Risk Management in Haemodialysis Departments using a Decision Support System

C. Cornalba, R. Bellazzi, S. Quaglini, R.G. Bellazzi[1], M. Stefanelli

Dipartimento di Informatica e Sistemistica, University of Pavia Italy
[1] Unit of Nephrology and Dialysis, S.O. Vigevano, A.O. Pavia, Vigevano, Italy

Introduction

Nowadays, health care organizations (HCOs) are developing into complex enterprises, where the ability of managing risks is a key factor of success for the efficiency (economic results) and the efficacy (outcome results) of the delivered care. In HCOs we can distinguish two different kinds of risk management: "pure" risk management and clinical risk management. The former is the management of the generic risks of any company (such as fires, natural disasters, liability lawsuits, work injuries, and other types of accidents or legal actions), the latter is linked with the particular service supplied, which is the health good. The adverse events which provoke a damn and financial losses are more frequent during the health service's supply than in other activity and it is therefore crucial to develop methods for adaptively measuring risks and define decisions to reduce them [1].
In our case, we will concentrate on the problem of managing clinical risks, e.g. to identify and measure the risk of hospitalization and mortality and their expected costs, in haemodialysis departments.

Managing risks in hemodialysis departments

End Stage Renal Disease (ESRD) is a severe chronic condition that corresponds to the final stage of kidney failure. Without medical intervention, ESRD leads to death. More than 80% of the ESRD patients are treated with Hemodialysis (HD). In HD the blood passes through an extra-corporal circuit where metabolites are eliminated, the acid-base equilibrium is re-established and the water in excess is removed: a device called hemodialyzer regulates the overall procedure. In general, HD patients undergo a dialysis session for four hours three times a week. The dialysis treatment has very high costs and it is very demanding from an organizational viewpoint. A medium size centre may manage up to 60 patients per day.
This process requires highly specialized personnel, day hospital beds, and at least 30 hemodialyzers plus the disposable material. HD patients undergo several clinical risks, including re-hospitalisation due to cardiovascular complications and death. Recent clinical studies have shown that such risks are increased by several factors, mainly related to a poor adherence of patients and health care givers to the treatment plans periodically provided by nephrologists [2]. This paper describes a project which is aimed at exploiting the non-adherence monitoring results to dynamically extract risk profiles for the patients and the clinical centres and to define decision support strategies able to adaptively minimize risks and, consequently, costs.

A risk management system

The decision support tool we have defined relies on a Bayesian Network model to represent the probabilistic relationships i) among the monitoring variables, and ii) between such variables and the re-hospitalisation and mortality risks. In more detail, the data collected on each patient during HD monitoring are summarized through a set of discrete stochastic variables, expressing i) efficiency of the dialysis, evaluated by measuring the blood flow in the extracorporal circuit (QB), the body weight loss (WL) and the dialysis time (T); ii) efficiency of the hemodialyzer, evaluated through the pressures of the extracorporal circuit after blood extraction (arterial pressure, AP) and before blood re-entry (venous pressure VP); iii) body water reduction and hypotension episodes; iv) overall patient's status, measured through the levels of PO4, albumin and residual creatinine clearance. The comparison of such values with predefined targets allows to extract outcomes ("success" or "failure") for each dialysis. In our case, 6 binary outcomes were derived (and became part of the dataset) from: i) the comparison of the median HD session levels of VP, AP with the target; ii) the difference (QBR) between the prescribed QB and its median values; iii) the difference (TR) between the prescribed dialysis time and the observed one; iv) the difference (WLR) between the prescribed weight loss and the weight loss measured at the end of the dialysis; v) the difference between the weight reached at the end of the dialysis and the target weight of the patient (PSR). The probabilistic relationships between the outcomes and the monitoring variables can be learned for each patients through the available data set, while the relationships between the outcome variables and the risks of re-hospitalisation and of death are derived from a Cox proportional hazards model previously published in the literature [2]. Such model includes other risk factors, such as sex, age and type of renal disease. The overall result is a model with a different Bayesian Network for each patient, expressing the individualized risk profile, as learned from the monitoring data. The model also includes direct expected costs, calculated through DRGs reimbursement rates. The BN is augmented with decision nodes, expressing the therapeutic protocol which sets the HD targets. The system may therefore be used to define the current risk profile of each patient and to guide physicians in choosing the optimal treatment strategy to minimize risks.

Current status of the project and upcoming effort

Current research is directed to adding more granularity to the network, to assess the impact of such system in clinical practice and to define decision support strategies at an organizational level, since our system can be viewed as a tool for supporting organizational learning. The most basic level, known as “single loop learning”, is the detection and correction of errors or unjustified clinical actions. It can be implemented with the system described above, although it tends to leave organisational goals and design of processes unchanged. This question can be exceeded through a more sophisticated “double-loop learning”, implemented using a decision model. The strategic decisions have impact on the single patient’s care;
moreover, the risk profile of each patient has an impact on the risk profile of the HD centre. The implementation of double loop learning is the most ambitious goal of our project.

References

[1] Walshe K., The development of clinical risk management, in: Clinical Risk Management: Enhancing Patient Safety, Vincent C. et al., Bmj Publishing Group; 2nd edition (2001).
[2] R. Saran, J. L. Bragg-Gresham et al. Nonadherence in hemodialysis: Associations with mortality, hospitalization, and practice patterns in the DOPPS, Kidney International, Vol. 64 (2003), pp. 254–262.

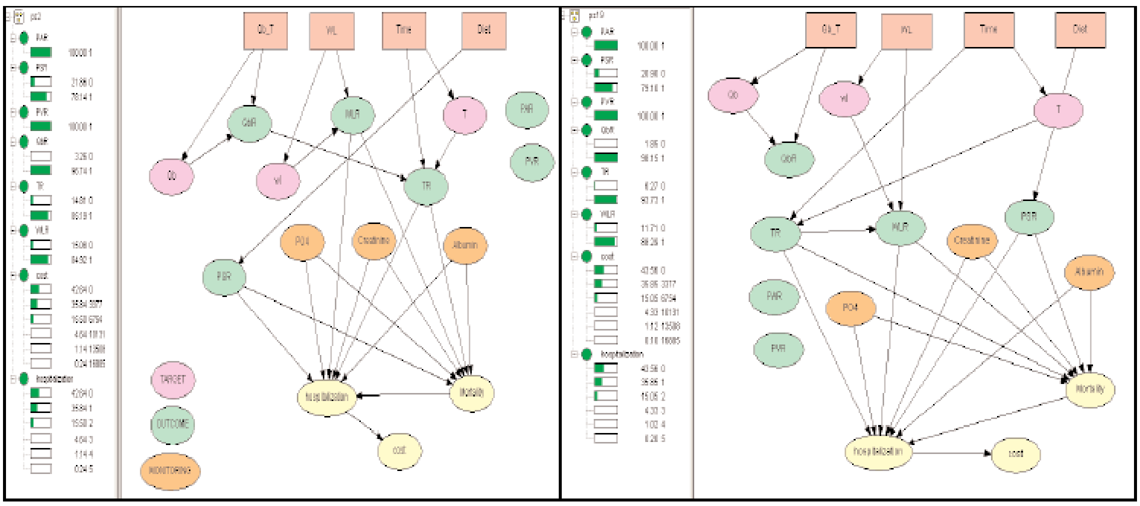

Figure 1: the 2 BNs learned on 2 patients, using the Hugin package.