Analysis by data mining in the emergency medicine triage database at a Taiwanese regional hospital

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ABSTRACT

"Emergency medicine" is the front line of medical service a hospital provides; also it is the department people seek medical care from immediately after an emergency happens. The statistics by the Department of Health, Executive Yuan, indicate that over years, the number of people at the emergency department has been increasing. The US has introduced and practiced the triage system in the emergency medicine in 1960, whereby to aid the emergency department in allocating the patients, to give them appropriate medical care by the fast decision of the nurses and doctors in case of the patients' seriousness through their judgment.

This study takes on the knowledge contained in the massive data of unknown characteristics in the triage database at a Taiwanese regional hospital, using the cluster analysis and the rough set theory as tools for data mining to extract, with the analysis software ROSE2 (Rough Sets Data Explorer) and through rule induction technique, the imprecise, uncertain and vague information of rules from the massive database, and builds the model that is capable of simplifying massive data while maintaining the accuracy in classifying rules. After analyzing and evaluating the knowledge obtained from relevant mining in the hospitals past medical data for the consumption of emergency medical resources, this thesis proposes suggestions as reference for the hospitals in subsequent elevation of medical quality and decrease in operative costs.

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1. Motivation and objectives of the research

1.1. Background and motivation of the research

Emergency department, the front line of a hospital facing urgent patients, consists of doctors, nurses, technicians, social workers, emergency medical technicians, administrative persons, employees and volunteers as members, who maintain a 24-h operation and are able to do anything like first aid, observation in detention or surgical operation, in a way as if of a hospital in hospital (Shi, 2008). According to the 2007 statistics by the Department of Health, Executive Yuan, as shown in Fig. 1, the daily emergency medical services provided by all hospitals in Taiwan increased from 14,405 person-visits in 1997 to 18,392 person-visits in 2007, a significant growth. The statistics by US Center for Disease Control and Prevention also showed an increase in the number of emergency patients from 94.9 million in 1997 to 175 million in 2001 (McCaig & Burt, 2003). These all suggest a trend, worldwide, of continuous increase in visitors to emergency department, which has also kept such environment in hectic condition like in warfare.

To avoid the delay in saving the really urgent patients among the numerous visitors to the emergency room, the emergency triage system was established. As such, the US introduced the triage system in emergency medicine in 1960 (Weiner & Edwards, 1964); the US Emergency Nurse Association published the "Standards of Emergency Nursing Practice", which specifically provides that the emergency nurses should conduct a triage on every patient showing up in the emergency room from the physiological and psychological angles to identify the priority of medical care among patients (Gilboy, Travers, & Wuerz, 1999).

Triage is the screening station set up in the emergency medicine; its purpose is chiefly to "place the right person at the right time in the right place to use the right resources" (Chan, 2006).

This study investigates the current condition of the emergency patients, extracting by data mining techniques, from the implicit and latent data of emergency patients in the hospital, the trend and data that can serve as reference, and analyzing and understanding the correlation between triage and patient structure and consumption of medical resources. The study, then, evaluates the data obtained from relevant mining to present suggestions for improvement as reference for the hospitals in subsequent elevation of medical quality and decrease in operative costs. It is hoped to serve the basis of reference for the government's health agencies in deliberation on the human power training and allocation in

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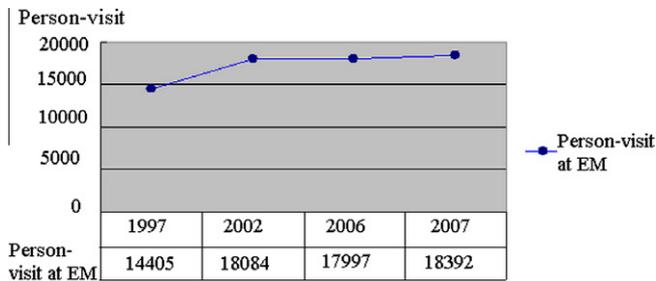
Fig. 1. Averaged daily emergency medical services provided by hospitals in Taiwan.

emergency medicine related units at hospitals when reviewing medical expenses and revising health insurance policies in future. Also, the medical modes and trends obtained by data mining techniques can be stored in the existed database of medical knowledge and will be able to make the management of information and knowledge, which is very useful to the medical institutions.

1.2. Research objectives

Taking a regional hospital for example, this study explores the effect of patients' use of resources by analyzing the data of triage of emergency patients. The study also finds the knowledge of diagnosis by employing the knowledge discovery theory in the field of data mining—rough set theory, RST. Through the application of RST method, data mining is conducted in the historic triage data at a Taiwanese regional hospital to uncover the implicit knowledge in the database, to build the model that can simply massive data while maintaining the accuracy in rules of classification, which serves as the tool for analyzing the original anamnesis data that are massive, vague and full of uncertainty, whereby to analyze the triage data.

This study has the following objectives:

1. To use the cluster analysis to classify the triage and modification cases in the triage database to reduce the noises in the classification and, then, to find out the classifying model of routine triage and modification by classification.
2. To analyze the data and to employ the rough set theory to uncover the implicit knowledge in the database, to build the model that can simply massive data while maintaining the accuracy in rules of classification.
3. To analyze the triage database to identify the key attributes of the triage and to summarize the important rules of decision.

2. Documentary review

This chapter comprises two parts; the first presents the definition for emergency medicine, followed by sorting the related research in triage during the period from 2000 to 2008 in Taiwan, in hope of straightening up the definition of triage. It is also found from many studies, both domestic and abroad, the problems currently facing emergency triage. The second part describes the development of the technique of data mining, including the rise, the definition, the technique and functions, the medical application of and the research in medical industry with data mining, with the hope of using data mining as the research tool here after having made in-depth understanding of its techniques.

2.1. Definition of emergency medicine

Thanks to the feature of convenience from the 24-7 service of emergency medicine, people are allowed to make full use of its

resources. But, from the angle of medical management, the function of the emergency medicine in a hospital is greatly different from what people think of. Among the differences are the treating process of complex conditions and the urgency of medicine that differ significantly from the treating process in general in-patient service (Huang, 1993).

With the above reorganized summary, we can roughly understand the definitions and views by the researchers, both from Taiwan or in abroad, about emergency medicine; of which definitions and views the most important point in common is the widely referring to various kinds of urgent conditions (that affect safety of life and health condition) as emergency medicine. Such definition has encompassed the general explanation by most scholars about "emergency medicine"; however, in this era with rising consumer sense, where people all strongly call for personal life quality and physical health condition, the patients are seeking the assistance from emergency medicine just because they feel under the weather or have slight pain, creating congestion in the emergency department and more workload on the medical persons there. The purpose of solving this and of assisting the medical persons to work more efficiently thus gives rise to the work of "triage". To have deeper cognition about triage, the explanation for the purpose and the methods of triage will be given immediately below.

2.2. Data mining

Data mining is a new technique that emerged with the development of artificial intelligence and database techniques in recent years. It focuses on the re-analysis of database, including the construction of models or the determination of data pattern, with the purpose mainly of discovering the valuable information concerned about yet unknown to the owner of database (Hand, Blunt, Kelly, & Adams, 2000). Data mining is a "process of automatically selecting, by computers, some important and potentially useful data types or knowledge from massive data or large database". This technique uses classification, relationships, sequential analysis, cluster analysis and other statistic methods to find out, from enormous database, implicit, unknown yet very useful information for business operation. While the historical data of most enterprises are millions or tens of millions in number, which are difficult to analyze, it becomes possible to extract useful information from huge information by using the tool of data mining.

Data mining is sometimes called knowledge discovery, KD; but, in fact, by definition, knowledge discovery is a non-tedious procedure for identifying effective and potential benefits amid data. It is known from Fig. 2 below that data mining is one of the important processes of knowledge discovery.

From the definitions by the scholars, it is clear that the usage of data mining is an analysis process within a series of knowledge discovery. But, as time changes, the term "data mining" gradually replaces "knowledge discovery". The above summarized, the ulti-
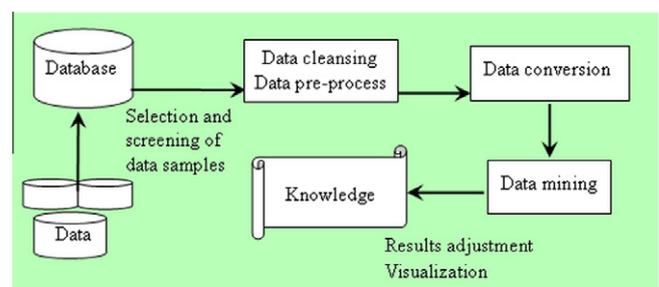

Fig. 2. Flow chart of knowledge discovery in database. Data source: organized by this study.