Time-based management of patient processes

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Abstract

Purpose – The purpose of this paper is to present a conceptual framework that would enable the effective application of time based competition (TBC) and work in process (WIP) concepts in the design and management of effective and efficient patient processes.

Design/methodology/approach – This paper discusses the applicability of time-based competition and work-in-progress concepts to the design and management of healthcare service production processes. A conceptual framework is derived from the analysis of both existing research and empirical case studies.

Findings – The paper finds that a patient episode is analogous to a customer order-to-delivery chain in industry. The effective application of TBC and WIP can be achieved by focusing on through put time of a patient episode by reducing the non-value adding time components and by minimizing time categories that are main cost drivers for all stakeholders involved in the patient episode.

Research limitations/implications – The paper shows that an application of TBC in managing patient processes can be limited if there is no consensus about optimal care episode in the medical community.

Practical implications – In the paper it is shown that managing patient processes based on time and cost analysis enables one to allocate the optimal amount of resources, which would allow a healthcare system to minimize the total cost of specific episodes of illness. Analysing the total cost of patient episodes can provide useful information in the allocation of limited resources among multiple patient processes.

Originality/value – This paper introduces a framework for health care managers and researchers to analyze the effect of reducing through put time to the total cost of patient episodes.

Keywords Time-based management, Patient care, Health services

Paper type Research paper

Introduction

Health care systems are facing increasing pressure to provide objective evidence of the quality and efficiency of their organizations. The move to fixed fee payment systems based on diagnostic groups (DRGs) or similar systems have left the financial risk of inefficient care to hospitals (Evans *et al.*, 1997). In addition to the direct production cost of medical care, the importance of the total cost of a patient episode for all external stakeholders is emphasized (Gustafson *et al.*, 1995). This information can be used to prioritize how resources should be distributed amongst different care divisions in order to provide maximum benefits for the society at large. Healthcare managers and medical professionals who traditionally have concentrated on the quality of care are forced to review their overall management practices for cost effectiveness.

In commercial activities the most generic quality criteria are based on the following assumptions. First, that *ceteris paribus* customers prefer error-free products or services

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over defective ones, second, that customers prefer products that are suited to their particular needs and tastes over unsuitable ones. All quality attributes can be logically derived from these assumptions (Lillrank, 2003). By adhering to these same principles we may postulate that in healthcare the generic quality criteria are, first, patients prefer to get well, postpone death or improve their autonomy given the constraint of their condition and what is medically possible. Second, patients prefer to avoid pain as far as possible. Third, patients prefer not to wait for examinations or treatment longer than medically justified. While the two first clinical quality criteria fall into the sphere of medical sciences, the third is a matter of healthcare administration. It is reasonable to assume that administrative knowledge accumulated in other aspects of management, such as industrial production, can be applied to the third quality criteria.

Industrial processes provide a benchmark for the health care sector in the improvement of production efficiency, assuming it can be achieved without sacrificing clinical quality. The improvement process in industry has been driven by fierce competition, in which only those organizations that are able to provide the best value for customers have survived. Quick adaptation of new technologies and production techniques has had an important role in this improvement process, but much of it can be also attributed to the adaptation of better managerial practices. On the contrary, the improvement of care processes in the healthcare sector can be mainly attributed to the development of new medical technology, procedures and medical breakthroughs. The driving force in the effective application of these new solutions has been medical personnel's moral and ethical desire to provide the best possible care for patients. However, until recently, there have not been similar pressures to apply new managerial practices that would enable the creation of more cost effective health care systems.

The slow exploitation of operations management techniques is not caused by a lack of knowledge or research. An extensive body of knowledge exists concerning the application of industrial process management approaches in healthcare (Yasin *et al.*, 2002; Parvinen and Halonen, 2004). Healthcare service production processes have also been analyzed as production systems from the process point of view (Towill and Christopher, 2003; Vissers, 1998; de Vries *et al.*, 1999; Vissers *et al.*, 2001; van der Bij and Vissers, 1999; Bragato and Jacobs, 2003). Operation management techniques such as the optimization and the simulation of processes have been used to analyze various parts of the hospital system (see, for example, Samaha *et al.*, 2003). Lean management principles have been applied to streamline healthcare production processes (Laursen *et al.*, 2003). Process re-engineering has been useful in improving patient processes (Probert *et al.*, 1999). Quality management approaches such as ISO 9001 quality management systems or quality award criterion have been extensively applied to the management of healthcare organizations. In general, research findings suggest that such management interventions may yield positive results, but there are significant variations in the success of those implementation programs.

An integral part of these process management and improvement programmes is the status of the monitoring process that supplies information about performance before and after improvement interventions. Thus performance measurement is an essential requirement for purposeful improvement. There are a few studies, which have focused on the different approaches to performance measurement in health care organizations. Typically, they have focused on the performance of a particular clinic or involved tracking waiting times for certain medical procedures (Martin *et al.*, 2003;

Aharonson-Daniel *et al.*, 1996). Time is, at present, measured and registered by health care organizations, but it is neither systematic, nor is it an element of an integrated patient process (McCarthy *et al.*, 2000). The reasons behind such an inefficient system are a variety of old-fashioned mechanisms that are used to collect and process data (Fauman, 2003; Sanmartin *et al.*, 2000; Gardner, 2003). Time-related studies in health care are focused mainly on waiting times or on the duration of individual medical procedures and they lack the total patient episode viewpoint (Martin and Smith, 1996; Propper *et al.*, 2002; Naylor and Sykora, 1995; Heckerling, 1984; Rotondi *et al.*, 1997). Time-related indirect costs have also been a popular research subject since the 1960s (Rice *et al.*, 1985). These studies are mainly concerned about the potential production loss, however the methods used in such studies vary greatly and there is a lack of commonly accepted theory (Rice *et al.*, 1985; West, 1985; Greenberg *et al.*, 1995; Hutubessy *et al.*, 1999; Goeree *et al.*, 1999; Marcotte and Wilcox-Gök, 2001).

Decreasing the patient episode throughput time has become a major challenge for various health care organisations (Karr, 1997). This paper aims to develop an approach to monitor, analyze and manage healthcare service production processes from a time perspective, building on the knowledge that has been collected from industrial management research and case reports on application of time based management in healthcare.

Additionally, this research takes a contingency approach, suggesting that the varied nature of different patient episodes (e.g. DRG based on diagnostic groups) should be taken into account. The feasibility and practical validity of the framework were explored in five different patient groups: lumbar disc herniation, adulthood depression, ST-elevation myocardial infarction, cataract and hip arthrosis. The objective of these case studies was to evaluate practical validity and to identify key factors that have an influence on care design.

Time-based management

In the 1980s some Japanese companies adopted the novel strategy of using time as a source of competitive advantage. It became known as Time Based Competition (TBC), which generated a set of principles labelled Time Based Management (TBC). By reducing unproductive time, companies were able to reduce costs, improve quality, and stay close to their customers. This, however, required a rather fundamental change in management logic, from the traditional belief that seeks to operate at maximum capacity to the new concept, which sought the total optimisation of product flows. Essentially a change in perspective on the unit of analysis was required. In traditional manufacturing the unit of analysis was a productive resource, such as a plant, a manufacturing department, or a piece of equipment. The performance of these was measured in terms of capacity utilization rate, yield, quality, and unit production cost. In TBM the perspective shifted to the analysis of a single customer order and to track its path from order to delivery. The time it spent in various process phases was measured and compared to total throughput time. It was realized that in a typical manufacturing process only 0.05 to 5 percent of the total throughput time for an individual order was spent in actual production, the remaining time was spent waiting for something to happen. The waiting time did not mean that productive resources stood idle, but rather that a particular, individual customer order was waiting for something else to happen. This "something else" was divided neatly into three categories: waiting for the batch to be processed,

waiting for approvals or other administrative acts, and waiting for errors to be corrected (Stalk, 1988; Stalk and Hout, 1990).

Further, it was discovered that throughput time was connected to several performance indicators. Long throughput times tend to generate inventory, work in process (WIP), which by absorbing working capital increases financial costs. Managing inventory is costly, parts may fall in price while waiting, and they may rust or become obsolete. Inventory clogs production facilities and makes it difficult to grasp the actual flow of activities (Vonderembse and White, 1996). Large amounts of inventory impede rapid response to fluctuating demand. In many cases short delivery time is a competitive advantage, customers prefer to get their stuff (receive their goods) sooner rather than later. With these links to other types of performance, time becomes a critical measure of competitiveness, comparable to traditional financial measurements (Stalk, 1988).

The objective of TBM is to minimize throughput time. This is achieved, first, by reconfiguring processes so that the flow of customer orders through the system improves, second, by removing non-value adding activities from production processes.

The principles of reconfiguring processes are basically the search for and the elimination of bottlenecks, the rearrangement of certain process steps so that they operate parallel to each other instead of sequentially, and by reducing batch-size through faster and easier set-up. When aiming to reduce throughput times, it is essential to distinguish between value-adding and non-value-adding time. Reducing productive time is similar to more traditional productivity and effectiveness improvements such as working faster. It may, particularly in service sectors, lead to decreased quality. Reducing unproductive time components of a process, however, is typically an administrative issue involving scheduling and resource allocation. It does not increase productivity in terms of input-output conversion efficiency, rather the effects are demonstrated by lower capital costs and increased customer satisfaction, as shorter throughput times reduce waiting times and improve responsiveness to customer needs.

Patient in process

The patient-oriented approach is a relevant starting point for analyzing healthcare service production processes, because the value generated by any given situation in healthcare is directly related to the changes in that patient's condition. Patient episodes are also challenging from a management perspective, because they are often cross-functional and span organizational borders. The importance of patient-oriented approach in both research, as well as design and operational management of health care systems has been widely recognized (see, e.g. Tarte and Bogiages, 1992; Vissers, 1998; Lillrank *et al.*, 2003).

In this research we defined the time period during which a patient is involved with a health care organization the patient episode throughput time. A patient episode describes what happens to a patient in the sequence of events from first contact to closing of case. For simplicity we look initially at only episodes that are organized around a single ailment, its diagnosis and treatments. While a patient episode describes what happens to a patient, patient process describes how healthcare system resources are organized to provide services. An episode provides a patient perspective, a process a producer perspective. A patient episode is analogous to a customer

order-to-delivery chain in industry; a patient process is analogous to an industrial production process including resources and procedures. Consequently, the focus in healthcare should be on minimising non-value-adding time during the patient episode.

The assumption here is that a patient episode can be described and analyzed using concepts borrowed from industry. The demand for healthcare services is formed as a result of the deteriorating health in an individual or an individual becoming aware of options available to improve their condition using healthcare services. The latter is equivalent to the marketing process used to create demand for services. Demand for healthcare services with varying amounts of urgency, complexity and uncertainty is expressed upon primary contact with the supply system. A sense-making and negotiation process, similar to sales and order negotiation process in industry, is initiated to determine the exact nature of patient disease and appropriate care. The main difference to industry is that the healthcare supplier often has a dominant negotiation position due to both the urgency of the situation and information asymmetry. The initial patient contact corresponds to a customer inquiry, and a diagnosis corresponds to an approved customer order that is to be filled by the healthcare system. It provides a signal to allocate capacity and begin medical procedures. The relationship between healthcare systems and the patient often continues after medical operations are completed, similar to a guarantee period and customer service in industry. The main difference is that a healthcare system generally aims at keeping a patient out of hospital, while in industry the objective is to receive future orders from customers.

Analogously to the Work in Progress (WIP) measure in manufacturing, in health care we suggest the Patient in Process (PIP) –concept. The focus and unit of analysis in studying PIP should be a patient episode. Some researchers suggest that by focusing solely on minimizing the patient throughput time, i.e. length of stay, does not reduce the cost of care (Evans *et al.*, 1997). Thus it is essential to go beyond the general aim of decreasing lead times and to focus on those patient processes and process faces where a decrease in lead times have the maximum impact on process efficiency and effectiveness. Table I defines potential areas in which time can be the most important cost driver. It provides the basis for analyzing whether minimizing patient throughput time can lead to more efficient resource utilization and cost saving in specific patient processes.

Patient in process creates significant costs for hospitals and all stakeholders that are involved or impacted by patient episodes. Direct inventory costs in a healthcare context include the use of hospital beds and other resources. Hospital beds have been recognized as one of the key cost drivers and it is also one of the main bottlenecks limiting throughput of healthcare production systems. Extra waiting time is generally non-value adding time, during which resources are not used to improve a patient's medical condition. These costs are a burden to the hospital in the form of additional medical work or to external stakeholders, such social services who provide assistance for a disabled patient who is waiting for a medical procedure. Inventory obsolescence is directly related to the degradation in a patient's condition due to extra waiting times. The cost of capital employed is similar in both manufacturing and in healthcare. Manufacturing as well as healthcare consumes resources, which increases the amount of working capital required before it can be charged to the customer. Extra patients in process causes decreased production capacity and control over production process. In

WIP in manufacturing process	PIP in healthcare production processes
Direct inventory costs (space, etc.)	Use of hospital facilities (beds, etc.)
Resources spent on non-value adding activities (e.g. inventory management)	Resources used for queue management, hotel services for patient waiting in hospital, additional medical operations (e.g. new laboratory tests) Resources spend by other stakeholders for non-value adding activities (e.g. social services providers)
Inventory obsolescence	Deterioration of patient medical condition leading to additional or more costly treatments, and/or decreased quality of care outcome
Cost of working capital employed	Working capital employed due patients in process for hospital
Decreased production capacity	Patients filling to capacity, inefficient use of bottleneck resources, extra beds in corridors, increased fixed cost per patient episode due to decreased throughput
Decreased control of production process	Overtime work, employee dissatisfaction, patient dissatisfaction
Unsatisfactory service punctuality, flexibility and delivery times	Decreased timely access to medical services leading cost for patient (lost income, suffering), insurance company (medical expenses), employer (lost work output) and/or patient's family

Table I.
WIP related costs in healthcare production processes

addition to internal costs it leads to decreased timely service quality for patients and other external stakeholders.

The main difference between industrial and healthcare production processes is that a patient in process causes significant costs for patient, and for other external stakeholders. The trouble, however, is that these costs are borne by stakeholders who do not have a direct influence on the service production process, which may lead to sub-optimization of the process from a single stakeholder perspective.

Time categories of a patient episode

In industry time has crudely been divided into value-adding and non-value-adding time. Harrington (1987) allows for three types of activities, those that create value for customers, those that create value for the business, such as payroll administration, and those that create no value at all. In healthcare the time categories need to be more sophisticated. In healthcare there are times, like in wine making, where the product improves without the production system actively participating. We propose dividing patient episode time into three major groups: diagnostic and care time, administrative time and waiting time. The distinction between time categories is based on expected change of patient's medical condition, information management, the types of services provided and the resource consumption as shown in Table II.

Table II.
The distinction between time categories is based on expected change of patient's medical condition, information management, the types of services provided and the resource consumption

Expected changes to patient's medical condition	–	Improve	Improve	Decrease	–	Improve	None	Decrease
Information management								
Process control information	–	–	–	–	Yes	Some	Some	Some
Diagnostic information	Yes	–	–	Yes*	–	No	No	No
Service production								
Diagnostics	Yes	No	No	Yes*	No	No	No	No
Clinical intervention	No	Yes	No	Yes*	No	No	No	No
Monitoring	–	–	Yes	Yes*	No	No	No	No
Resource consumption								
Medical system resources	Yes	Yes	Some	Yes	No	No	No	No
Administrative resources	Yes	Yes	Yes	Yes	Yes	Some	Some	Some
Other (PIP costs)	–	–	–	–	–	–	–	–
	Diagnostic time	Active care time	Passive care time	Superfluous care time	Administrative time	Positive waiting time	Passive waiting time	Negative waiting time

Notes: [a]Not relevant in determining time category; *Superfluous care time include one or more from the marked categories; ** Other PIP related costs such as cost for patient, employer do not have influence on time categorization and they are DRG-specific

We propose that this classification of time categories provides a better starting point for the development and management of patient processes as compared to a simple division into value-adding and non-value-adding time.

Diagnostic and care time includes the entire time when the patient is cared for in the processes. It can be divided to four sub-categories: *Diagnostic time* includes collecting and analysing diagnostic information. *Active care time* consists of clinical interventions. During *passive care time* resources are not used actively, but the patient is under observation in inpatient units. *Superfluous time* is defined as a medical diagnostic and care that is not based on official care process recommendation.

Administrative time includes all the non-medical tasks related to a patient episode. It covers such tasks as capacity allocation, scheduling, queue management and reporting. Administrative time delays cannot be totally avoided, but the objective should be to minimize or perform them parallel to care time them when it is economically and technically feasible.

Waiting time is defined as all the time when a patient is waiting for a medical procedure based on official care process recommendation and a patient episode is not handled by producer's processes. It is further divided into three categories that describe the effect of time has on a patient's medical condition: positive, passive or negative. During *positive waiting time* the patient's condition is likely to improve spontaneously. In the *passive waiting time* category patient condition is stable and delay does not influence either the patient's medical condition or the prognosis of the success of medical operation. *Negative waiting time* indicates that patient condition is likely to deteriorate and they may require more complex procedures. It could also be that the prognosis of patient's (medical) condition after care episode is less favourable.

The productive time categories are: diagnostic times, active and passive care times and positive waiting times. Other categories are unproductive and must be therefore eliminated or sufficiently minimized. Negative waiting times are not only unproductive, but also destroy value.

These basic time categories can be grouped in various ways along the patient episode. One useful term related to time categories is visit time, which is the time one healthcare visit lasts, either inpatient, or outpatient-care. The visit time can include all categories defined before. The episode of illness begins when the first symptoms are identified. The patient episode refers to the time when a patient is a customer of the heath care system. A patient episode can be grouped into blocks of time spent in various administrative units, such as primary and special care and rehabilitation. The objective of a healthcare system is to minimize the number of episodes of illness and to effectively manage patient episodes (see Figure 1).

For a social and economic evaluation of various time categories, several stakeholder standpoints should be considered. The medical point of view focuses on identifying the effect of various care options and waiting time to the medical condition of the patient and to create ideal care paths where the patient moves through the system at the pace determined by clinical considerations without other time delays. It is the responsibility of medical research to present evidence-based medicine in the management of patient episodes. From the patient perspective the entire time spent in the health care system is a direct cost due to the loss of potential earnings and the cost of inconvenience, as well as that of missed opportunity, such as a loss of leisure time and peace of mind (Lillrank *et al.*, 2003). From an operational research perspective the objective would be to

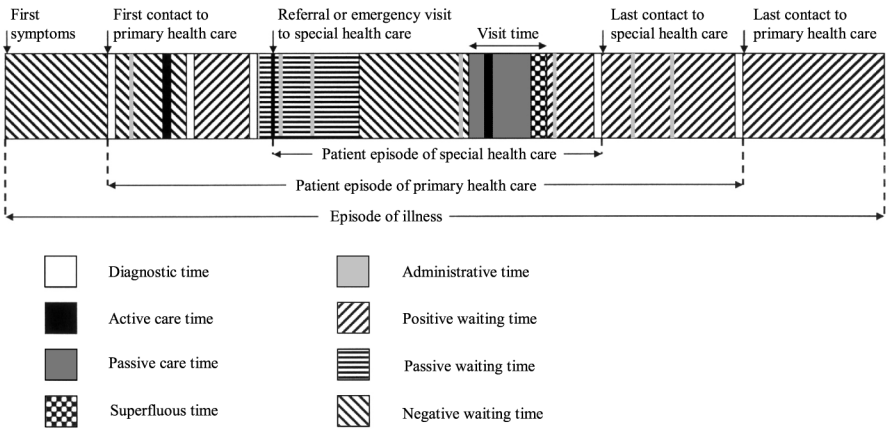

Figure 1.
An example of patient episode and related time categories

understand the underlying reasons for delays such as waiting in bottleneck, the ineffective allocation of resources, low quality of information or problems with communication between departments. From the point of view of the patient's employer, the work contribution and expertise are not available or patient's ability to work is reduced.

It is essential to identify the total cost of a patient episode in order to allocate the optimal amount of resources, which would allow a healthcare system to minimize the total cost of specific episodes of illness. The objective of the development of patient processes should be the achievement of a situation where the patient episode is in a state of technical and economical optimum. This kind of episode includes all the required diagnostic and care tasks, positive waiting times, and a technically and economically reasonable amount of administrative time and non-productive waiting time. Additionally, the total cost of patient episodes can provide useful information in the allocation of limited resources among multiple patient processes.

Discussion

WIP – This concept has mainly been applied in the analysis of repetitive manufacturing processes. Its application to the analysis and the improvement of healthcare service production is a challenge for organizations that have traditionally been managed as a professional organization where tasks are grouped as functional specialties. There are significant challenges but also opportunities for learning in this process, which are further discussed below.

The value generation in the healthcare service production processes comes from effective medical operations. Thus it is logical to take medical requirements that ensure a high quality care as a starting point for designing efficient patient processes. Defining optimal care should be left to medical professionals and achieved by following the methodology of evidence-based medicine. They should also provide an indication of how deviances from optimal patient process (e.g. waiting times) influence the quality of care (e.g. mortality). Using this information as a starting point, healthcare managers and persons responsible for process development can continue by defining

an optimal patient process that also takes in to account both technical and administrative limitations.

The definition of an optimal patient process is one of the main challenges in the practical application of PIP-concept. From a medical point of view there have been several attempts to create such care process recommendations, but they cannot be directly used to define optimal patient process. Additionally, what constitutes a high quality medical care process is often contentious in the medical community. In practice it leads to a high variety of processes in medical care, as each medical professional can define their own approach. An application of PIP-concept could provide an opportunity for healthcare managers to insist that medical professionals agree on standard processes, which are easier to manage and control.

The healthcare sector as such is a large "industry" containing various types of service delivery processes of different natures (for example acute care vs elective care, surgical vs conservative care). There are also illnesses that are chronic and others that can be more or less cured with treatment. These factors were taken account when testing the practical validity of the proposed framework by applying it to five different patient groups in two hospitals in Finland.

PIP may not applicable to everything, but is effective within certain conditions. First, there should be some care process recommendations, which make it possible to analyze the patient episodes coherently. Within these diagnostic groups, a specific recommendation was provided only for the lumbar disc herniation group. Second, the patient episodes of a group must follow a consistent process and they have to be similar enough to create any meaningful statistics. This requirement was most accurately realized in the cataract and hip arthrosis groups. Third, the application of PIP is easier if the disease or reason for symptoms can be identified early enough so that the right patient process can be defined. Diagnosis and decision for treatment in the early stages was possible for ST-elevation infarct, cataract, and hip arthrosis. The benefits of applying PIP-concept are bigger for patient groups where patient-episode throughput time is long and significant costs occur to external stakeholders.

The case study approach was based on the data that was available in the hospital information systems and ex post review of patient records with medical personnel to construct patient episodes, divide them into time categories and to calculate cost related to each patient episode. Based these case studies it can be concluded that the information required to construct patient episodes is not easily accessible. Additionally, in acute diagnostic groups, such as ST-elevation infarct, it was difficult even with the help of medical personnel to divide patient episodes into time categories. The use of PIP concept for practical management would require integrated information system, which automatically keep track on patient flow in the hospital and enables report deviations in individual patient episodes to recommended patient process.

The PIP-approach as presented in this paper is based on the assumption that homogenous patient groups can be identified. The complexities arising from multiple diagnoses and degenerative diseases are ignored for the moment. If there is considerable variation of care paths, process-based approaches should be complemented with effective case management (see, e.g. Karr, 1997). It can also be a challenge for healthcare service production in patient groups that have a considerable variety in their resource use and should be organized around patient processes. A more

viable approach could be based on treating each individual patient as a project and managing production systems using management approaches from project-oriented companies.

Conclusions

This paper presents a conceptual framework that would enable the effective application of time-based competition (TBC) and work in process (WIP) concepts in the design and management of effective and efficient patient processes. We propose that these objectives can be achieved by focusing on throughput time of a patient episode by reducing the non-value adding time components and by minimizing time categories that are main cost drivers for all stakeholder involved in the patient episode.

The introduction of the PIP concept has been received positively among health care professionals. The participants in the health care sector are intensively searching for new approaches to cope with the challenge of providing high quality care while efficiently coping with increasing demand while constrained by the slow growth of resources. Health care managers have been somewhat hesitant to apply industrial methods. We believe, however, that with the proper adjustments and conceptual translations, several of the methodologies that have contributed to the enormous creation of wealth in the industrial world can also be applied to health care.

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