An Integrated Computerized Triage System in the Emergency Department

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Emergency department (ED) triage is a fast-paced process that prioritizes the allocation of limited health care resources to patients in greatest need. This paper describes the experiences with an integrated, computerized triage application. The system exchanges information with other information systems, including the ED patient tracking board, the longitudinal electronic medical record, the computerized provider order entry, and the medication reconciliation application. The application includes decision support capabilities such as assessing the patient's acuity level, age-dependent alerts for vital signs, and clinical reminders. The browser-based system utilizes the institution's controlled vocabulary, improves data completeness and quality, such as compliance with capturing required data elements and screening questions, initiates clinical processes, such as pneumococcal vaccination ordering, and reminders to start clinical pathways, issues alerts for clinical trial eligibility, and facilitates various reporting needs. The system has supported the triage documentation of >290,000 pediatric and adult patients.

Introduction

Triage is a process for prioritizing the allocation of limited resources when the demand for resources exceeds their availability (1). Triage is a population management method that favors societal aspects over individual patients' health care needs (2). As adequate resources are generally available in the Emergency Department (ED), ED triage prioritizes the order and timing of resource allocation accounting for current and anticipated patients seeking care. Patients with less acute needs are required to wait, which may lead patients to leave the ED without being seen by a physician.

The skills required by triaging staff include clinical experience, good judgment, availability, sense of humor, stress-tolerance, knowledge of available resources, problem solving abilities, and sense of anticipation (2). Triaging patients accurately and efficiently is a challenging task, in particular as many EDs are increasingly experiencing overcrowding, which leads to longer wait times and increased treatment delays (3).

Triage evaluation is commonly completed by a triage nurse who collects patient information and assigns a triage category to the patient. Several triage scoring algorithms have been developed to support the triage process with objective criteria. Examples of broadly accepted triage algorithms include the Emergency Severity Index (ESI) (4), the Canadian Triage and Acuity System (CTAS) (5), the Australasian Triage Scale (6), and the Manchester Triage Scale (7). The documentation of triage information is commonly paper-based. Several approaches on computerizing the triage documentation have illustrated the advantages of applying information technology, such as decreased reliance on memory and increased reliability (8-10). Most approaches, however, are stand-alone systems. Triage applications that integrate with an institution's information technology infrastructure remain scarce, despite the potential of sharing data across the institution.

This paper describes the design and implementation of a computerized triage application that was built using the institution's common vocabulary infrastructure. The application provides users with decision support, including the determination of the Emergency Severity Index (4), and is integrated with the hospital's registration system, the computerized ED patient tracking system, the institution's electronic medical record system, and the medication reconciliation application.

Methods

The system's design, development, and implementation was a collaboration among the ED and biomedical informatics, and included experienced triage nurses, nurse educators, the nurse managers, the directors of the adult and pediatric ED, registration staff, trauma team members, a biomedical informaticist, and software engineers. Ongoing improvements are regularly proposed and discussed during the weekly ED information system meetings.

Design Objectives

As part of transitioning from the paper-based to a computerized triage assessment, the team originally identified several design objectives:

1. *Improve the quality of triage documentation:* The triage information should be comprehensive, legible, and ubiquitously accessible during and after the ED visit. The system should be intuitive, decreasing educational efforts, help improve the accuracy and completeness of documentation, and preload existing data from existing information sources.
2. *Computerized decision support:* The system should support the triage assessment through sim-

ple, (e.g., range and validity checks, critical value alerts) and more complex decision support (e.g., pregnancy calculator, ESI, vaccination eligibility, logic for clinical trial subject recruitment)

3. *Controlled vocabulary*: Mapping the triage data variables to the institution's controlled vocabulary would facilitate and promote the sharing of triage data with other applications.

4. *Integration with the hospital's information technology infrastructure:* The triage system needs to be integrated wit the clinical workflow and exchange relevant information with other applications, avoiding redundant data entry during triage and facilitating the sharing of information with other application that need to integrate triage data.

5. *Compliance with regulatory and institutional requirements*: The system should support mandatory tasks during triage, such as identifying patients through two separate mechanisms, initiating clinical pathways, assessing patient's cultural needs, screening for domestic violence, or vaccination initiatives.

6. *Support biosurveillance*: The triage application should provide an environment for sharing biosurveillance data with external agencies.

7. *Support research activities*: The triage infrastructure should help to identify automatically subjects who are eligible for recruitment in clinical trials.

8. *Administrative reports and quality assurance*: The application should provide ED leadership with reports, such as monitoring triage durations by individual nurses.

System Description and Functionality

The triage system (Figure 1) is accessible in the adult and pediatric ED, which are located in different hospitals. Both settings are equipped with clinical workstations throughout the ED, including the patients' rooms, allowing bedside triage assessment. The system is launched from the ED patient tracking system and requires user identification and authentication. The application includes a main triage page (Figure 1), which captures the large majority of patient triage information. To improve data quality, completeness, and compliance, many data elements are mandatory. For example, the documentation that the nurse identified the patient through two mechanisms, the pain assessment, or the assessment of cultural needs are all mandatory data fields following the requirement of the Joint Commission of American Hospital Association.

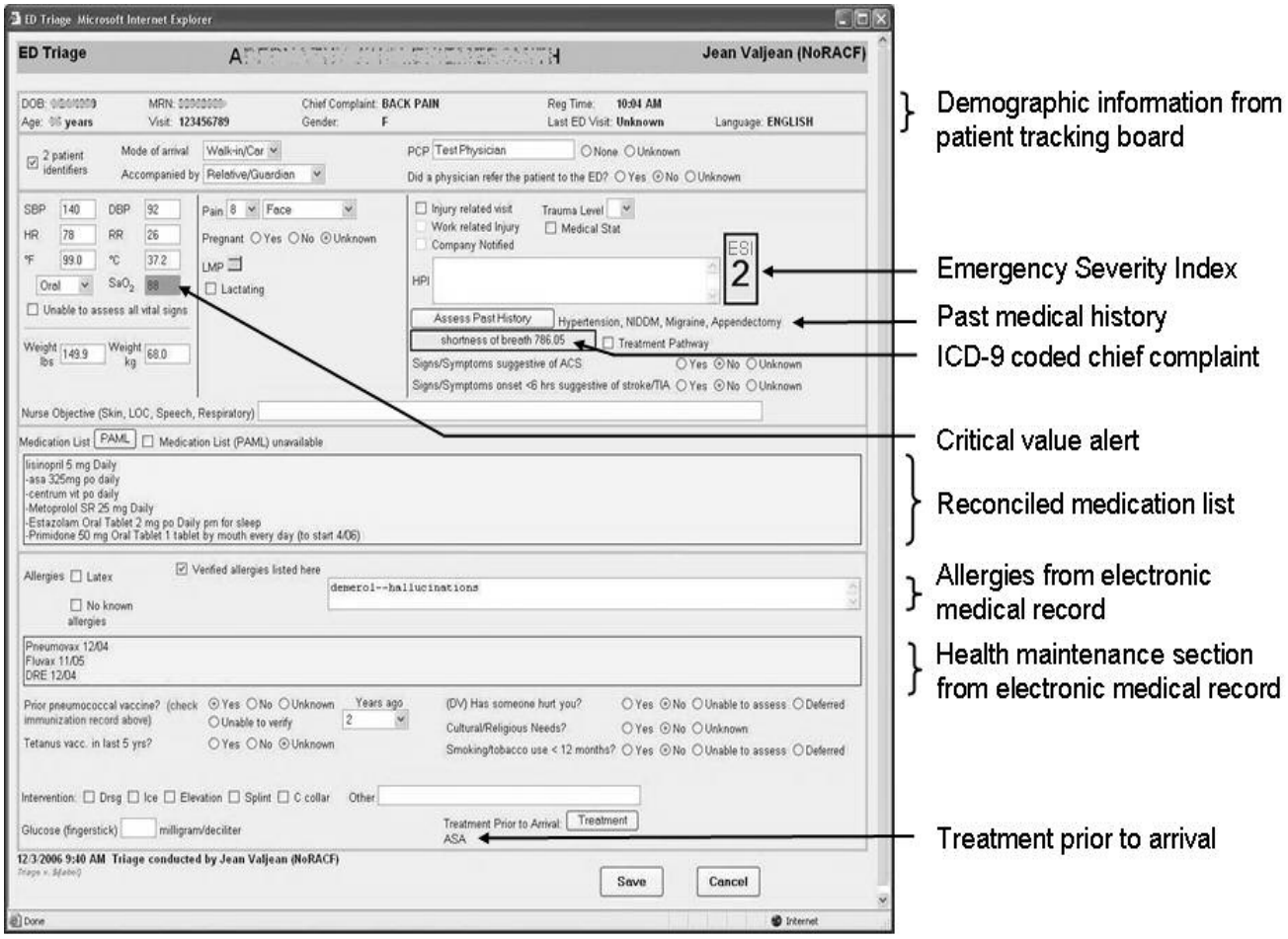

Figure 1 - The main triage screen is partitioned into a) patient demographic information, b) arrival information, c) initial assessment including vital signs, history of present illness (HPI), past medical history, chief complaint, Emergency Severity Index (ESI) and nurse objective, d) medication information, and e) allergy, health maintenance information, screening questions, interventions at triage, and treatment prior to arrival.

Secondary pages exist for the past history, the chief complaint, the ESI assessment, and the treatment prior to arrival page. The past history page consists of a coded list of most common comorbidities including a field for free text entries. The chief complaint page includes a list of about 140 ICD-9 coded chief complaints that are similar to the standardized list of ICD-9 coded chief complaints proposed by the Frontlines of Medicine Project (11).

The ESI assessment page includes rules for vital signs and supports users in following the algorithm and selecting an appropriate acuity level. Acuity levels can be overridden, but require a descriptive reason. The treatment prior to arrival page captures information about medications and interventions preceding the ED encounter, such as EKG, pain medication, or aspirin administration.

The patient information that the triaging nurse abstracts on the secondary pages are all displayed on the main page, so that all patient data are available and viewable at one place. The system supports age dependent triage. For example, pediatric specific data elements include head circumference, a field indicating whether the child was crying, which may impact vital signs, age-driven ESI criteria, age-driven alerts for critical vital sign values, and the inclusion of pediatric comorbidities.

ED administration required documentation of triage assessment for all patients, including ambulance or aeromedical patients who do not require triage as they generally receive attention without delay. Patients in life-threatening conditions are assigned a preregistered "STAT" name. The system recognizes "STAT" registrations and allows the nurse to bypass all assessments except for the assignment of an acuity level and a chief complaint.

A few fields are managed dynamically, such as displaying and capturing the gestational age only for patients reporting to be pregnant, more detailed domestic violence screening questions only if a patient responded positively, or inquiring about smoking cessation interest only for currently smoking patients. For patients with suspected acute coronary syndrome or suspected onset of stroke symptoms within 6 hours two separate questions appear next to the patient's chief complaint, facilitating rapid initiation of clinical pathways.

At the end of the triage assessment, the application evaluates whether the nurse completed all the mandatory fields and generates a summary page (Figure 2) listing conditions that require the nurse's immediate attention (ordered with input from the ED clinicians). The application also captures the start and end time of the triage process. Clinicians can access the completed triage information directly

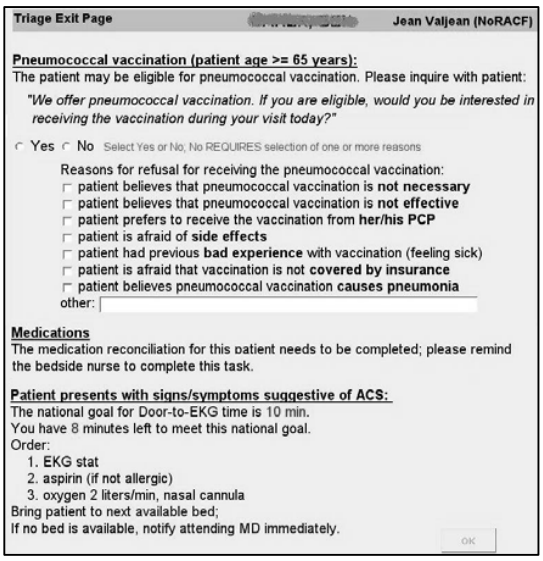

Figure 2 – An example of a summary page displaying reminders for pneumococcal vaccination, the medication reconciliation process, and alerts for patients with suspected acute coronary syndrome.

from the ED patient tracking board or from the electronic medical record system, which displays a formatted ED triage document.

Integration

To decrease redundant data entry in the triage system or in information systems that integrate triage information, the application obtains and exchanges patient information from various institutional information systems (Figure 3).

The triage application obtains preexisting patient information from various information sources:
a) The *triage application database* provides patient information from previous triage visits: date of previous visit, past medical history, and cultural/religious needs. This process decreases the amount of triage time as information needs to be verified rather than elicited during each encounter. This is particular helpful in patients that use the ED

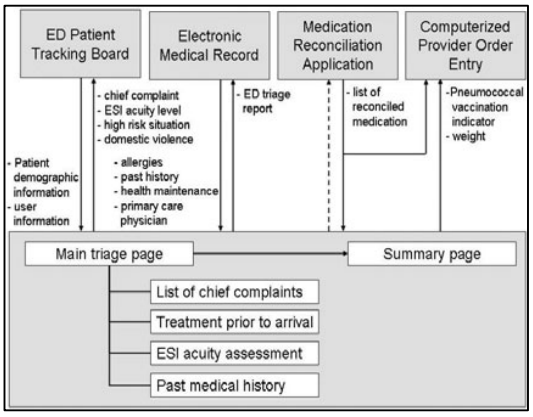

Figure 3 - Flow of information exchange between the triage application and the institutional information systems.

frequently for their health care needs.
b) The *ED patient tracking board* supplies the patient's demographic information: medical record number, patient name, date of birth, age, gender, registration time, language, and the free text chief complaint.
c) The institution's *longitudinal electronic medical record* provides information from the patient's problem list, such as past medical history, allergies, vaccinations, health maintenance information, and primary care physician information.
d) The institutional *medication reconciliation application* is launched from the triage system, helps the nurse to reconcile patient medications, and returns the resulting list to the triage application.

Upon completion of the triage application, the system stores coded information in a database, and shares data with other information sources:

a) The *ED patient tracking board* receives the coded chief complaint, the ESI acuity level, domestic violence flags, and high risk indicators for patients with suspected stroke or acute coronary syndrome. In patients with high risk indicators the background of the chief complaint field on the ED tracking board is highlighted alerting clinicians about initiating time-critical treatments.
b) The *electronic medical record* receives a formatted triage document and coded data elements that other applications need to prepopulate data fields with triage data. For example, the computerized provider order entry system obtains the patient's weight, which was entered at triage, through the electronic medical record. This enables weight-based dosing and eliminates clinicians' needs to obtain and enter the weight information at the beginning of an order entry session. Similarly, other institutional applications prepopulate their fields with data elements from the triage system.
c) The *computerized provider order entry system* obtains the patient weight and a flag indicating that a patient is eligible for pneumococcal vaccination and has consented to receiving the vaccine.
d) The *clinical trial alert component* identifies patients meeting the eligibility criteria for clinical trials and sends a de-identified pager notification to clinical trial staff.

System Architecture
The triage system is a Java web application currently running on Weblogic® 8.1. The infrastructure is implemented with the Java programming language, Java Server Pages, Servlets, Spring, Struts, Quartz, JavaScript, AJAX, and Cascading Style Sheets. It interacts with other applications via J2EE stateless session beans and JMS queuing. The application is browser-based, compatible with Microsoft Internet Explorer® and Mozilla Firefox.

Status Report
The application was implemented in June 2005 in the pediatric and adult ED and has since supported the triage documentation of more than 290,000 patients. To examine whether the differences between the paper-based and the computerized triage documentation existed, a task-analysis study comparing triage nurses' activities before and after implementation of the triage application was performed (12). During a total of 42 hour observation the number of tasks and the average number of interruption duration decreased, while the average triage time and the number of interruptions remained unchanged.

Data from the triage application are the basis for several reports. The triage application sends a daily electronic biosurveillance report to the city's public health department. The daily reporting approach could easily be adapted to real-time data transmission. The triage duration times are part of a nursing score report card that provides the adult ED nurses with feedback for several ED nurse quality indicators. During influenza season the patients' chief complaint are used for the institution's daily FluReport, allowing hospital administrators to plan hospital bed capacity during peak influenza season. Information for trauma patients can facilitate the institution's trauma registry.

Information from the triage application facilitates clinical workflow processes. Two examples are an ED based pneumococcal vaccination initiative for patients 65 years and older (13), and the automatic identification of patients eligible for asthma guidelines (14). To determine the patient's pneumococcal vaccination status the triaging nurse uses information from the health maintenance section of the problem list and from inquiring the patient directly. The rules from the US Centers for Disease Control's pneumococcal vaccination guideline were integrated with the triage application. The system determines the patient's eligibility and prompts the triage nurse for obtaining the patient's consent (Figure 2). If the patient accepts, an indicator is sent to the computerized provider order entry system, which prompts the physician to order the vaccine. The asthma real-time identification algorithm integrates triage information and generates an indicator that can prompt clinicians about using paper-based or computerized asthma guidelines.

Discussion

The ED benefited from the integrated computerized triage application in many ways; however, several considerations that accompany the electronic data abstraction process and impact the clinical workflow are important. Once the ED realized the benefits of applying information technology to the triage

process, the desire grew to use the environment for collecting data that are not directly related to the basic objectives of triaging patients, in particular for information used to meet compliance requirements. A balance between the necessity for a quick triage assessment and the desire to collect many data elements early during an encounter needs to be found and optimized for patient care.

One example is the medication reconciliation process. The availability of a reconciled medication list early during an ED encounter is desirable, as medication orders may occur even during triage. In an ED setting, however, medication reconciliation can be challenging and time-consuming, and delay the triage assessment of other critically ill patients who are waiting to be evaluated. Another example is the assessment of smoking status and the offering of smoking cessation information. This assessment has limited impact on the triage decisions and may be better completed at the bedside. A last example is the screening for domestic violence, a process that has failed in our ED setting despite the design of an elaborate workflow. Screening may be more successful at the bedside, in a more enclosed environment, after a relationship between the patient and the healthcare provider is established, and more time is available for sensitive health care aspects.

Several aspects impacted an optimal clinical workflow. Despite electronic availability of and quick access to the triage document, clinicians continue to prefer a printout added to the patient's medical chart. Another limitation includes the inability for quickly switching context and applications. To accelerate the initiation of clinical pathways, the ability of entering standing orders during the triage documentation task is desirable; however, this remains a sequential task that may lead to the nurses forgetting to enter the order after completing the triage assessment. In the case of an EKG, a frequent exam initiated in triage, this may lead to decreased revenue due to the lack of documentation of the order in the computerized provider order entry system. Finally, when triage nurses get interrupted for a longer time period, saving a draft is desirable. However, workflow then requires a process to assure that drafts are finalized within a reasonable time period of the patient's ED encounter.

In summary, the computerized triage application has demonstrated to be a versatile, adaptable, and effective approach for supporting the ED staff with the triage assessment. Sharing patient triage data with other information systems has facilitated the implementation and improvement of various clinical processes, potentially supporting the ED staff in delivering high quality of patient care.

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