KNOWLEDGE DISCOVERY IN SUPPORT OF HEALTH MANAGEMENT DECISIONAL PROCESS: IMPLEMENTATION OPPORTUNITY

Zouri Nicoleta[1,2], Zouri Muthana[1], Cumpăt Marinela Carmen[3] and Ferworn Alex[1]

[1] *Ryerson University, Toronto, Canada;* [2] *Centennial College, Toronto, Canada*
[3] *Alexandru Ioan Cuza University, Iasi, Romania*
E-mail: nzouri@ryerson.ca; E-mail: mzouri@ryerson.ca;
E-mail: c_cumpat@yahoo.com; E-mail: aferworn@ryerson.ca

Abstract
A knowledge based decision support system would be able to augment the managerial decision making process through the evidence based approach on the impact on performance indicators. While many research areas in decision support systems focus on clinical applications there is potential to integrate these decision systems to support operational and managerial processes. In this paper, we evaluate decision support systems for both clinical and managerial operation and provide a framework on how these can be adapted to support achieveing a high level of key performance indicators.

Introduction
The decisional process of health organization managers is challenged by the multitude of factors that must be taken in consideration. Beside the focus on the health outcome of the patients, managers must also consider the ethical and economical aspects of those decisions.
In Romania, the public health organizations must strive to achieve optimal key performance indicators as established by the Ministry of Health (Cumpat et al., 2019). The key performance indicators are a set of measures and corresponding acceptable range values for economics metrics (such as: length of hospitalization, cost of hospitalization, etc.), service quality metrics (such as: mortality rate, nosocomial infection rate, rate of re-admission within 30 days, etc.), management of human resources metrics (such as: number of patients discharged per doctor, number of consultations per doctor, etc.), service utilization metrics (such as: length of hospitalization, rate of bed utilization, etc.) (Mleşniţe, 2018).
Most applied studies focus on the solution for specific issues in individual units. There is a need to focus on generalizable approach for addressing common problems that face managers and physicians (Gunal and Pidd, 2010) In practice, the decision making process of health organizations managers is heavily influenced by the political climate at the time of

the decision and perceived favorable responses from the health system (Cumpat et al., 2019).

Decision support systems that use knowledge discovery could help the decision process by analyzing the impact of the decision on various aspects of key performance indicators therefore helping health organizations managers make economic, ethical and efficient evidence based decisions.

In this paper we discuss the use of knowledge discovery computerized systems as a decision support tool for a more effective and ethical decisional process. This paper is organized as follows. In the first section we evaluate related research work, in the second section we present the key performance indicators, in the third section we discuss knowledge based managerial decision support systems, in the fourth we discuss the integration of knowledge based decision support systems, and lastly, the fifth section is reserved for the conclusion.

Evaluation of Related Research Work

Various computing methodologies have been researched in an effort to develop evidence based managerial decision support systems. The researched focuses, in general, on selected measures of the key performance indicators. However, not all decision support systems are researched from a managerial decision making perspective but rather from a clinical perspective.

Systems designed to analyze the use of antibiotics have been researched in the context of monitoring infections, evaluating the outcome of the antibiotics treatments with the scope of optimizing the prescription of anti-infective drugs, and reducing the rate of nosocomial infections (Cánovas-Segura et al., 2016). While the system were primarily designed from a clinical perspective the models can be easily adapted to take in consideration the economic factors as well such as drug costs and length of hospitalization.

An economic driven knowledge based decision support system focused on integrating transaction costs has been researched by Yang (2016). The theoretical concept developed focused on the paradigms that influence managerial decision in practice such as: the fast pace of technology advancement, the degree of knowledge specificity required, the complexity of health care delivery in an organization, and the need to share information with others in the medical system network (Yang, 2016).

A theoretical concept of improving the human resources indicators was developed by Mura, et al. (2016). The framework is based on improving interpersonal relationship among employees which is expected to lead to an adequate improvement in effectiveness of the operations.

A recent research (Zeiberg, et al., 2019) used machine learning techniques for early detection of acute respiratory distress syndrome based on inputs in the electronic health record for admitted patients. The model intention is to optimize the timing of the clinical intervention for such patients which is expected to result in better health outcome for the patients, reduced health complications, reduced mortality rate, and reduced hospital stays.

A model for the predictability of ante-natal care use for pregnant women was researched by Workie and Lakew (2018). The study intended to determine the probability rate of ante-natal services used by patients based on several social variables such as mother's education, economic stability, geographical area, and access to some type of communication media. Because the use of ante-natal services is associated with reduced maternal mortality and a reduced rate of pregnancy related complication we can infer that managerial decision that affects at risk community members may results in improved hospital outcome as well.

A frequently used methodology for decision support system in health care is computer simulation which has been applied to specific health-care applications, such as modelling facilities, and simulation operations within the hospital. Cumpat et al. (2019) developed a simulation model using system dynamics methodology to study the impact of the rate of

nosocomial infections on key performance indicators in a medium size rehabilitation hospital in Romania. The key performance indicators studied in the simulation were representative for each indicator category: personnel requirements, service utilization, costs, and service quality. The simulation shows that investment in equipment, personnel, and supplies to reduce the rate of nosocomial infection will result in reduced rates of nosocomial infection therefore improving key performance indicators.

In our previous work, we presented an ontology approach for knowledge discovery of ECG data. While most of the analysis of ECG data is focused on diagnosis, the use of ontology can provide decision and policy makers insights into trends and patterns related to the medical status of patients in order to provide better service or to improve policies and procedures (Zouri et al., 2019).

In (table no. 1) we have summarized several studies for decision support systems that could be introduced or adapted in the managerial decision process.

Table no 1. Decision support systems used in health organizations

Study	Perspective	Scope	Managerial decision impact on key performance indicators
Cánovas-Segura et al., 2016	Clinical	Antibiotic stewardship	Reducing drug costs, reducing length of hospitalization.
Cumpat et al. 2019	Management	Impact of nosocomial infection rate on selected key performance indicators	Reducing length of hospitalization, reducing hospitalization costs, reducing mortality, optimizing service time of medical practitioners, reducing cost per bed.
Zeiberg, et al., 2019	Clinical	Early prediction of acute respiratory distress syndrome	Reducing length of hospitalization, reducing, mortality rate, reducing drug costs.
Zouri et al., 2019	Clinical	Ontology of ECG signal and patient demographics	Predicting disease trends and demands on the health care system.
Workie and Lakew , 2018	Clinical	Prediction of ante-natal service use	Reducing length of hospitalization, reducing mortality.

Overview of Key Performance Indicators

The key performance indicators are established through legislative order at the national level in Romania by the Ministry of Health. The key performance indicators are divided into four categories: human resource management, service utilization, economic indicators, and quality indicators. The human recourse indicators include the number of patients discharged per doctor, the number of ambulatory consultation per doctor, proportion of physicians from all personnel, proportion of health care professionals from all personnel, and the proportion of health care professionals with a BSc or higher. The service utilization indicators include the number of patients discharged per hospital and per each department, bed utilization rate, index of case complexity, the rate pf patients with surgeries, the rate of emergency admissions, proportion of patients with referrals that were admitted, total number of ambulatory consultations, and proportion of medical services performed for day admission from the total number of medical services per hospital and per department. The economic indicators include percentage of money spent from the allocated budget, proportion of human resources expenditures from all expenses, percentage of expenditures covered by

insurance, percentage of expenditures on drugs, cost of hospitalization per day and per department, percentage of hospital income. Lastly, the quality indicators include the mortality rate per hospital and per department, the rate of nosocomial infections, the rate of readmission within 30 days of discharge, the rate of correlation between the admission diagnosis and the discharge diagnosis, the percentage of patients transferred to other hospitals, and the number of patient complaints (Ordin nr. 112).

The legislation also includes calculation instructions for each indicator and a methodology for evaluating results. The results are posted on each hospital public website and become an image of the efficiency and service quality of the hospital and the managerial performance (Ordin nr. 112).

Knowledge based managerial decision support systems

A decision support system for managerial decision is based on cascade calculation of impact for the key performance indicators of the factors for which a decision is to be made. The cascade calculation of impact is based on evidence from past performance and includes expected changes in performance of the new investment for which the managerial decision is expected. However, the investment must be considered in the context of economic indicators for optimization.

An investment sustainability is dependent of the prior knowledge of the environment the organization is operating within. The user needs, which in a health organization environment are either patients or health care professionals, are at the center of the managerial decision. However the investments must be supported by solid evidence of gains for the health organization. The balance between the user needs and a cost analysis for investment is dependent on the organizational autonomy, existence of trained staff, and expected outcome on key performance indicators (Hanohov and Baldacchino, 2017).

A knowledge based decisional support system will integrate data collection and data retrieval utilities with modeling and simulation techniques. A comprehensive system may be based on a collection of subsystems each targeting a category of key performance indicators. Resource allocation and process improvement can be optimized by the use of various computational methodologies which can be applied to assist in decision making related to healthcare design and planning. A typical procedure in designing a modeling decision support system includes the following steps: Data Collection and Analysis, Process Mapping, Base model design, Simulation scenarios, results analysis and design decisions (Cai and Jia, 2018).

A hospital manager in Romania must evaluate and consider any direct or indirect impact of their decisions on the performance indicators therefore decisional optimization must be the core tenet of any managerial approach.

In (fig. no. 1) we show how managerial decision are influenced by factors from each category of key performance indicators which in turn are influenced by investment decisions. The data in this figure is based on the key performance indicators for Romanian's Hospitals.
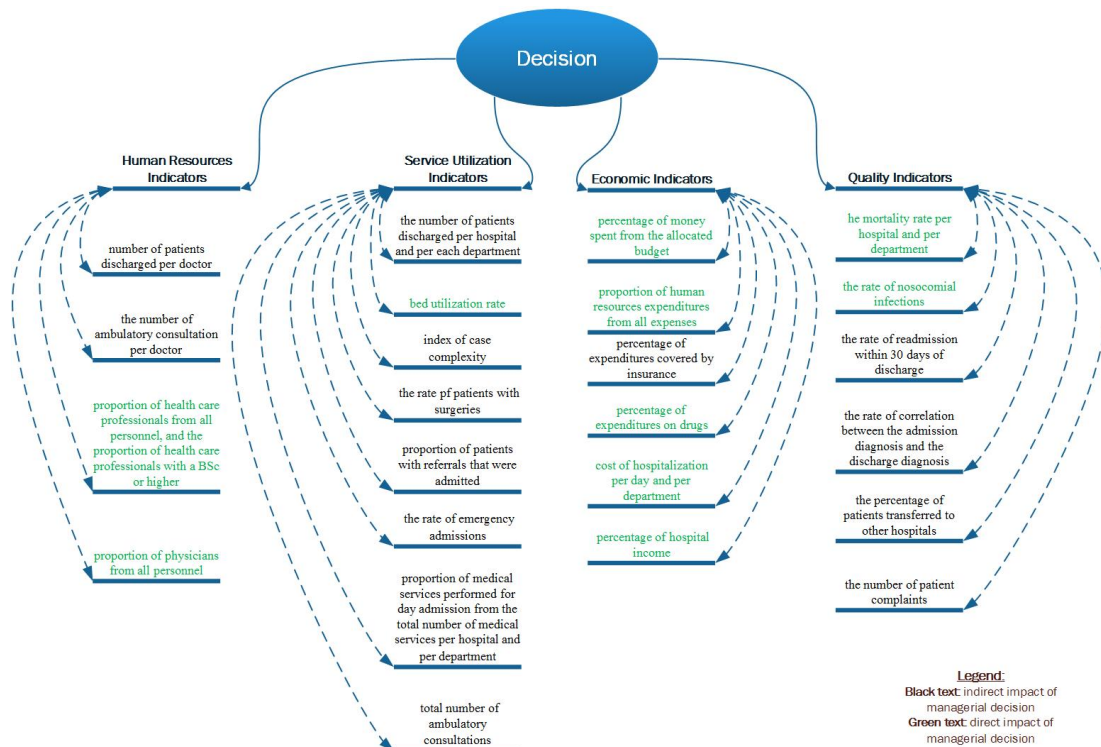
Fig. no. 1. Decision impact considerations and decisions direct impact on key performance indicators

Integration of knowledge based decision support systems

Integration of decision support systems in managerial decisional process involves not only the simulation component but also a data collection component and a dialogue component. The data collection includes two types of data: internal and external. Internal data refers to historical organizational data, while the external data refers to legislative directives, information about the subject of the financial investment the manager is considering in the managerial process, and latest research. The dialog component would allow the managers to as ask questions related to the various factors considered in the decisional process as well as to compare outcome with alternative decisions (Liu et al., 2007). In (fig. no. 2) we show the integration concept of a managerial decision support system based on the three components described above.
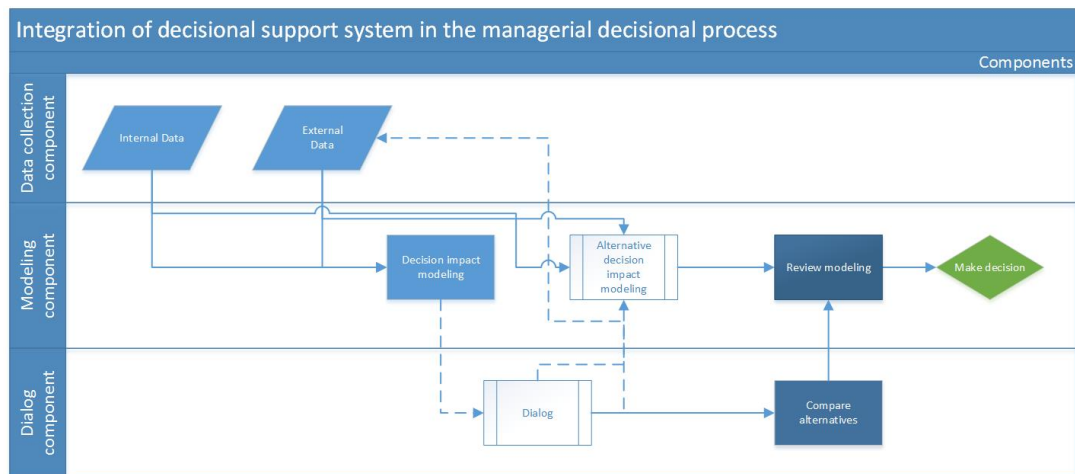
Fig. no. 2 Integration of decisional support systems in the managerial decisional process

Conclusions

The knowledge discovery decision support systems could help health organization managers make evidence based decisions with the focus on key performance indicators. The requirements of a managerial decision support system may intersect with clinical decision support system requirements however the goal is extended to include not only health outcome optimization for patients but also improvements and optimization of economic measurements for the health organization.

The implementation of knowledge discovery decision support systems could help health organization managers obtain answers to questions such as: buying this new equipment will help my organization improve, maintain or achieve the key performance indicators measures? Or developing a new policy on prescriptions will help my organization save on drug costs?

However, any knowledge discovery based decision support system will only be as good as the quality of the knowledge acquisition. The systems must be developed in the context of the health organization environment and must integrate the limitations of the physical work space, legislative constraints as well as socio-political climate.

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