 3 weeks. Home monitoring of portable spirometer and palm top computer. Data transmission by telephone modem. Development of support tools for notifying physicians and patients about changes in data trends. Results showed that the system provides reliable reciprocal exchange of all relevant information between a physician and asthma patient in home settings. Average data transmission time was about 1 minute by fixed telephone and 6 minutes by mobile phone. The analysis of the spirometry data detected early signs of deterioration in 19 pts. Significant decrease in emergency room visits and improvement in peak expiratory flow rates in telemedicine group.</td>
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<td>Finkstein et al, 1998[19]</td>
<td>10 healthy volunteers</td>
<td>Home monitoring of portable spirometer and palm top computer</td>
<td>Use of Handheld wireless computer devices (eg, personal digital assistant or pocket personal computer) to prevent emergency department visits and to improve outcomes for patients with severe persistent asthma. Results from the surveys and interview data indicate that users are happy with LinkMedica.</td>
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<td>Bruderman and Abtou, 1997[49]</td>
<td>39 patients</td>
<td>High-risk patients randomly assigned to control or intervention group</td>
<td>Developed an improved tele-monitoring system for the management of asthmatic and lung transplant patients that consisted of three main components: a patient, a hospital and a laboratory sub-system. With the daily monitoring, the system intends to achieve a better follow-up of patients and for the asthmatics, hopes to get an objective measure of their response to therapy and a better control of their illness.</td>
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<td>Anderson et al, 2001[50]</td>
<td>20 patients</td>
<td>Use of mobile phone and electronic signal transfer by e-mail and voice mail to study travel breath sounds in individuals</td>
<td>Use of mobile phone and electronic signal transfer by e-mail and voice mail to study travel breath sounds in individuals. Spectrograms from the patients and non-patients were significantly different. This method could be a non-invasive method of monitoring airway diseases.</td>
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<td>Chan et al, 2003[51]</td>
<td>Not applicable</td>
<td>Utilization of an internet-based store-and-forward video telehealth system to manage asthma in children.</td>
<td>With the daily monitoring, the system intends to achieve a better follow-up of patients and for the asthmatics, hopes to get an objective measure of their response to therapy and a better control of their illness.</td>
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<td>Motion et al, 1999[52]</td>
<td>6 patients</td>
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<td>Chang et al, 2003[53]</td>
<td>Adolescents with severe asthma</td>
<td>Use of Handheld wireless computer devices (eg, personal digital assistant or pocket personal computer) to prevent emergency department visits and to improve outcomes for patients with severe persistent asthma. Results from the surveys and interview data indicate that users are happy with LinkMedica.</td>
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<td>Arth et al, 2004[54]</td>
<td>Two user surveys were carried out for tool</td>
<td>‘AstraZeneca’ launched a web service for asthma patients and health-care providers called LinkMedica, which included three main sections: Asthma Management Centre (AMC), Knowledge Centre (KC) and Forum. Patients were able to create their own accounts online, while health-care providers required to contact AstraZeneca to get registered. The registered patient may select one or more doctors or nurses from the list of available health-care providers. This procedure ensures that both parties have accepted their collaboration via LinkMedica and finally, patient receives a notification based on the doctor’s decision either accepted or rejected.</td>
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<td>Guendelman et al, 2002[55]</td>
<td>60 patients</td>
<td>N = 134 8–16 years, attending primary care clinic, with diagnosed asthma.</td>
<td>The Health Buddy (HB) Interactive communication device connected to a home telephone system. Questions on asthma management and functioning, trivia and asthma facts were transmitted daily for children to answer. Immediate feedback to answers provided from the device. Control group completed a standard asthma diary.</td>
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<td>Ostojic et al, 2005[56]</td>
<td>16 asthma subjects</td>
<td>N = 16 asthma subjects</td>
<td>Telemedicine in PEF monitoring. A 16-week randomized controlled study was done to assess the GMS-SMS technology reliability in self-management.</td>
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<td>Ryan et al, 2005[57]</td>
<td>91 patients</td>
<td>N = 91 patients</td>
<td>Use of mobile phone technology in asthma telemanagement.</td>
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<td>Linda et al, 2005[58]</td>
<td>300 asthmatic patients, 6 months prospective study was conducted</td>
<td>All subjects were randomized to 3 parallel groups: (1) Internet-based monitoring; (2) specialist monitoring; and (3) general practitioner monitoring.</td>
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<td>Dobre et al, 2002[59]</td>
<td>Not applicable</td>
<td>‘ASISTASTM’, developed for the assistance of diagnosis and treatment of chronic asthma.</td>
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Evaluation and an online survey among users, a mailed questionnaire to health care providers, as well as in-depth interviews with 10 patients and 5 general practitioners.

In general, patients find that the asthma diary helps them manage their disease and doctors find that the diary improves asthma control in patients using it. LinkMedica is considered a trustworthy and reliable system that offers high quality disease information by patients and doctors. Despite positive attitude, there was unwillingness among patients to use the device for more than short periods, the primary reason being that LinkMedica did not fit into their everyday lives because of technical and psychological aspects.

Children in HB group less likely to have limitations in activity than diary group. HB group had odd’s of sub-optimal peak flow than diary group. HB group more likely to take medications without reminder at 12 weeks. Those who used HB or diary without reminder reported less wheezing and coughing and lower restriction of activities. Daily compliance with both HB and diary declined with time, although faster decline in HB group. Peak expiratory flow (PEF) variability was significantly smaller in the study group when compared with control. Controls had significantly higher scores in the morning and night symptoms. No significant difference between the groups in daily consumption of inhaled medicine, forced vital capacity and asthma compliance. This study concludes that SMS is convenient, reliable, affordable and secure means of telemedicine that may improve asthma control when added to a written action plan and standard follow-up.
Rubin et al., 1989, 2005

N = 54 (moderately severe asthma were randomly assigned)

An interactive computer game for children with asthma was written on an Apple Iie microcomputer in BASIC language. Total subjects were grouped into control subjects (n = 29) played routine computer games and Experimental (n=25) played Asthma Command. Follow-up studies were also conducted to asthma behavioral questionnaire.

Yawn et al., 2000

N = 87 (3 classes at elementary school (age 9-10 yrs)

"Air Academy The Quest for Airtopia"; CD-ROM aimed to promoting asthma self-management and intervention using interactions and analogy. To classes acted as an intervention and control groups. Intervention group given opportunity to use it in school approx 60 mins per week over 6 weeks, for patient’s identification and usage of the facilities offered by the Internet. A significant difference was evidenced by improved inhaler technique in all patients. There were fewer ED visits for asthma exacerbations, fewer unscheduled active clinic visits and no hospitalizations during study. Children with asthma followed by teleconsultation have improved control, although the enthusiasm for the prescribed asthma medication was disappointing due to the lack of compliance of the primary care providers with the prescribed pathway. To overcome these drawbacks, there is a need to develop unique disease specific platforms.

McPherson et al., 2006

N = 101 children aged 7-14 years attending asthma outpatient clinic

"The Asthma Files" Interactive CD-ROM using secret agent theme providing information about asthma self-management. It stores information about the child and produces a self-management plan. Children randomized to receive booklet (control group) or computer-assisted reinforcement of information proved to be an effective method of increased asthma knowledge and in improving children’s knowledge about asthma avoidance activities.

No significant increase in asthma. Parents had a poor understanding of preventing exercise-induced asthma, side effects of inhalers, how to talk to children about an asthma attack. All reported they had enjoyed using the program and had benefited from using it.

Children in both groups improved - reduced emergency visits and reported asthma severity. Aids, improvements in child behaviour and use of peak flow meters, but no difference between the groups. Increased knowledge scores in computer group significantly higher than control.

Post-test scores for intervention group significantly higher than pre-test, but no between-group differences. Intervention group had significantly greater scores on open questions than control and had greater increases in self-efficacy. Significant improvements in asthma knowledge and self-efficacy for both self-management behaviours and talking to friends immediately after playing and one month later. Improved communication with parents about asthma in month following game use.

All children and parents demonstrated improved knowledge levels between baseline and 6 month follow-up. Improvement in knowledge scores for intervention group. Higher knowledge levels at 6 months in all children associated with fewer urgent physician visits and reduced short-acting reliever medication Higher knowledge levels in carers of children aged and emotional functioning. Both groups demonstrated significant improvement in range of health outcomes. Intervention group showed significantly greater improvements in number of days experiencing asthma symptoms, emergency care and doses of inhaled steroids. Program easy to use by children and parents, although only 23% of children and approx. 37% of parents rated it as enjoyable. Majority would use it again.

Computer group had greater knowledge than control at 1 month. Control group more likely to have required oral steroids or time off school than control group during 6 month follow-up period. Program popular across age-range.

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booklet plus computer game (intervention group). Game taken out to children’s homes on laptop computer. Measures taken at baseline, one month and six months. Developed the Home Automated Telemangement (HAT) system for patients with different chronic health conditions to facilitate their self-care. This system consists of a home unit, HAT server and clinician units. Patients at home use a palmtop or a laptop connected with a disease monitor on a regular basis. Every HAT session consists of self-testing, feedback and educational components. The self-reported symptom data and objective results obtained from disease-specific sensors are automatically sent from patient homes to the HAT server in the hospital. Any web-enabled device can serve as a clinician unit to review patient results. The HAT system monitors self-testing results and patient compliance. The HAT system has been implemented and tested in patients receiving anticoagulation therapy, patients with asthma, COPD and other health conditions.

Evaluation results indicated high level of acceptance of the HAT system by the patients and that the system has a positive impact on main clinical outcomes and patient satisfaction with medical care.


N=100 enrolled prospectively in the study during their first consultation in the outpatient clinic.

Reznik et al, 2004[4,5]

N= 60 An interactive video-conferencing was introduced to deliver asthma education to inner city immigrants in 2004. Short presentations were given on asthma triggers, medications and the prevention of asthma exacerbations. To test gains in knowledge, a self-completion questionnaire consisting of true/false statements before and after the videoconferences were administered.

No significant differences between groups on asthma symptoms, quality of life or lung function. Intervention group knew more about medication and alternative. Comparing electronic with paper questionnaires, this study revealed statistical evidence to support the use of electronic data capture (EDC) of the (SALOQ), (PAQOL) and (PACQLQ) for populations with asthma.

User-friendly and query based action plan database.

Mangold et al, 2005[6,7]

Electronic Asthma Action Plan Database. Database was designed by using Microsoft Access for the creation of asthma action plans that can be shared between providers caring for patients with asthma and contains 400 asthma action plans in the database. Use of “form entry” is very user-friendly and one can easily create an asthma action plan, store it to the database, print the final product to provide and review with the patient, feedback form for medical staff, help accessibility, able to be queried and able to be networked.

All the experts evaluated the ES conclusions. Experts judged that the severity scores given by ES were as good as those proposed by their colleagues and that the overall conclusions given by ES were as good as or better than those given by their colleagues.

Manon et al, 2003[8]

Not applicable

Use of Asthma Critic as a critiquing system, for regular collection/recording of electronic patient data to select and analyze records of patients with asthma or chronic obstructive pulmonary disease (COPD). The system provides a professional autonomy, Interference consistency, Timing, Information conciseness, Information Justification and Personal autonomy to physician. An Expert System Knowledge Base, a novel approach to promote guideline congruent asthma care. This system is related to both the clinical asthma management and the enhancement of patient and family self-management. The resultant knowledge base comprises 142 multilayered decision rules that describe clinical and overall treatment.

Shegg et al, and accessible 2004[9]

Not applicable

The AI score assessed higher levels of severity than the other scores. Significant correlation observed between AI score and forced expiratory volume in one second (FEV1). This score appears easy to use for the first constitution of an asthmatic patient.

Austin et al, 1996[10]

Not applicable

General Architecture for Medical Expert Systems (GAMES-II) methodology was used for the development of prototype computer decision support system. The prediction model may draw attention to some high-risk patients who have not been found by clinicians. Modelling results indicated that there was different behaviour for the 20-25 and 25-44 age-groups and separate neural-network models were constructed for each of these two age-groups. A set of inference rules was then extracted from each of the two neural networks. When applied to test data, the inference rules predicted the occurrence of asthma correctly in approximately 70% of the cases. Our approach may prove to be useful in simulating the effect of scenarios of environmental change on the occurrence of asthma.


Not applicable

To assess the asthma severity using knowledge-based Expert System (ES). Implemented with Nexpert and Hypercard, it runs on a MacIntosh personal computer. This expert system provides a systematic approach for intervening with family asthma related behaviors.
Development of prediction models using data mining applications i.e., Classification and Regression Tree (CART) algorithm to forecast asthma exacerbations using patient information collected by home tele-monitoring systems (HAT), on daily basis. Three models were developed using all respiratory symptoms, peak expiratory flow (PEF), drug utilization (independent parameters) and asthma severity (dependent) data. Model I utilized all predictive variables, model II employed only 3 variables identified by CART as the most powerful predictors, and model III used only asthma symptom variables. To develop an efficient tool for quality assurance and chronic disease management using GIS. Drug dispensing registry, demographic data, Emergency room visits and hospitalization databases were used for data collection. Six markers were created for identifying inadequate pharmaceutical treatment of childhood asthma from the Israeli clinical guidelines. Using GIS, thematic maps were established to locate clinics with a high percentage of children for whom the treatment provided was not in accordance with the clinical guidelines. Environmental quality and pollen counts were used to represent local exposure to potential environmental stimuli. Personal questionnaire interviewing collected additional data about patient lifestyles, social-economic conditions and quality of life perceptions. Assessment tools such as GIS and object-oriented databases were designed to locate and compile environmental information about the patients’ locations and lifestyles in the study areas (London and Barcelona). GIS was used to examine the association between Childhood asthma and traffic flow. Socioeconomic and lifestyle factors were found to have limited detectable effects on the patients’ basic lung function levels. Patients’ gender, age and predicted PEF were significantly associated with minimum respiratory measurements. Lung function data were compared with air quality and pollen indicators to examine relationships on a daily or lagged-day basis controlling for confounding factors. The study discusses the new methodology and the practicalities of using the telemedical system as a tool for assessing the impacts of environmental stimuli on respiratory health. Results of this exploratory study suggest that higher traffic flows may be related to an increase in repeated medical visits for asthmatic children. Repeated exposure to particulate matter and other air pollutants from traffic exhaust may aggravate asthma symptoms in individuals already diagnosed with asthma. CART algorithm prioritized three predictor variables (normalized number of puffs of quick relief inhaler, normalized PEF and asthma symptom score) based on their level of influence on the “asthma severity class” variable. The resulting forecast rules yielded good overall prediction success rates from both the learning (87.2%; 98.6%; 96.2%) and testing (86%; 96.5%; 95.2%) samples of models I, II, III respectively. Model I generated 63 decision rules accurately characterizing both “low” and “high” severity classes. CART algorithms showed acceptable accuracy in forecasting asthma exacerbations.

Eighty-one percent of the children were found to have at least one marker for inadequate treatment: 17.5% were found with more than one marker. Children with markers were shown significant higher rates of Emergency room visits and hospitalizations when compared with children without markers. Integration of clinical guidelines, administrative data and GIS can create an efficient interface between administrative and clinical information.

Various research groups have exploited the date-to-date advancements in ICT for TM of asthma, thereby, leading to the improvement of disease management. Kokubu et al.[18] developed a telemedicine system to monitor the airway status at home for patients with poorly controlled asthma, whereby a nurse, under the supervision of their physicians, provides instructions to individuals via the telephone to help them manage exacerbation. The number of emergency room visits decreased significantly and the activities of daily living improved in the telemedicine group. Home TM system was developed for improved management of asthmatic and lung transplant patients, with daily monitoring and better follow-up.[19,20] These systems allow early recognition of potentially dangerous situations and timely interventions. A telematic system for monitoring of asthma severity in patients’ homes was developed by Finkelstein et al. to deal with these limiting factors.[21] Results showed that the system provides reliable reciprocal exchange of all relevant information between a physician and patient in home settings. A follow-up study was done by same group[22] to evaluate the validity of spirometry self-testing and to assess the acceptance of an Internet-based home asthma TM system by patients. Majority of patients indicated that the self-testing was not complicated at all and also showed strong interest in using home asthma telemonitoring in the future. Anderson et al.[21] used mobile phone and electronic signal transfer by e-mail and voice mail to study tracheal breath sounds, which are widely accepted as an indicator of disease activity in patients. Spectrograms from patients were significantly different from those from people without asthma. The immediate benefit of mobile phone recordings includes accurate timing of the measurement, which might for instance improve compliance with an associated peak flow measurement.

For the first time, a web-based home monitoring integrated store-and-forward video technology was developed by Chan et al. to improve the adherence to medications, especially those requiring careful technique.[22] There was high rate of satisfaction with home TM, followed by no emergency department visits, hospitalizations and few unscheduled visits. Handheld wireless computer devices such as Personal Digital Assistance (PDA) were used to facilitate data transfers and frequent communications between the nurse and the adolescent asthmatic patient.[23] Usage of PDA resulted in obtaining information about patients’ behavior and maintaining patients’ behavior to control their asthma on a regular-basis, which ultimately increased the quality of life. PDA technology cost will be less than the cost of emergency department visits ($1,324 per patient) or inpatient hospital stays ($5,316 per patient). In May 2000, AstraZeneca launched a Web service called LinkMedica for asthma patients and health-care providers.[24] Patients found asthma diary helps them to manage their disease, and
doctors found that the diary improves asthma control in patients using it. But there was unwillingness among patients and doctors to use the site for more than short periods, the primary reason being that LinkMedica did not fit into their everyday lives due to technical and psychological aspects. Similar to LinkMedica, another program, the Health Buddy (Health Hero Network), was designed.\(^{(26)}\)

Ostojc et al.\(^{(27)}\) established the feasibility and utility of Global System for mobile communications (GSM) mobile telephone short message service (SMS) for PEF monitoring. The results concluded that SMS is a convenient, reliable, affordable and secure means that may improve asthma control. Mobile phone technology was used in asthma telemangement by Ryan et al.\(^{(28)}\) to assess patient compliance. The primary outcome measure was compliance. Despite positive results, some technical difficulties were observed. A study was conducted to assess the outcome of monitoring and treatment using a physician-managed online interactive asthma monitoring tool, which comprises three modules; an electronic diary, an action plan for the patients and a decision support system for the physician, in comparison with conventional asthma treatment by Linda et al.\(^{(29)}\) The outcome was significantly improved quality of life, lung function and airway responsiveness for the Internet group, but the costs were higher.

Above-mentioned TM allows the patient to monitor his or her disease severity continuously in natural environment, which avoids the ‘white-coat’ effect and allows the physician to obtain a more realistic view of the patient’s health status on a day-to-day basis. The main setbacks of TM development include the initial costs of systems, physician licensing and reimbursement.

**Teleconsultation (TC)**

The use of ICT is to enable clinical consultation between geographically separated individuals, such as health care professionals and their patients.\(^{(30)}\) TC is the deliberation by two or more physicians with respect to diagnosis or treatment in a particular case via ICT. Often, it involves the process of obtaining an opinion from a specialist, where there is no consideration payable to the specialist assuming care for the patient. Telemedicine lends itself readily to the process of consultation. It may allow a venue for patient referral and, in many cases, will help to avoid or at least facilitate patient transfer.

ASISTASTM is a system developed for the telematic assistance in diagnosis and treatment of chronic asthma.\(^{(31)}\) The system offers assistance for the medical act in finding, diagnosing, establishing the therapeutic conduct and tracking over a period of time by use of smart cards for patient’s identification and usage of the facilities offered by the Internet. Francis et al.\(^{(32)}\) implemented a web-based store-and-forward teleconsultation asthma management system to coordinate care between the primary care provider and asthma specialist. In this study, different technical devices were used, such as a desktop computer with Personal Computer Memory Card Interface Architecture, spirometry card, digital video camera and flatbed scanner (for radiographs) and a website. No patients were hospitalized during study, and the provision of asthma education increased from 18 to 73%. Children with asthma followed by TC have improved outcomes, although the enthusiasm for the prescribed asthma pathway was disappointing due to the lack of compliance of the primary care providers with the prescribed pathway. To overcome these drawbacks, there is a need to develop unique disease-specific platforms. Twiggs et al.\(^{(33)}\) developed an automated asthma medication management information system that provides pediatric asthma disease management program. Post hoc review analyzed case errors to determine prevalence of nonguideline medicating practices among these practitioners. Practitioners used severity-appropriate medications for 60% of cases.

**Patient Education (PE)**

Communication between the patient and the family physician is a key factor affecting both the process and outcome of care. Well-informed patients are more likely to become active partners in the management of their own health.\(^{(34-36)}\) According to the Diagnosis and Management of Asthma Expert Guidelines,\(^{(37)}\) PE is a critical component of quality asthma care.\(^{(38)}\)

\(\textit{a. Pediatric and adolescent asthma education:}\) Various researchers have developed interactive computerized PE programs and concluded that they are effective in the management of several diseases.\(^{(39-42)}\) Asthma command program showed improvements in knowledge and in self-reported asthma management in patients, when compared with children in the control group.\(^{(43,44)}\) Bronkie the Bronchiasaurus has been shown to positively affect knowledge, self-efficacy and communication about asthma in children who use it.\(^{(45)}\) Airtopia has been shown to positively affect asthma knowledge in children who used in the context of a general health curriculum\(^{(46)}\) and gained knowledge was retained over a 4-week period. However, in the above studies there were no demonstrated differences in visits to physician, emergency rooms or hospitals. To determine computer-assisted instruction effects on adherence to implementing house dust mite avoidance measures in adult atopic asthmatics, Huss et al.\(^{(47)}\) conducted a randomized study. Results have indicated significantly greater adherence scores to computer group when compared to other.

Another interesting education program ‘Breathe-Smart,’ a touch screen using photographs and cartoon graphics, was developed by Fall et al.\(^{(48)}\) but they found much encouraging outcomes. Homer et al.\(^{(49)}\) created ‘Asthma Control,’ which helps to improve children’s behavior in terms of protecting from indoor and outdoor triggers. This program was found to be considerably useful for making self-management decisions. Shegog et al.\(^{(50)}\) developed a pediatric asthma self-management education program ‘Watch, Discover, Think and Act.’ Evaluation reports demonstrated significant higher scores and improved self-efficacy. Chan et al.\(^{(51)}\) developed the first time a
web-based integrated store-and-forward video technology to test the feasibility and effectiveness of Internet-based asthma education. A handheld communication device such as PDA was used to improve the outcomes of adolescent patients with severe persistent asthma. Guendelman et al. reported that educational interventions through an integrated self-management educational program Health Buddy (Health Network) encouraged children’s active involvement in the control of their asthma problems. Krishna et al. developed an ‘Interactive Multimedia Program for Asthma Control and Tracking’ to access the information on causes, triggers and treatment of asthma through an Internet. An improvement of knowledge levels, fewer urgent physician visits and reduced medication were observed. Very recently, McPherson et al. established an Interactive CD-ROM using ‘secret agent’ theme providing self-management information, and outcomes revealed that intervention group gained greater knowledge. Most of the studies have reported similar findings when evaluating educational programs for children, most notably higher knowledge levels, although the method and content vary between studies. Positive effects upon clinical outcomes have been demonstrated in some studies.

b. Adult asthma education: For adult asthma patients, computer-assisted instructions (CAI) have been used to help them monitor and avoid house dust and/or mite allergen. Two asthma studies evaluated instructional computer programs to educate patients about allergen-avoidance activities. Takabayashi et al. studied the effect of asthma educational software for computer-assisted instruction. Emergency visits or admissions at least 1 year after the first CAI trial decreased. Finkelstein et al. developed the Home Automated Telemanagement (HAT) system and indicated high level of acceptance by the patients and that the system had a positive clinical impact and patient satisfaction. An interactive video-conferencing was introduced to deliver asthma education, and participants gained significant asthma knowledge. Interactive video-conferencing allowed asthma education to be delivered to a large immigrant population, elicited concerns from the audience and was effective in improving knowledge.

Despite benefits, there are a few considerable drawbacks of using computer technology for health education, such as lower socioeconomic groups, lack of technology availability, lack of literacy skills and algorithm complexity. Future computer interventions must be evidence based, and detailed evaluation work is essential.

Telepharmacy (TP)
Pharmacy is a knowledge profession built on the collection, evaluation, communication and use of drugs, diseases and patient information. In 1997, the National Association of Boards of Pharmacy officially defined TP as ‘the provision of pharmaceutical care through the use of telecommunications and information technologies to patients at a distance.’ According to Trotman, New York State Board of Pharmacy approved a regulation allowing prescriptions to be e-mailed over the Internet.

There is an urgent need to improve patient awareness about pharmacotherapy/drug usage by using system approaches, viz., ‘TP’, to enhance pharmacy care that might be an effective way to reduce inappropriate medication use. Providing instructions for correct MDI technique to patients can have a significant impact on asthma care. Pharmacists are valuable members of health care teams, especially for patients of communities residing in areas where there is shortage of rural health professionals; such patients require consistent, reliable and readily available counseling services for chronic disease management. Various communication systems that function as medication reminder aids may be useful. Monane et al. conducted a study to evaluate whether a computerized drug utilization review database linked to a TP intervention can improve suboptimal medication use in the elderly. Using a system integrating computers, pharmacists and physicians, large-scale intervention improved prescribing patterns and quality of care. Steven et al. used a ‘Paging System’ to improve medication self-management in asthmatic patients. Bynum et al. conducted a study to determine the effectiveness of pharmacists using interactive compressed video in teaching MDI technique and patient satisfaction among adolescents with asthma. Both TP counseling and control groups participated in pre-, post-tests. Results demonstrated that patient education provided by pharmacists via interactive compressed video was superior to written instructions. Interactive compressed video is an effective medium for teaching and improving the critical health-related educational services to patients, including proper administration and dosages of drugs.

These evaluation studies concluded that ICT is a potential intervention tool available to pharmacists in asthma care. The reviewed literature supports the use of ICT in pharmacy. Future research should focus on the demonstration of enhanced health outcomes resulting from improved prescribing choices.

Databases and other information systems
For any control program, baseline information in the form of systematic database is a primary requisite. The inter-relationships of the parameters can be studied through Database Management System. Collecting, storing, processing, managing and distributing information on all disease aspects can enhance efficiency in reducing asthma morbidity. In asthma management, several workers have developed various databases. Molly et al. used medication-dispensing information or prescription database from a large health maintenance organization to examine the utilization of anti-asthma medications. Results demonstrated the feasibility of using an automated outpatient pharmacy database to identify patients with asthma. Bushnell et al. studied the utilization of electronic and paper administration of the standardized, pediatric and pediatric asthma caregiver’s quality of life questionnaires. This study revealed statistical evidence to support the use of electronic data capture for populations with asthma. A user-friendly asthma action plan...
Decision support systems (DSS)

Artificial intelligence (AI) is the area of computer science focusing on creating machines that can engage on behaviors that humans consider intelligent. AI has split into several different approaches based on the opinions about the most promising methods and theories. DSS is a computer application designed to aid clinicians in making diagnostic and therapeutic decisions in patient care.

Clinical practice guidelines have been written to stipulate recommendations for the appropriate delivery of care in specific clinical situations. These guidelines have little impact upon actual clinical practice unless they are effectively integrated into the clinical setting. Hence, there is an urgent need to utilize ICT, which can facilitate the use of electronic medical records, Computer-based DSS could be used to integrate practice guidelines into the process of health care delivery. Asthmaexpert, a Knowledge-based Expert System to assess asthma severity, has been developed by Redier et al. It has been critically evaluated by the clinical experts and identified as a useful tool for discussing the management of asthma. During 1996, Austin et al. developed a prototype Computer DSS based on their General Architecture for Medical Expert Systems II methodology. This system is expected to provide a diagnosis or treatment regime having integrated information on symptoms, medications and measurements, with some internal knowledge of medicine. Computer-based prediction models were developed by Tracy et al., who concluded that these models can identify asthmatic children at high risk for future hospitalization and emergency department visits and may direct attention towards some high-risk patients who have not been found by clinicians. Simon et al. investigated the role of demographic and environmental factors in patterns of adult asthma symptom prevalence using connectionist-based analysis. Juan et al. employed algorithm proposed by Panhuysen and co-workers approach for the diagnosis of asthma in Chinese population with a high prevalence of smoking, as well as in an inability to explore any potential interactions between the genetic factors and cigarette smoking in the pathogenesis of asthma. From this study, they found that there is no correlation between the asthma and mapping genes that contribute to asthma, because these objects may be influenced by a smaller number of genes. Asthma Critic is a non-inquisitive critiquing system that generates critiquing comments and adds these comments to the patient record. This system uses routinely recorded electronic patient data to select and analyze records of asthma and chronic obstructive pulmonary diseases. Shegog et al. developed an Expert System Knowledge Base to promote guideline-congruent asthma care. This tool comprises 142 multilayered decision rules, which provide a systematic and accessible approach for intervening in family-asthma-related behaviors. Recent studies by Duvvuri and Finkelstein employed AI applications, viz., Classification and Regression Tree Algorithm, to forecast asthma exacerbations using patient information collected by HAT, on daily basis. This asthma DSS intends to aid the physician in prioritizing asthma-triggering parameters and to predict the asthma severity zone.

These are the works that highlight the usefulness of DSS, but a number of short-term and long-term risks are inherent in the use of such systems, however. The most immediate risks are those associated with the reliability and integrity of the software itself. Only properly trained health professionals know when to rely on such system and how to use the rules/output generated from such systems.

Geographical information system (GIS)

Epidemiological data from all over the world show an increasing prevalence of asthma morbidity and mortality despite the availability of effective treatment and also large geographic variations in asthma outcomes. These facts led to the emergence of new approaches for the management of chronic disease. GIS refers to computer-based programs with five basic functional components: 1. Acquisition and verification of data, 2. Data storage and database management, 3. Transformation and Analysis of data, 4. Data Visualization and 5. User Interface. One of the more powerful features of GIS is the ability to link several databases such as demographic, clinical and billing systems and create a high-resolution demonstration of the spatial distribution and behavior of the phenomenon. Therefore, the use of GIS in health-related studies is emerging as an important tool in health care planning, quality assurance and research. Several studies for asthma disease management were conducted using GIS approach, such as thematic maps to locate the clinics with percentage of children for whom the treatment provided was not in adherence with the clinical guidelines. These maps demonstrated in a robust way the association between inappropriate treatment and adverse effect. As an outcome, an efficient tool based on GIS approach was developed for allocating sites for quality assurance interventions. In a study to examine the effect of pollutants and allergens on asthmatic respiratory health, GIS with object-oriented databases were designed to accurately locate and compile environmental information about the patient’s location and lifestyles in study areas. In a case-control study, GIS was used to examine the association between childhood asthma and traffic flow. GIS allowed quick linkage of traffic count information to geocoded (ability to locate residences in...
space) address of asthma patients. The exploratory study suggested that high traffic flows might be related to an increase in repeated medical visits by asthmatic children due to exposure to pollutants.[87] The integrative features of modern GIS technology are incredibly helpful in summarizing the complex relationships between chronic diseases and environment and human population.

CONCLUSIONS

Rapid technological advances have prompted the development of a wide range of telementagement systems to enable the prevention, early diagnosis and management of chronic conditions. The Internet age is altering the patient-physician relationship. Through the understanding of evolving professional roles, the decision-making process among physicians and patients may improve with efforts to share the burden of responsibility for knowledge. This change could usher in a new era of patient-physician relationship, with a potential gain for all collaborative parties. The challenge is to leverage the opportunity of shifting home telemedicine technology from provider-focused to patient-focused healthcare delivery. As a population and providers of health care, we are in the infancy stages of this approach. There are many questions to be answered. There are many challenges - technical, professional and interpersonal. But from all preliminary indications, patients have embraced this approach, both clinically and economically. Those patients who currently feel that the health care delivery system is reducing their health care benefit may achieve a whole new level of access and satisfaction with a home tele-health-based disease management approach.

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