Implementation and evaluation of an integrated computerized asthma management system in a pediatric emergency department: A randomized clinical trial

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ABSTRACT

Objective: The use of evidence-based guidelines can improve the care for asthma patients. We implemented a computerized asthma management system in a pediatric emergency department (ED) to integrate national guidelines. Our objective was to determine whether patient eligibility identification by a probabilistic disease detection system (Bayesian network) combined with an asthma management system embedded in the workflow decreases time to disposition decision.

Methods: We performed a prospective, randomized controlled trial in an urban, tertiary care pediatric ED. All patients 2–18 years of age presenting to the ED between October 2010 and February 2011 were screened for inclusion by the disease detection system. Patients identified to have an asthma exacerbation were randomized to intervention or control. For intervention patients, asthma management was computer-driven and workflow-integrated including computer-based asthma scoring in triage, and time-driven display of asthma-related reminders for re-scoring on the electronic patient status board combined with guideline-compliant order sets. Control patients received standard asthma management. The primary outcome measure was the time from triage to disposition decision.

Results: The Bayesian network identified 1339 patients with asthma exacerbations, of which 788 had an asthma diagnosis determined by an ED physician-established reference standard (positive predictive value 69.9%). The median time to disposition decision did not differ among the intervention (228 min; IQR = (141, 326)) and control group (223 min;

IQR = (129, 316)); ($p = 0.362$). The hospital admission rate was unchanged between intervention (25%) and control groups (26%); ($p = 0.867$). ED length of stay did not differ among intervention (262 min; IQR = (165, 410)) and control group (247 min; IQR = (163, 379)); ($p = 0.818$).

Conclusions: The control and intervention groups were similar in regards to time to disposition; the computerized management system did not add additional wait time. The time to disposition decision did not change; however the management system integrated several different information systems to support clinicians' communication.

1.   Introduction

In the United States, approximately 4 million children experience an asthma exacerbation annually leading to more than 1.8 million emergency department (ED) visits [1]. Patients presenting to the ED with an asthma exacerbation often require treatment and observation over several hours. This care can be complex and involves a coordinated care team. Ideally, upon arrival, patients are given an initial asthma severity rating using either an asthma scoring metric [2] or peak flow measurement. According to national recommendations [3] the patient's asthma severity and response to treatment should be re-evaluated every 1–2 h. With each assessment treatment, decisions should be adjusted to the new severity level, ideally leading to a disposition decision within 4–6 h. Treating asthma exacerbations involves a temporal and multi-disciplinary evaluation element, including patient re-evaluation, treatment adjustments and timely disposition decisions. The challenge is to provide standardized, multi-faceted care in a fast-paced, interruption-driven and often overcrowded environment like the ED.

Clinical guidelines and pathways exist to help guide asthma care and positive effects on patient outcomes have been demonstrated [4,5]. The asthma guideline from the National Heart Lung and Blood Institute (NHLBI) [3] focuses mainly on the outpatient environment, but includes information on care for emergency exacerbations. The most frequent approach to implementing guidelines in a clinical environment is still paper-based [6], but computer-based implementations are also used [7,8]. Researchers have examined the benefits of paper-based and computer-based guideline implementations, but sustainable computer-based approaches in a clinical environment remain infrequent. An automatic, informatics-supported management system could assist clinicians in delivering more homogeneous and better coordinated care for asthmatic patients.

Automating disease detection can help prompt clinicians to initiate treatments earlier and remove the burden of guideline initiation. We hypothesized that the integration of an asthma management system will decrease time to patient disposition decision. We designed and implemented a computerized disease detection and management system for asthma care in the pediatric ED embedded in the clinicians' workflow. The goal of this project was to determine whether patient eligibility identification by a probabilistic disease detection system (Bayesian network) combined with an asthma management system embedded in the workflow decreases time to disposition decision.

2.   Materials and methods

2.1.   Setting

This study was conducted at an urban, pediatric ED that provides care for 55,000 patient visits annually with approximately 7–10% of patients presenting with an asthma exacerbation [9]. The ED has 68 attending and resident physicians, 95 nurses, and 16 respiratory therapists. The pediatric ED has a fully computerized information technology infrastructure involving an electronic medical record (EMR) [10], electronic triage application [11], computerized provider order entry (CPOE) [12], and a computerized patient status board [13]. All four of the systems in the electronic infrastructure are entirely home-grown and integrated. The EMR is a web-based medical record system for clinical communication including inpatient and outpatient visit information. The electronic triage application is used to collect all relevant information about the patient's current ED visit; this information is automatically sent to the EMR. All orders are entered in the CPOE system which provides decision support for medication orders. Finally, the computerized patient status board integrates and displays information relevant to the current visit from the previous three systems. Prior to the start of the study, an 8-page, paper-based guideline including a validated asthma severity metric [2] has been available for guiding asthma care including reassessment and treatment suggestions; however, the guideline was used in only 7–10% of asthma cases [9].

2.2.   Asthma management system

A computerized asthma management system was developed by the investigators. The asthma system includes two components: (1) the automatic disease detection system and (2) a computerized management system that has been reported previously [14]. The automatic disease detection system was based on a Bayesian network [9,15,16] developed in the same pediatric ED as the study. The Bayesian network uses electronic information available at the time of triage including age, respiratory rate, chief complaint, oxygen saturation, and acuity level and historical data from the patient's electronic medical record including past medical history, medications, and billing codes. It required no additional data entry by clinical staff and ran seamlessly during each encounter.