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A Model for Controlling the Patient Care Process - the Challenges and Opportunities of Electronization

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Abstract — **Hospitals are in a great pressure between cost savings and a growing need for patient care. This pressure makes it essential to measure, follow up and develop the processes in order to make them more efficient. This kind of development requires new managerial tools and also new ways of storing the data in hospitals. This study evaluates the opportunities and challenges of electronization in hospitals from the managerial point of view. These opportunities and challenges rise from developing a model for measuring the costs, quality and time of the patient care process in one case hospital. As a result we conclude that if benefits from managerial innovations are to be achieved, electronization of hospitals databases is required.**

Keywords — **patient care process, process control, health care, electronization**

I. INTRODUCTION

A. Background

The primary goals of health care are to give good treatment and heal the patients. When the resources of health care are used cost efficiently, it ensures good patient care for more patients than earlier. The activities of health care must be made more effective in order to keep the total budget of social and health care services on reasonable level. The ageing population and also the medical development, new treatments and the growing expectations of the population increase the costs.

Special health care can meet these challenges only by increasing productivity. The best way to increase the productivity of patient care is to develop efficiency of activities. In health care this means changing over from measuring the results to managing the activities.

There is also need for the electronization of patient care data in order to make the patient care more efficient and improve its quality. With electronization the patients' security could improve, the information would be more real-time, the care process could be shortened, the number of overlapping activities would decrease and the activities would become more efficient, which means more patients with less costs. The problems related to the electronization include resistance to change and also concern about data security.

B. Objectives

This study introduces a model developed for measuring the costs, quality and time of the patient care process in one case hospital. On the basis of this modelling process, the opportunities and challenges of electronization in hospitals are evaluated.

In this research paper the information needed for the modelling and the need for electronization are discussed. Also the benefits of the electronization of patient information and modelling the patient care processes are considered. These include the visibility of time and cost information and the efficiency achieved through electronization.

II. LITERATURE REVIEW

Botta-Genoulaz and Millet [4] have researched the use of ERP (Enterprise Resource Planning) systems in the service sector. Their aim is to get an insight into how services approach ERP implementation. In their study there are six cases, of which one is a hospital. The problems related to the implementation of ERP in hospitals include country-specific factors, such as reimbursement systems and patient care systems, where practices vary from country to country. In the service sector, the human factors are considered more important than in other industries. Despite the difficulties, the overall ERP experience was considered as a success. The ERP systems accelerated the transition to activity-based costing and increased the level of data standardization within the hospitals. The management also received information on the use of resource, which was not available previously. The benefits received included the following:

- better organization of processes
- more rigorous software in comparison with manual information processing
- more satisfied users
- ability to trace information in the whole system

Jansen-Vullers and Reijers [8] have studied the potential contribution of Business Process Redesign to the society's demand for decreasing the costs of healthcare. They focus on the reduction of throughput times and service times by improving the tasks, routing structure and resources of the business process. They present a case of the intake process of mental healthcare. After mapping the intake process they introduce seven different scenarios for decreasing the throughput time: post, periodic meetings, social-medical worker, medical file, notice recording, registration cards and treatment plan. Four of the seven redesign scenarios resulted in the improvement of throughput time. This method enabled the mental healthcare institute to come up with new ideas, which actually improved their intake procedure. Even though this case study cannot be generalised for all processes in healthcare, the intake procedure is rather common and this kind of approach can be used for other processes as well.

Staccini & al. [10] have proposed an object data model of a process and its components and programmed a web-based tool in an object-oriented environment. This tool makes it possible to extract the data dictionary of a given process from the description of its elements and to locate documents according to each activity or role. They point out that clinical information systems must satisfy two kinds of clients. They have to provide the end-users with full event traceability, real-time data entry and retrieval features, context-based decision supply and measurement of activity performance. They must also reassure patients that everything is being done. Staccini & al. [10] also point out the usefulness of process mapping in clinical pathway management. Process mapping can be used for reducing the waiting time, improving quality, measuring patient satisfaction and reducing costs. They also conclude that the model has to be simple, transparent and as understandable as possible. The model must not be too theoretical for the healthcare professionals in order to enhance their collaborative participation in the development process.

Seila [9] has introduced some lessons learned in modelling projects at medium size hospitals. These rules are presented from the perspective of the modeller.

- Health care managers are not interested in modelling methodology
- Data is a limiting factor
- You must understand the health care system
- You should model the health care work processes
- The model should include a financial component
- The model should include data management processes
- The model must be built quickly

Aktas & al. [1] have proposed a management-oriented decision support model to assist health system managers in improving the efficiency of their systems. In their study the efficiency is measured by the total time spent in the system. This reflects the fact that the quality of service and the desire to not wait in queues are of critical importance for the users of health services.

Takeda and Endoh [11] introduce three major goals identified in a 2013 prognosis paper:

- patient-centred recording and use of medical data for cooperative care
- process-integrated decision support for health care professionals
- comprehensive use of patient data for clinical and epidemiological research and for health care reporting

They also point out that it must be clearly understood that ICT must be implemented according to three basic principles: (1) information can not be meaningful when it is not efficiently used; (2) it is important to think from the standpoint of the recipients of services; and (3) the safety of information must be secured.

Chalmers & al. [5] point out the importance of reliable terminology. They argue that this problem will not be resolved by mere digitization, but on the contrary, will tend to get worse as the volume of electronic medical communication increases. The lack of precisely defined medical terminology makes it impossible to create data sets which can be interpreted between researchers.

Eggli & al. [6] propose a conceptual framework which is universal and based on descriptors of six entities: general population, people with poor health, patients, services, resources and effects. They suggest twelve indicators for the surveillance of the ambulatory care system, almost all based on routinely available data: morbidity, accessibility, relevancy, adequacy, productivity, efficacy, effectiveness, efficiency, health services coverage and financing. They argue that comparable data should be available allowing for benchmarking or performance modelling. They also point out that these indicators can be achieved without threatening privacy protection, using modern cryptographic techniques.

Alden & al. [2] have drawn theories from business and health to develop an integrated model featuring antecedents to and consequences of reproductive health-care client satisfaction. They point out that in many studies the client satisfaction is measured either indirectly, using waiting times, or directly by asking about the client satisfaction. Their own results show that the most important things affecting client satisfaction were the doctor's responsiveness and empathy, and the doctor's expertise and access, viewed primarily as "waiting time".

III. CASE: MODELLING THE PATIENT CARE PROCESS

A. *The modelling process*

In this study, a model developed as a part of a larger project for controlling the patient care process is introduced [7]. The caring process of lung cancer patients is used as data in the modelling process. The model has been tested with 22 lung cancer patient cases. With the help of this data, we can make conclusions on the information needed for the modelling and also of the benefits of electronizing patient care systems.

The building of the model started by defining the optimal treatment process of a lung cancer patient and the tests needed in diagnosing and defining the disease. This process mapping was the basis when designing the optimal diagnosis process, which is presented in figure 1. The diagnosis process means the time elapsed from receiving the referral to starting the treatment, and its ideal throughput time was defined less than 36 days. Certain delays between operations are allowed, for example the referral has to be handled right away but the patient's first appointment has to be within a week, due to the practicalities. Spontaneous cure of lung cancer is not possible, which means that the waiting time during the diagnosis process is negative for the patient all the time. During the treatment process some waiting time can be positive for the patient, for example while waiting for the effects of the cytostatikum treatment.

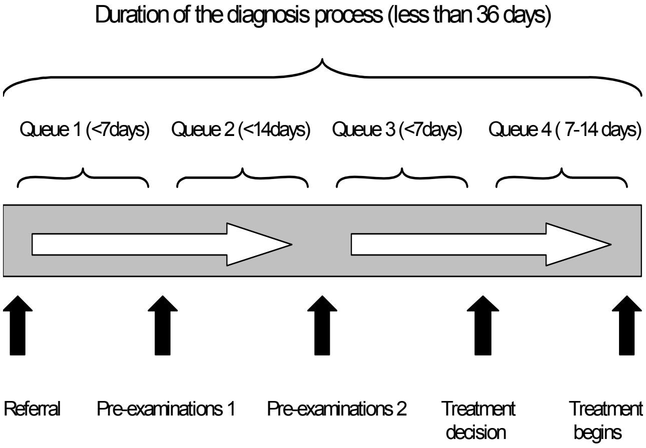

Figure 1. The optimal diagnosis process of a lung cancer patient and its throughput time

The model was developed with a spreadsheet. The model needs information about the patient's occupation, the date of the referral, the tests made for the patient, the time spent at bed rest in hospital, the date of the treatment decision and the date of starting the treatment or ending the tests. As a result the model gives the cost information of each patient and the graphics of cost accumulation. The model also calculates various key ratios. The main key ratios are the time ratio, cost ratio and diagnosis quality. Finally the model calculates a total grade, which is determined on the basis of the main key ratios. This total grade tells about the success of the diagnosis process in a very short form, and with this grade the processes of different patients can be compared with each other. Using the model requires the definition of an optimal patient care process. In order to do an analysis of the process and its costs and time, the results are compared to the optimal process. Appendix 1 clarifies the structure of the model.

B. Results

With the help of the developed model, the costs and time elapsed for the process become more visible than earlier. The model can be used as a tool in managing the activities of the patient care process. The model also makes the costs for the society visible by taking into account the time costs. The time costs are here defined separately for working people, the unemployed, the retired and students. The time costs are calculated based on the average monthly income.

As an output the model gives a cost accumulation graph and some key ratios. The cost accumulation graph for the optimal diagnosis process is presented in figure 2. The costs of the bed rest in a hospital and the costs of the tests can be seen in this graph as a clear growth of costs at the point when these costs are realized. Time costs are accumulated evenly during the whole process.

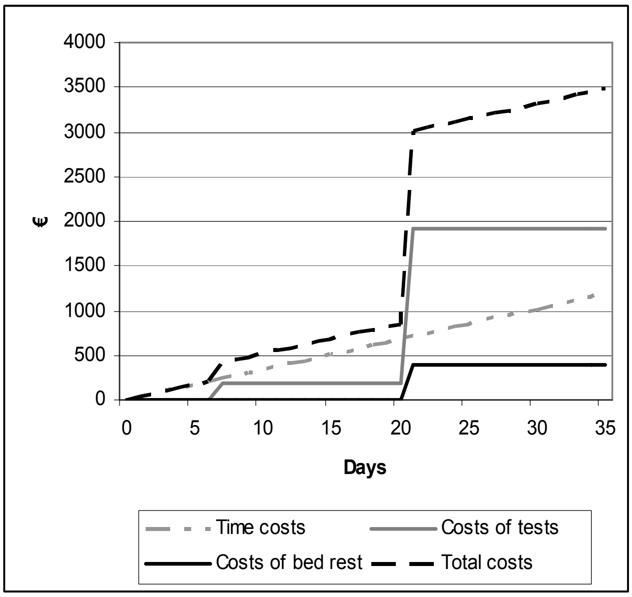

Figure 2. Cost accumulation graph of the optimal diagnosis process

Table 1 presents the key ratios and total grades of the diagnosis process of a lung cancer patient. The time ratio presents how much longer or shorter the duration of the diagnosis process is compared to the duration of the optimal process (36 days). The cost ratio presents the relation between the actual costs and target costs. The diagnosis quality is estimated with the fulfilled tests and the duration of the diagnosis process and comparing these to the optimal situation. The structure of the model and the key ratios are presented in appendix 1. When these ratios are smaller or equal to 100%, the process has reached the targets.

TABLE 1. THE KEY RATIOS OF THE DIAGNOSIS PROCESS OF A LUNG CANCER PATIENT

Patients	Working=W, Retired=R	Time Ratio (%)	Cost Ratio (%)	Diagnosis quality (%)	Total Grade (%)	Assessment
1	R	83	63	57	68	excellent
2	W	386	533	114	344	poor
3	R	149	210	71	143	satisfying
4	R	229	216	86	177	tolerable
5	R	723	940	200	621	poor
6	R	143	296	100	180	tolerable
7	R	140	81	43	88	good
8	R	166	174	57	132	satisfying
9	R	103	59	57	73	excellent
10	R	154	149	29	111	good
11	W	80	169	57	102	good
12	R	231	201	57	163	tolerable
13	R	474	474	143	364	poor
14	R	129	106	71	102	good
15	R	200	299	71	190	tolerable
16	R	223	209	71	168	tolerable
17	R	134	178	86	133	satisfying
18	W	177	155	100	144	satisfying
19	R	46	88	100	78	excellent
20	R	300	155	114	190	tolerable
21	R	66	94	114	91	good
22	R	140	190	100	143	satisfying
Average		203	229	86	173	tolerable
Target		<100	<100	<100	<100	

From these key ratios it can be concluded that:

• The duration of the diagnosis process and the days spent in bed rest in a hospital are the main factors influencing the total costs and the total grade calculated. The number of tests made for the patient is not important.

• To achieve the total grade 'excellent', the diagnosis process should be short and not include many days in bed rest in a hospital. From the point of view of total costs it is more reasonable to make even more tests as long as the duration of the treatment process is short.

• The data shows that the most significant cost drivers are long bed rest periods in a hospital during the diagnosis process. For some patients this means a more severe disease, but part of the patients are taken in a hospital because it guarantees quicker access to different tests. This clearly reflects poor process planning and it should be taken into account as soon as possible.

IV. OPPORTUNITIES AND CHALLENGES OF ELECTRONIZATION

A. Challenges

Here the opportunities and challenges of electronization that we found out during the case study are discussed. In this context electronization does not only mean a paper-free office, but it contains the idea about processing the information into a usable form for the decision makers. Our focus is merely on the findings related to the managerial point of view and not so much on the technological. For example the main concern related to health care information systems is confidentiality, but we will not raise that up here because we consider that it is mainly technological issue.

During the modelling process there were some difficulties due to lack of data. We discovered that although much information is gathered in hospitals, this data is hard to get and there really is a growing need for electronization. The patient data system that this hospital has acquired contains much data, but using the data is difficult. For example, crucial information in this case is the date of the treatment decision. This date is in the information system but it is hard to find, and collecting information based on this date is nearly impossible (compare [11]). The date of the treatment decision can also be marked unclearly and in these cases finding the accurate information requires knowledge about the treatment process (compare [5]).

From the technological point of view the major challenge is the compatibility with other information systems, which may harm also the managerial use of the information systems. There are not many ERP-type systems for hospitals, and due to the nature of public organizations, the acquisition of computer systems is done in pieces, and so compatibility may cause real problems in the future. At the moment some information is already in the electronic form but some is not. For example the x-ray pictures of lungs are partly in electronic form and partly not. The doctors still need to wait for some information on paper, and some of the benefits of electronization disappear. This case hospital has acquired a new electronic patient data system, but using it for managerial purposes might be problematic. So it would be beneficial to clarify if there are any modules that can be added to the system in order to use it more broadly in controlling the activities of the hospital.

The challenge in enhancing process management is more in people than in information systems. Although all data were available, modelling the processes requires competent staff who are familiar with the medical aspects (compare [9]). The one most difficult challenge related to new information systems and also to new managerial systems is the change of organizational culture. Most of the medical staff do not realize that better process management would help in their daily work.

B. Opportunities

If the patient records and other data in hospitals were in an electronic form, it would help in finding the right data when needed. Statistics and reports would be easy to make and these could be used in managing the hospitals. The challenges in this kind of reporting include the fact that if reports are made, the information should be spread all over the organization. If reports are made only for the management, most of the benefits disappear. Also the results and ratios received from the reports should be understood correctly in order to use them for managerial purposes.

The modelling makes the processes transparent, so it becomes easier to see where the delays come from, in this case what causes the delays in the diagnosis process. When the process is known, redesigning the activities would make it possible to cut the delays (compare [8]). If the information was available on time, the throughput time would be shortened, which would lower the costs and also improve the quality that the patient experiences (compare [1], [2], [10]).

Electronization will help in making statistics and reports but it can also help the organization in process management (compare [4]). In this study, the electronization of databases would have helped the modelling of the patient care process. It would be an ideal situation if the modelling process did not suffer from hard data collection but the modelling process was a fluent process and all the needed data were available. This way there would not be a need for compromises in the models.

The challenges and opportunities discussed above are mainly from the managerial point of view. If electronization was used in bettering the management, the results could be very good. If the information gathered would be used instead of just collecting it, the efficiency of health care organizations could be remarkably better than it has been. As showed in this study and also other studies [3], [7] the management tools used in industrial companies fit also to the health care sector with some adjustments.

V. CONCLUSIONS

With the help of the results of this study, the processes of patient care can be modified and made more streamlined. The modelling makes the processes and costs more visible, so it is easier to manage the processes if there are problems. This visibility and possibility to enhance the processes should lead to more efficient patient care.

The model introduced in this study suits at least the caring process control of lung cancer patients. The model requires information about the patient and the optimal caring process as benchmark. Electronization of the patient database would be beneficial. Now the information needed for the model was poorly available. Developing the model further requires more testing with other groups of patients. With some adjustments the model could also be used in comparing the results of different hospitals. The model measures quality with time and the number of tests made. Additionally it would be beneficial if the effects of the treatment could be evaluated, especially if the model is to be used to compare different clinics. The comparison could create healthy competition, which could increase the motivation to enhance the operations (compare [6]).

The information systems used in health care are not designed to produce information for controlling the activities. The information included in the systems is hard to get and also often defective. The future challenge is to create a system which enables diverse information collection and handling across organizations. The model introduced in this study could be part of this kind of information system or the model could get the information directly from this kind of patient database. The modelling, collecting the information and using the information to manage the operations could lead the health care sector towards better process management.

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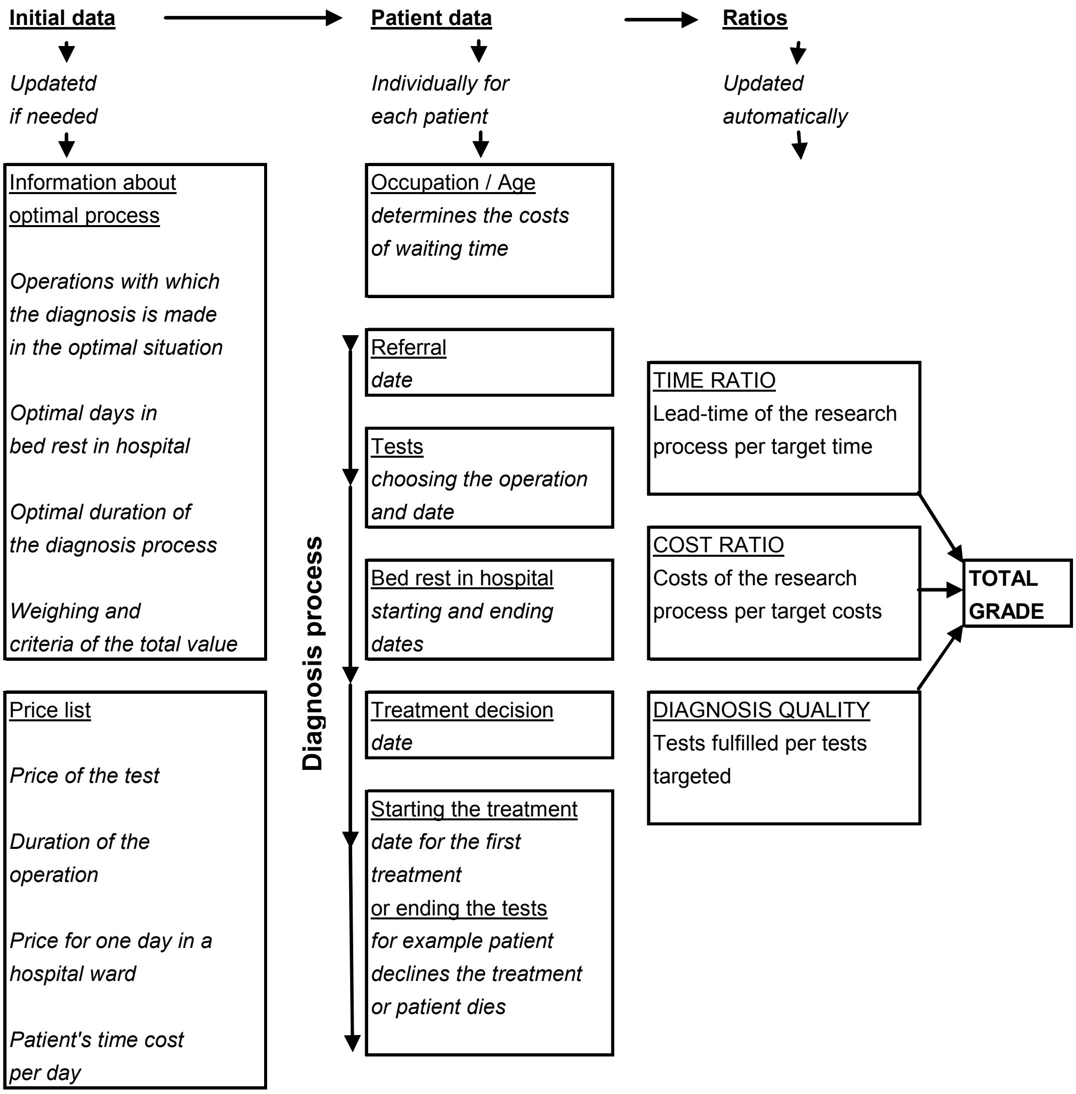
APPENDIX 1. STRUCTURE OF THE MODEL MEASURING THE PATIENT CARE PROCESS OF A LUNG CANCER PATIENT



Additional information

Time information

Active reseach time per whole lead-time (%)

Waiting time per whole lead-time (%)

Time elapsed from the treatment decision to starting the treatment compared to the target (%)

Time elapsed from the treatment decision to starting the treatment (days)

Whole lead-time

Cost information

Costs of the operation

Costs of the bed rest → *Total costs*

Time cost of patient

Cost accumulation graph

Diagnosis quality

Duration of the research process