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Abnormal diagnosis of Emergency Department triage explored with data mining technology: An Emergency Department at a Medical Center in Taiwan taken as an example

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ABSTRACT

Triage helps to classify patients at emergency departments to make the most effective use of resources distributed. What is more important is that accuracy in carrying out triage matters greatly in terms of medical quality, patient satisfaction and life security. As the numbers of patients in emergency departments increase, learning from the examples of abnormal diagnosis of triage in order to make modifications, constitutes a significant issue. The researcher worked with the Emergency Department of a Taiwan Medical Center to build a model to view abnormal diagnoses in the database from the establishment of a flow path and the selection of parameters for sampling. Data on patients were derived from the database. Two-stage cluster analysis (Ward's method and *K*-means) and decision tree analysis were made on 501 abnormal diagnoses in an emergency department. It was found that nursing personnel make more frequent triage diagnoses than physicians do. Most of abnormal diagnoses stems from patients rather than the diagnosis on the day. Pulse and temperature have greater distinction. The researcher proposes seven correlation laws based on confidence and support proportions, derived from sample point conforming to correlation law that abnormal diagnosis is most likely in diseases of pneumonia and cirrhosis, etc. Through data mining technology, the researcher's triage expert system is written in simulation. After periodic updates, it can improve the system and education training without the influence of the subjective factor.

1. Introduction

Emergency departments are the front lines facing patients in emergency medical conditions. The department covers: physicians, nursing personnel, technicians, social workers, first aid technicians, administration personnel, janitors, and volunteers in 24-h operation for first aid, observation or surgery. It is a small hospital within a hospital. Process of emergency department: triage and consulting rooms of each department for treatment. According to statistics (Fig. 1) by the Department of Health (Brillman, Doezema, & Tandberg, 1996), the number of service personnel at emergency medical treatment centers has continued to grow, from 4,350,000 in 1994 to 6,870,000 in 2004, for a 58% increase in numbers. This has caused chaos at emergency departments due to a lack of knowledge regarding the procedures and department medical systems.

A triage system helps patients in critical conditions. Weiner and Edwards (1964) believed that proper triage is expected to reduce the high economic price for patients in non-critical conditions. Triage consistency to physicians' classification affects the satisfaction of patients and the waiting time (VanBoxel, 1995). Over triage will entail a waste of medical resources while under triage endangers the rights of patients and medical distribution. Triage significantly affects medical quality, patient satisfaction and life security.

In accordance with hospital Emergency Department assessment standards (1995), emergency patient triage can be divided into four levels: Level I (requiring immediate treatment), Level II (to be treated in 10 minutes), Level III (to be treated in 30 minutes), and Level IV (treatment can be delayed). Decisions of the triage in current domestic emergency departments are mostly made by senior nursing personnel. Estrada (1981) held that senior experienced nursing personnel could also do the job well. Decision-making may be affected by job complications, conflicts, nursing experience, education and professional knowledge (Brillman et al., 1996). Triage nursing personnel (hereafter nursing personnel) may be perplexed in regard to triage levels. Finding the

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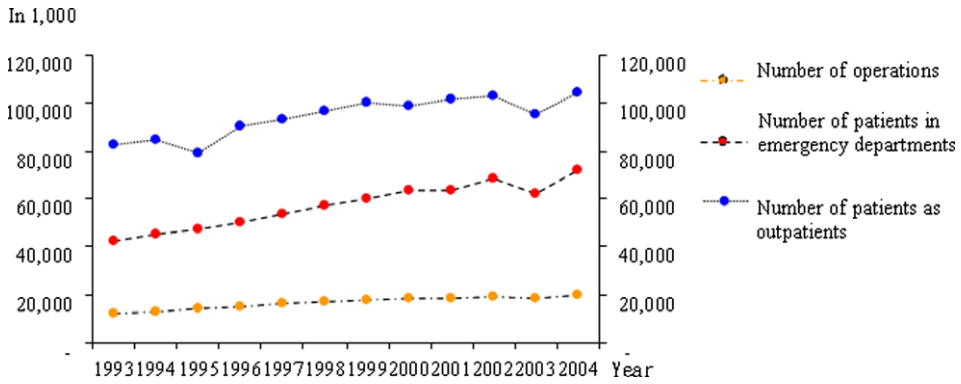

Fig. 1. Number of service person times in past years. Source: Department of Health, 2004.

hidden rules of triage from patients' data will help nursing personnel engaging in triage.

With the demand of businesses, data application has evolved from database and data storage to data mining. Data mining refers to a: "process to locate non-obvious, unknown, and potential *possible* usable information from data" (Frawley, Paitetsky-Shapiro, & Matheus, 1991); Reinschmidt, Gottschalk, Kim, and Zwietering (1999) stated that the aim of: "data mining is to extract effective, useful and unknown comprehensible information to serve as foundation of decision-making for enterprises." Appropriate use of information will provide businesses with greater wisdom and decision information. Data mining has been successfully applied in industries, commerce and medicine. Huang and Chen (2005) used various data mining technologies to help machines learn to distinguish types of glaucoma; Abdelfattah et al. (2006), with data mining and serum examination and radioactive treatment, predicted whether Type C pneumonia pathologically changed to cirrhosis.

The researcher explored abnormal diagnoses in emergency medicine with data mining, in cooperation with an Emergency Department of a Taiwan Medical Center (hereafter Emergency Department) to understand current triage operation and obtain basic statistics and patient data from the database. The study is made on medical management and nursing, with the knowledge of the administrative head at the Emergency Department, in the hope to effectively improve consistency of triage with the combination of data mining theories and practice. The purposes are as follows:

(1) Based on information management, the information system is applied in triage of the Emergency Department to generate patients' data.
(2) Exploration of correlation between triage and abnormal diagnosis; cluster analysis conducted on variables with clinical meanings (Lee, Kim, Kwon, Han, & Kim, 2008).
(3) Establishing triage abnormal diagnosis clusters with hierarchical clustering (Ward's method) and partitioning clustering (*K*-means algorithm); obtaining correlation law of abnormal diagnosis with decision trees (Piramuthu, 2008).
(4) Improving consistency of triage with data mining; offering quantified and scientific rules for triage decision-making in the hope of serving as a foundation for future researchers and clinical examination.

2. Definition

Flow path suggestions, parameter selection and sampling have been proved by the literature after discussion and approval by administration head and professional personnel. Triage study structure and methods are as follows.

2.1. The nature of the triage model

Purpose of triage at Emergency Department is: "not delaying the treatment of patients in truly critical conditions due to large number of patients." Process of treatment at an Emergency Department is: "nursing personnel conducting triage, patients going to consulting rooms of different departments; arranging patients' next step based on the conditions after treatment by physicians, and evaluation on triage made by nursing personnel." Consistency in triage between nursing personnel and physicians means accurate triage; nursing personnel judging more critical conditions than physicians; whether there is over triage or under triage.

Nursing personnel judge the level based on: complaints of (c/o), medical history, general appearance, vital signs, syndromes and signs, and body evaluation results (Handyside, 1996). Medical history, general appearance, vital signs, syndromes and signs, and body evaluation results still cannot be quantified at present. They are combined as c/o (description of conditions by patients). Vital signs include respiration, temperature, pulse, diastolic (dias.), systolic and SaO2 parameters. C/o columns are too complicated for classification and quantification. The researcher adopted vital signs for the ensuing analysis. Other than nursing personnel and physicians, patients' conditions, such as sudden deterioration, improvement or worsening after leaving the hospital, are also major considerations in triage abnormal diagnosis. Examination time spent on patients is also included in this research. After patients leave the emergency department, there are seven conditions: admission, transfer, operation, death, out-patient, ADD and departure without notice. Admission, transfer, operation and out-patient are under control and permission of physicians. Death, ADD and departure without notice are obviously beyond the control of physicians.

The research simplifies the procedure at the Emergency Department into input, process and output. Parameter data are available from the database of the Emergency Department (registration enquiry, triage database, and physician order database). Extreme and missing values have been modified in advance with professional personnel at the emergency department. Ensuing analysis is made on patients' data to find potential rules of triage. A triage model is presented in Fig. 2.

2.2. Data mining process

Data mining is a procedure by which to extract useful knowledge from data, like digging for ore in a mine. Such knowledge includes unexplained or undiscovered causal relationships. In general, data mining has two major functions: the first one is to predict future tendency from an established model; the other is to locate unknown models from data. Models include: classifica-