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Time-based analysis of total cost of patient episodes

A case study of hip replacement

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Abstract

Purpose – Healthcare in the public and private sectors is facing increasing pressure to become more cost-effective. Time-based competition and work-in-progress have been used successfully to measure and improve the efficiency of industrial manufacturing. Seeks to address this issue.

Design/methodology/approach – Presents a framework for time based management of the total cost of a patient episode and apply it to the six sigma DMAIC-process development approach. The framework is used to analyse hip replacement patient episodes in Päijät-Häme Hospital District in Finland, which has a catchment area of 210,000 inhabitants and performs an average of 230 hip replacements per year.

Findings – The work-in-progress concept is applicable to healthcare – notably that the DMAIC-process development approach can be used to analyse the total cost of patient episodes. Concludes that a framework, which combines the patient-in-process and the DMAIC development approach, can be used not only to analyse the total cost of patient episode but also to improve patient process efficiency.

Originality/value – Presents a framework that combines patient-in-process and DMAIC-process development approaches, which can be used to analyse the total cost of a patient episode in order to improve patient process efficiency.

Keywords Patient care, Time-based management, Quality management, Six sigma, Finland

Paper type Case study

Introduction

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

Industrial processes provide a benchmark for the healthcare sector managers wishing to improve efficiency. One recent application is time-based competition (TBC), which emphasises the reduction of unproductive time so that companies are able to reduce costs, improve quality, and stay close to their customers (Stalk and Hout, 1990). Throughput time is connected to several performance indicators, and long throughput

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times tend to generate inventory or work-in-progress (WIP), which, by absorbing working capital, increases financial costs (i.e. Blocher *et al.*, 1999). Managing inventory is costly, parts may fall in price while in storage, and may deteriorate or become obsolete.

Minimising throughput time in patient processes will decrease the costs and increase care efficacy. The influence of time to care efficacy can be estimated by clinical research, but we concentrate on investigating the influence of time on healthcare costs. In this article we first present the main principles of patient-in-process (PIP) (Lillrank *et al.*, 2003; Peltokorpi and Kujala, 2004). Six sigma define-measure- analyse-improve-control (DMAIC)-process development approach is also introduced as a practical tool to apply PIP concepts to improve patient processes. The practical validity of the proposed framework is illustrated by a case study using hip replacement patients.

Patient in process

The patient-oriented approach is a starting point for analysing healthcare 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 organisational borders. The importance of a patient-oriented approach in research, as well as design and operational management of healthcare has been widely recognised (Tarte and Bogiages, 1992; Vissers, 1998; Lillrank *et al.*, 2003). In this study we defined the time period during which a patient is involved with a healthcare organisation as "the patient episode throughput time". A patient episode describes the sequence of events following the patient from first contact to discharge. In contrast, patient process describes how a healthcare system's resources are organised to provide services. An episode provides a patient perspective and the focus of healthcare should be to eliminate activities that do not directly nor indirectly add value to the patient. The analogous healthcare WIP measure in manufacturing is the PIP (Lillrank *et al.*, 2003). The focus and unit of analysis in studying PIP should be the patient episode. Table I defines potential areas in which time is the most important cost driver. It provides the basis for analysis of whether minimising patient throughput time can lead to more efficient resource use and cost saving in specific patient processes.

The main difference between industrial and healthcare processes is that a patient in process is the source of significant costs for the patient as well as for other external stakeholders. The trouble, however, is that these costs are not only borne by the stakeholders (e.g. employer) but also the patient and employer who may not have a direct influence on the service production process. This may lead to sub-optimising the cost of a patient episode from a single stakeholder perspective, which may lead to an increase in the total cost of episode. For example if surgery on an employed patient is delayed, there is additional cost for employee, who has no influence on the timing of surgery.

Time categories of a patient episode

In industry, time has been divided into value-added and non-value-added. Harrington (1987) suggests three types of activity, 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, time categories need to be more sophisticated (Figure 1). We propose dividing patient episode time into three major groups:

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

Table I.
WIP-related costs in healthcare production processes and cost-related stakeholders in Finnish context

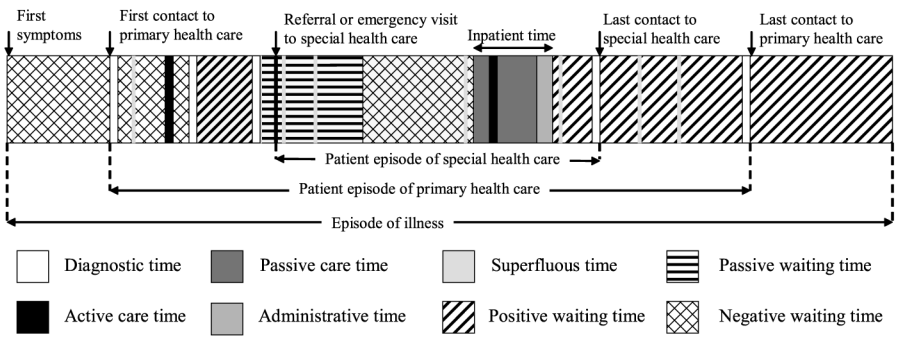

Figure 1.
An example of patient episode and related time categories

(1) Diagnostic and care.
(2) Administrative.
(3) Waiting times.

Diagnostic and care include the entire time a patient is being actively treated. It can be divided into four sub-categories:

(1) Diagnostic time includes collecting and analysing diagnostic information.
(2) Active care time consists of clinical interventions.
(3) During passive care time resources are not used actively, but the patient is under observation.
(4) Superfluous time is defined as a 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 scheduling, waiting list management and reporting (Lillrank *et al.*, 2003; Peltokorpi and Kujala, 2004).

Waiting time is defined as the total time a patient spends waiting for treatment based on official care process recommendations and producer's processes do not handle a patient episode. It is further divided into three categories:

(1) During positive waiting time the patient's condition is likely to improve spontaneously.
(2) 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 procedure.
(3) Negative waiting time indicates that patient's condition is likely to deteriorate or the prognosis of a patient's post-procedural condition is less favourable.

For example, negative waiting time includes the period starting with the decision to operate up to surgery only if patient condition deteriorates while waiting for surgery (Lillrank *et al.*, 2003; Peltokorpi and Kujala, 2004).

The productive categories are diagnostic time, active and passive care times and positive waiting time. Other categories are unproductive and must be therefore eliminated or at least minimised. Negative waiting times are not only unproductive, but also destroy value (Lillrank *et al.*, 2003; Peltokorpi and Kujala, 2004).

It is essential to identify the total cost of a patient episode in order to allocate the optimal amount of resources, which allows healthcare managers and practitioners to minimise the cost of illness. In an optimum state, the episode includes all the required diagnostic and care tasks, positive waiting times and a reasonable amount of administrative time and non-productive waiting time. Additionally, the total cost of patient episodes can provide useful information for allocating limited resources to multiple patient processes (Lillrank *et al.*, 2003; Peltokorpi and Kujala, 2004).

Application of PIP

In this section, we explain how PIP can be used to develop patient processes. The method is based on define-measure-analyse-improve-control (DMAIC) steps in the six

sigma management philosophy (De Feo and Barnard, 2003). The sequence of steps is represented in Table II.

The improvement project starts by defining the patient group and patient process. The ideal progress of an episode is based on the practitioners' opinion of and official care process recommendations on how to best care for a patient under ideal circumstances. The development of such care recommendations is the task of healthcare professionals and should be based on evidence-based practice (Eddy, 2005). After data gathering the next phase is to measure the amounts of different time categories in selected cases. This time analysis and stakeholder-related cost information forms a basis for the analysis of the episodes and process improvement proposals. Selected development proposals can be initially tested in an experimental pilot program, and if they are perceived as successful the next step is to implement new processes and monitor them.

Hip replacement case study

We applied PIP to five DRG-related patient groups. These patient groups were lumbar disc herniation, adult depression, myocardial infarction, cataract and hip replacement. Groups were selected based on their socio-economic significance and lucidity, and they constitute a multifaceted group of cases. In this paper we illustrate the processes using hip replacement as a PIP example, since that group is economically remarkable and its optimal care process is medically well defined. The patient group is interesting because hip replacement does not conform to forthcoming legislation in Finland concerning care guarantees, which defines the maximum waiting times for examinations and procedures (MSAH, 2003). In this paper only the results from hip replacement case study are presented, but the results of the other ailment cases were similar (MDF, 2004; Peltokorpi, 2004).

DMAIC steps	Steps to utilise PIP concept in developing the patient process
1. Define	Select the potential patient group(s) based on waiting time, volume and costs
	Define the present patient process from supplier perspective and process-related stakeholders
	Define the ideal progress of a patient episode from a medical perspective (minimum through-put time) and related time categories
	Define the necessary information to study patient episodes
	Define sample size and data-gathering methods (i.e. patient interviews, patient records, other patient information systems)
2. Measure	Measure the amount of time in each category in the selected episodes
	Measure the total costs of episodes for each stakeholder in time function
3. Analyse	Create episode descriptions and key ratios and cost analysis of episodes. Identify non-value-adding phases, which are the main cost-drivers
	Focusing on non-value-adding phases, create process improvement scenarios and identify their potential savings
4. Improve	Test the most potential scenarios in designed experiments
5. Control	Demonstrate the importance of time effectiveness in patient processes to get everybody involved in improvement activities
	Design and implement new process to optimise patient through-put time
	Create real time information systems to monitor time and cost-efficiency of patient episodes

Table II.
Six sigma DMAIC-process development approach for developing patient processes

Entering the field and data collection

The case study was conducted in Päijät-Häme Hospital District (PHHD) in Finland. The PHHD catchment area is 210,000 inhabitants and its health service performs an average of 230 hip replacements each year. Understanding illness progression was achieved by interviewing orthopedists in Päijät-Häme Central Hospital (PHCH). The case study group included patients who suffered hip arthrosis and whose treatment culminated in a total hip joint replacement. The most common symptom of hip arthrosis is pain. The disease cannot be treated, and in time the pain usually intensifies and movement becomes more difficult. The pain can be treated with analgesics. Painful arthrosis is treated with surgery.

In PHHD the treatment of hip arthrosis divides into pre-diagnosis and medication in primary care and surgery assessment and operation in secondary care. The ideal patient process was confirmed by orthopedists. It starts with examinations and x-rays in primary care, continues without delays to a referral to secondary care, an orthopedic examination and surgery decision, an operation, recovery first in a ward and then at home. Since the condition worsens over time we defined all waiting time preceding surgery to be negative waiting time. Examinations are diagnostic time, surgery with preparation is active care time and the time spent recovering in a ward is mainly passive care time. Convalescence after discharge is positive waiting time, because the patient then recovers spontaneously.

Stakeholders related to the case study were identified as orthopedists and PHCH managers. The essential stakeholders in our case study are patient, his or her employer, PHCH, home municipality and social insurance institution (SII), which compensates patient's costs arising from private doctor visits, travelling, medications and absence from work. In Finland, the municipality is mainly responsible for treatment costs incurred both in primary and secondary care, the patient and employer has lesser responsibilities. We defined the episode information we needed by investigating three episodes from PHCH's patient records with an orthopedist's help. Information included time and resource data about different care and information activities, medications, patient's condition, travelling and inability to work. In the first phase of the study, data were collected from 23 PHCH hip replacement patients. However, these records included only data about secondary care. We had to acquire the patients' permission to combine data from several stakeholders' information systems. Ten patients agreed and in the second patient cohort missing data was gathered from patient interviews, information systems in the municipalities' primary care centres and SII.

Results and recommendations

In the first study cohort, 23 hip replacement episodes in the PHCH were investigated. Two-thirds were women and the sample's average age at the time of referral was 65 years (SD 12 years). Ten patients were under the age of 65, and four were still working.

Average lead times in several stages of patient episodes are illustrated in Table III. It is essential to divide the episode to the time before and after referral, because waiting time before the referral includes monitoring and medical care and waiting time after referral is more negative. We can see from Table III, initially, that lead-time from the first symptoms to referral is the main cause for additional waiting time in the patient episode. Discussions with doctors indicate that in some cases the referral to examinations was delayed in attempt to avoid the expense involved with the procedure. Second, we see that the episode following referral includes a significant amount of waiting time. This waiting consists of

delays before the examination by the orthopedist and the ensuing period preceding surgery. However, age does not influence access to the procedure. Waiting time after referral seems to be longer for patients under the age of 65. There is no difference in lead-times after referral between patients in the first and second phases of the study. As can be seen from the last row of the Table III, the maximum delay in care guarantee was exceeded in both waiting time to the examination and to the surgery.

Pressure to cut waiting times for PHCH's examinations and surgeries are increasing. Currently, the average waiting time from referral to examination in secondary care is 69 days. This might lead to the temptation to detrimentally tighten surgery indications in order to achieve the guarantee, especially when the indications are less explicit. Figure 2 illustrates the time categories of ten extensively examined

Table III.
Averages and standard deviations of lead times of hip replacement patients' episodes

Patients	*n*	From first symptom to referral	From referral to examinations	From examinations to surgery
All in first phase	23	–	69 ± 29	158 ± 49
65 years or more	13	–	65 ± 26	152 ± 56
Under 65 years	10	–	72 ± 33	164 ± 42
All in second phase	10	2,119 ± 1,616	69 ± 28	172 ± 36
Maximum delay in care guarantee	–	–	21	90

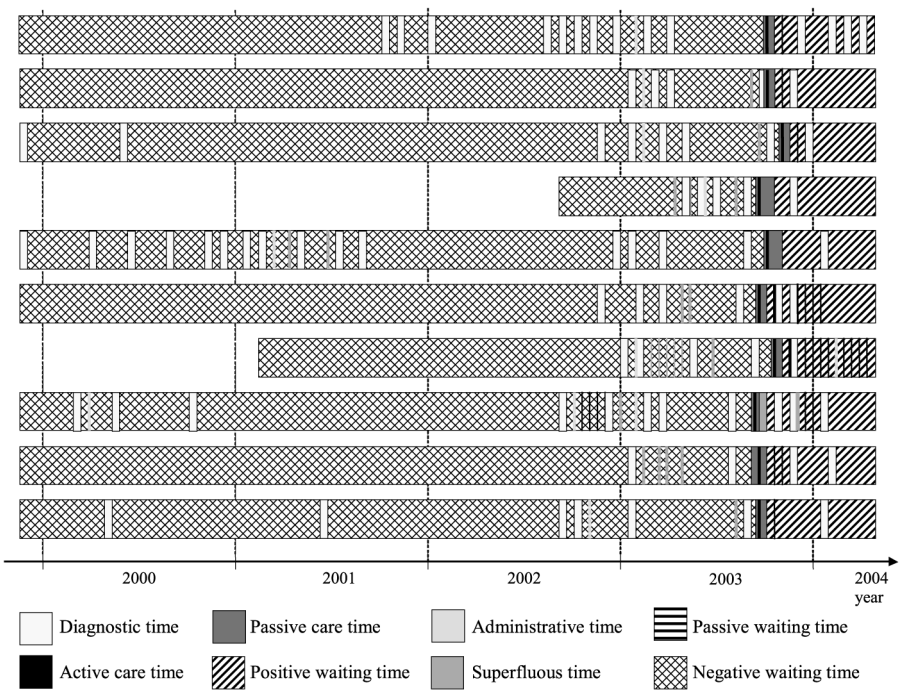

Figure 2.
Time category analysis of episodes of illness (from year 2000)

episodes. Although patients' history of illness is long, most healthcare contacts concentrate on the year before the procedure (black line in Figure 2). This indicates that by shortening the waiting time before orthopedic examination and before surgery, much superfluous primary care contacts can be eliminated. In addition the picture indicates that some patients have superfluous contacts years before the operation.

We also approximated the costs of an episode for relevant stakeholders. Costs included all healthcare services, medications, travel expenses, time costs and lost contributions to the employer. Periodical costs of illness are illustrated in Table IV. Costs are concentrated on timely operation visits (OV) and organising municipality care. The SII costs are highest when a working age patient is recovering from surgery or on sick leave. We compared the costs of an average episode with an ideal episode. The result was that with an ideal progress of care, the total costs could be reduced to €8,567, which means a 13.5 per cent savings without changes in the unit costs of initial care phases. We also approximated the effects of advancing the surgery year. This process improvement would lead to €315 (3.2 per cent) savings per episode. Approximate savings in both improvement scenarios derive mainly from reductions in superfluous examinations and lost work contributions.

The quantity of investigated episodes was too low to present a coherent picture of a considered patient process, and larger sample is needed. It is clear, however, that, in the management of hip replacement, the biggest savings can be achieved by shortening the delay from surgery decision to operation. Other improvement objectives in the patient process could be the more effective case management in primary care and reducing the expensive inpatient care after being discharged from the PHCH.

Discussion

Work-in-progress has mainly been applied to repetitive manufacturing processes. Its application to improving healthcare is a challenge for managers and practitioners who traditionally group tasks as functional specialties (Shortell *et al.*, 2000). There are not only significant challenges but also opportunities for learning. The purpose of our study was to gather data about episodes from several sources – three different patient records and patient interviews. The data gathering method involved triangulating multiple data sources. It provides a multifaceted viewpoint of the patient episode and increases the accuracy and reliability of the total cost of single episodes. However, our method produces accurate estimates of single episodes, but with the belief that obtaining statistical evidence by this method is too laborious and time-consuming, at least with the existing structure of registers. To get a statistically reliable result or to use the cost of patient episodes for

Stakeholder	4-3	3-2	2-1	1-0.5	0.5-0	OV	0-0.5	0.5-1	Total (€)	%
Municipality	65	85	19	166	156	6,690	468	5	7,654	79.8
Patient	23	37	10	82	103	250	168	13	685	7.1
Employer	0	0	0	0	78	186	0	0	264	2.8
SII	6	14	12	64	125	71	689	9	991	10.3
Total (€)	95	136	41	312	462	7,197	1,325	27	9,594	100
%	1.0	1.4	0.4	3.3	4.8	75.0	13.8	0.3	100.0	

Notes: Periods are years before or after operation visit (OV); SII = Social Insurance Institution

Table IV.
Average periodical costs of illness for stakeholders ($n = 10$)

operational management, the construction of an integrated patient data system is proposed, which gathers a real time data about episodes from different stakeholders.

The framework 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 in 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 organised 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 business and commerce.

The PIP combines the medical and process viewpoint in the analysis of a patient episode. This requires episode data to be analysed with the help of a disease-specialist and a process expert. A disease-specialist interprets the medical information, which has influence on progress of care pathway, and process expert directs the data scanning to relevant areas. Application of PIP shows that time and cost analysis of patient episodes can lead to justified proposals to reengineer existing patient processes. A change toward higher time-effective and customer-friendly care enables managers and practitioners to cut costs that are caused by, for example, superfluous examinations and ward delays. Reducing total cost of patient episode can be made without any changes in medical procedures such as surgery. Therefore the application of PIP in healthcare has no negative influence on quality of care. On the contrary, minimising negative waiting time should lead to better clinical outcomes.

Conclusions

We have presented a framework that combines PIP and DMAIC process development approaches, which can be used to analyse the total cost of a patient episode in order to improve patient process efficiency. Patient-in-process has proven a worthwhile and applicable analysis method in most of the patient groups and processes we have studied. Application of PIP is based on a careful recognition of underlying processes, illness progression and stakeholder concerns in a selected patient group. By identifying time categories and costs for stakeholders in a sample of episodes, process inefficiencies and bottlenecks can be found and improvement proposals created. It can also foster a common understanding between clinician and managers. Further research should focus on verifying the practical validity of the proposed framework for improving patient processes in different contexts.

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