

Generic Project Definitions for Improvement of Health Care Delivery: A Case-Based Approach

Gerard C. Niemeijer, MSc; Ronald J. M. M. Does, PhD; Jeroen de Mast, PhD;
Albert Trip, PhD; Jaap van den Heuvel, MD, PhD

Background: The purpose of this article is to create actionable knowledge, making the definition of process improvement projects in health care delivery more effective. **Methods:** This study is a retrospective analysis of process improvement projects in hospitals, facilitating a case-based reasoning approach to project definition. Data sources were project documentation and hospital-performance statistics of 271 Lean Six Sigma health care projects from 2002 to 2009 of general, teaching, and academic hospitals in the Netherlands and Belgium. **Results:** Objectives and operational definitions of improvement projects in the sample, analyzed and structured in a uniform format and terminology. Extraction of reusable elements of earlier project definitions, presented in the form of 9 templates called generic project definitions. These templates function as exemplars for future process improvement projects, making the selection, definition, and operationalization of similar projects more efficient. Each template includes an explicated rationale, an operationalization in the form of metrics, and a prototypical example. Thus, a process of incremental and sustained learning based on case-based reasoning is facilitated. **Conclusions:** The quality of project definitions is a crucial success factor in pursuits to improve health care delivery. We offer 9 tried and tested improvement themes related to patient safety, patient satisfaction, and business-economic performance of hospitals.

Key words: cost reduction, efficiency, Lean Six Sigma, patient safety, patient satisfaction

Innovation in medical science, including innovations in treatment protocols, medical equipment, and pharmaceuticals, is perhaps the first connotation with the topic of health care improvement. This article, however, addresses the improvement of health care by improving its delivery. Health care delivery is about the operating routines in hospitals, including primary patient processes and medical and nonmedical support processes. Characteristics of these processes, such as their efficiency and reliability, determine important performance dimensions of health care, such as patient safety (a direct outcome of failures in the processes), waiting times and delays (determined by process flow dynamics), capacity and throughput (resulting from staffing and efficiency of work procedures), and, ultimately, patient satisfaction, cost, and quality and timeliness of medical care. The improvement of all of these dimensions is generally seen as urgent.

The improvement of processes is the subject of a discipline that goes back to scientific management¹ and has resulted in such manifestations as total quality management, business process reengineering,² business process management,³

Author Affiliations: Department of Traumatology (Mr Niemeijer) and Department of UMC staff (Dr Trip), University Medical Center Groningen, Groningen, The Netherlands; Faculty of Economics and Business, University of Amsterdam, and Institute for Business and Industrial Statistics, Amsterdam, The Netherlands (Drs Does and Mast); and Reinier de Graaf Healthcare Group, Delft, The Netherlands (Dr Heuvel).

Correspondence: Gerard C. Niemeijer, MSc, Department of Traumatology, University Medical Center Groningen, (Internal ZIP-code BA13), Hanzeplein 1, Postbus 30.001, 9700 RB Groningen, The Netherlands (g.c.niemeijer@chir.umcg.nl).

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theory of constraints,⁴ and Lean Six Sigma.⁵ These approaches have been well studied in the academic literature and tried and tested first in industry and later also in service organizations. Recent years witnessed a growing interest from health care in these approaches.^{6–9} Our research concerns Lean Six Sigma in particular; we have reported our experience with its implementation in health care organizations in Dellifraigne et al,¹⁰ De Mast et al,⁵ Van den Heuvel et al,¹¹ Van den Heuvel,¹² and Bisgaard.¹³ Other examples can be found in Fischman,¹⁴ Thomerson,¹⁵ Lazarus and Stamps,¹⁶ Yamamoto et al,¹⁷ Kuo et al,¹⁸ and Sehwal and DeYong.¹⁹

Improvement initiatives in the paradigm of process improvement are typically structured as a project organization, with improvement projects as the main units of activity. The literature on project management recognizes the precision and quality of project definitions as one of the most important factors for project failure,^{20,21} and our objective is to offer actionable insights, which help health care professionals become more effective in project selection and definition. We aim to extract reusable elements from a large collection of reports of past project definitions and make them accessible for practitioners in the form of a case-based approach. We identify generic themes that lend themselves as topics for such projects, and we present these generic themes in the form of templates for project definition. The relevance of these contributions is proposed to be their facilitation of program management by offering tried and tested themes for improvement projects and their facilitation of project leaders by offering worked-out templates for defining their projects.

METHODS

One way to help practitioners in defining their improvement projects is by discovering principles in project definition and offering these in the form of rules and guidelines. Unfortunately, project definition is a rather ill-structured task, and it is difficult to offer strong and operational principles. Emerged in response to such situations, and as a complement to rule-based prescriptions, case-based reasoning (CBR)

is a paradigm for problem solving and decision making that is not based on knowledge framed in rules or principles. In CBR, agents facing a new task or problem deal with it, not by following rules but by finding a similar past case and reusing its lessons in the new situation. A physician applies CBR when he or she thinks: “I have seen a patient like this before,” and uses his or her recollection of these earlier cases in dealing with the new case.

The CBR was devised by artificial intelligence researchers^{22,23} and, after some early publications in the late 1980s, has recently been making a revival in medicine.^{24,25} The diversity of CBR applications in medicine includes diagnosis, classification, and planning and tutoring and ranges from psychiatry and epidemiology to clinical diagnosis.²⁴

We offer, in this work, a case-based approach that helps practitioners in defining their improvement projects. Such an approach consists of a substantial collection of past cases and a procedure that helps the practitioner retrieve cases pertinent to the project at hand, thus making the collection accessible for practitioners. We explain later the details of our collection of cases, the way we analyzed them, and how we proposed to make the collection accessible to practitioners.

Our collection of cases consists of 271 process improvement projects, carried out at some 10 hospitals in the Netherlands and Belgium; Table 1 gives an overview. These projects vary along key dimensions such as type of department (emergency department, operating theatre, nursing department, planning and control, human resources, facilities, outpatient clinic), type of organization (general, teaching, and academic hospitals of various sizes), scope, and size (benefits ranging from €10 000 to €2750 000). Staff employees ran 45% of these projects, managers 30%, nurses 20%, and specialists 5%. Lean Six Sigma project leaders are called black belts or green belts.

All of these projects followed the model of the Lean Six Sigma methodology.⁵ In this approach, projects are managed rigorously according to the 5 phases of “Define-Measure-Analyze-Improve-Control.” Each phase is completed on the delivery of specific

Table 1

HOSPITALS AND NUMBER OF LEAN SIX SIGMA PROJECTS IN THE NETHERLANDS (NL) AND BELGIUM (B)

Hospital	City	Type	Beds	Projects
Lange Land Hospital	Zoetermeer (NL)	General	245	9
Red Cross Hospital	Beverwijk (NL)	General	384	18
Deventer Hospital	Deventer (NL)	Teaching	477	14
Virga Jesse Hospital	Hasselt (B)	Teaching	567	29
Canisius Wilhelmina Hospital	Nijmegen (NL)	Teaching	635	37
Reinier de Graaf Healthcare Group	Delft (NL)	Teaching	881	28
Erasmus Medical Center	Rotterdam (NL)	Academic	1221	19
University Medical Center	Groningen (NL)	Academic	1339	112
Others	...	General	...	5

milestones. Thus, the status and progress of projects are assessed in a standardized way within departments and across the entire organization, much like the stage-gate approach outlined by Cooper.²⁶

The project selection and definition are done, in Lean Six Sigma, in the first 2 phases, “Define” and “Measure,” in which a project’s objective is clarified by specifying quantitative and measurable indicators called critical-to-quality characteristics (CTQs). A commonly used technique is the CTQ flowdown.²⁷ This tool makes explicit the rationale underlying the project by showing hierarchically how CTQs relate to higher-level concepts such as an organization’s performance indicators and strategic focal points. Read downward, it associates CTQs to measurements by providing operational definitions. The CTQ flowdown results in a measurement plan, which operationalizes a project’s objectives (Figure 1). In the “Analyze” and “Improve” phases, the data collected according to the measurement plan serve as a basis for process diagnosis and improvement actions; in the “Control” phase, these improvement actions are integrated in line and process management.

Part of the description of each of the 271 projects in our sample was a project definition, including at least the following:

1. A business case, specifying the business rationale for the project;
2. A (macro-level) process description;
3. The project’s CTQs;

4. A description of the measurement procedure for each CTQ.

Searching for a form in which the 271 cases can be made accessible and useful for practitioners, we reason as follows. Past cases offer lessons at various levels of generality, ranging from lessons highly specific to a case to very-general lessons. Following Smith,²⁸ we think that the most useful insights occupy an intermediate level of generality. Very-general lessons tend to be weak and nonoperational, while highly situation-specific lessons have just a small range of applicability (this is Newell’s power/generality trade-off²⁹). For this reason, we removed from the 271 project definitions the project-specific details; deprived of these specifics, many project definitions

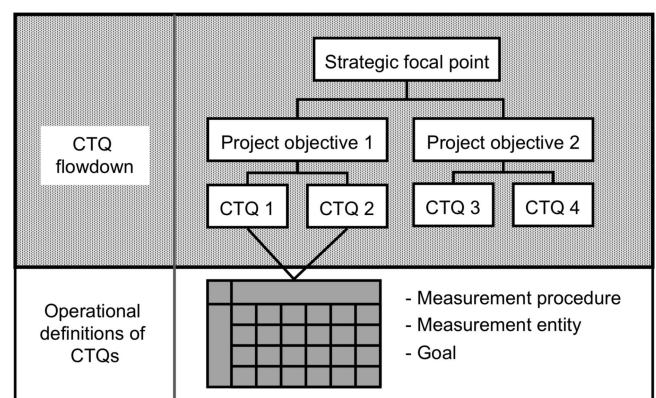


Figure 1. The two elements of Lean Six Sigma project definitions: CTQ flowdown and operational definitions.

have similar CTQ flowdowns (ignoring differences in wording). This provides us with an organizing principle that helps us make approaches extracted from the case base accessible for practitioners. Grouping cases with identical CTQ flowdowns (after removal of situational specifics), we found 9 groups, for each of which we chose a representative or prototypical case consisting of a CTQ flowdown and operational definitions. Thus, we arrived at 9 templates, which we refer to as generic project definitions. They are proposed to serve as exemplars, which project leaders may use in defining their own projects. These 9 templates make accessible the approaches of 271 project definitions for reuse in future projects and can inspire program managers in identifying candidate themes for improvement efforts.

Note that the 9 templates are not intended as a typology or taxonomy of projects, with the claim of completeness that these terms imply, as in Shenhar³⁰ or Cooper and Kleinschmidt.³¹ Combining similar cases into 9 templates serves the mere purpose to make experience accessible to practitioners without getting lost in situation-specific detail (cf. the use of *generalized cases* or *generalized episodes* in other CBR systems²³).

We propose that practitioners apply the templates in the following manner. Presented with the task of making a project definition for a process improvement project, the project leader matches a tentative and unstructured notion of the project's objectives with the descriptions of the 9 templates and the associated CTQ flowdowns. If he or she finds a template bearing sufficient similarity, he or she modifies the template's CTQ flowdown and operational definitions to the specific situation at hand. The resulting project definition is evaluated during a project review and improved if necessary. Thus, the retrieve, reuse, and revise steps generally followed by CBR systems are implemented.²³ Note that the proposed approach does not offer a strong method for the retain function, typical of many CBR applications. This function concerns the addition of a new case to the case base if it is sufficiently novel or has value for reuse in future cases. In the proposed approach, there is no updat-

ing of the case base beyond the updating done by the authors of this article.

RESULTS

We identified 9 generic project definition templates. The numbers of projects in our sample per template are denoted within brackets:

1. Reduce costs by improving productivity of personnel (65);
2. Reduce costs by improving utilization of equipment/facilities (34);
3. Reduce costs by improving purchasing processes (10);
4. Reduce costs by reducing unnecessary use of resources (21);
5. Reduce costs by reducing inventory (9);
6. Improve safety by reducing complications and incidents (10);
7. Increase revenue by improving registration (30);
8. Increase revenue by increasing the number of admissions (41); and
9. Increase revenue by increasing capacity (51).

Later, we elaborate these 9 generic templates, briefly discussing their objectives and offering suggestions for operational definitions. We also present a prototypical example for each template. Most of these examples are available in generally accessible publications.

PROJECT TEMPLATE 1: REDUCE COSTS BY IMPROVING PRODUCTIVITY OF PERSONNEL

Often, departments and teams are overstaffed because of poor planning. This is particularly alarming, given the fact that approximately 60% to 70% of the annual budget of a hospital consists of costs related to personnel. Projects improving staffing generally focus on 4 CTQs: time lost on irrelevant activities; processing time per task (cycle time); idle time due to overstaffing; and the discrepancy between the weight of a task and the functional level of the person who executes it (Figure 2).

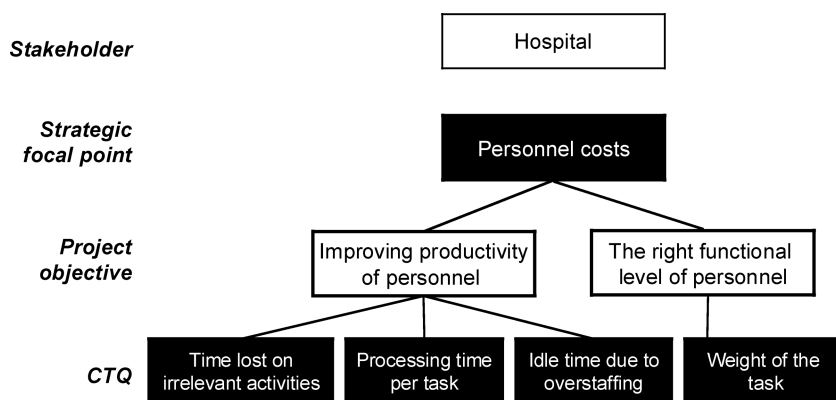


Figure 2. The CTQ flowdown for projects improving productivity of personnel.

Example 1

In the University Medical Center Groningen management suspected an imbalance of supply and demand of nurses in the current staffing of nursing departments. After careful debate and based on the core principle of carefully selecting projects that are clearly aligned with organizational strategy, management selected nursing efficiency in the maternity ward as a pilot project for the first wave of the Lean Six Sigma rollout. The analysis of activities performed by the nurses showed that more than 30% of their time was used for administrative tasks and team meetings. Lack of structure in formal and informal meetings was identified as 1 major reason for wasted time. Another was the use of multiple forms for related information causing unnecessary and often frustrating redundancy. The black belt proposed to bring more structure to meetings, to redesign and streamline the paperwork, and to remove redundancy. As a secondary benefit, greatly appreciated by the nurses, time was freed up for training, medical-ethical discussions, and other professional development. The annual cost of the nursing department was reduced by an estimated €147 000. The study³² also showed that further cost reductions of €53 000 were possible if temporary workers were used only if necessary. Note that at this hospital, there are about 40 different nursing departments. With a potential savings per department of about €200 000, this means

substantial amounts of cost reductions and quality improvements.

PROJECT TEMPLATE 2: REDUCE COSTS BY IMPROVING UTILIZATION OF EQUIPMENT/FACILITIES

In hospitals, available facilities and equipment are often only partially utilized, even at peak hours. Partly, items are underutilized because they are unavailable (due to maintenance, cleaning, or repair), and partly because they are missing. As a result, more items are needed, and staff time is lost in searching for missing items. The typical CTQs for this template of projects are (a) the percentage of items that are unavailable at a given time and (b) the percentage of items that are missing at a given time (Figure 3).

Example 2

In the Medical Spectrum Twente hospital in Enschede, the Netherlands, one of the projects focused on the reduction of total costs in the processes of buying and maintaining infusion pumps.³³ Departments have their own infusion pumps. If occasionally, more pumps are needed than available, employees spend time tracing one, since the hospital lacks a track-and-trace system. The maintenance of infusion pumps is not monitored at all. Therefore, it is unclear whether the current maintenance level meets regulations

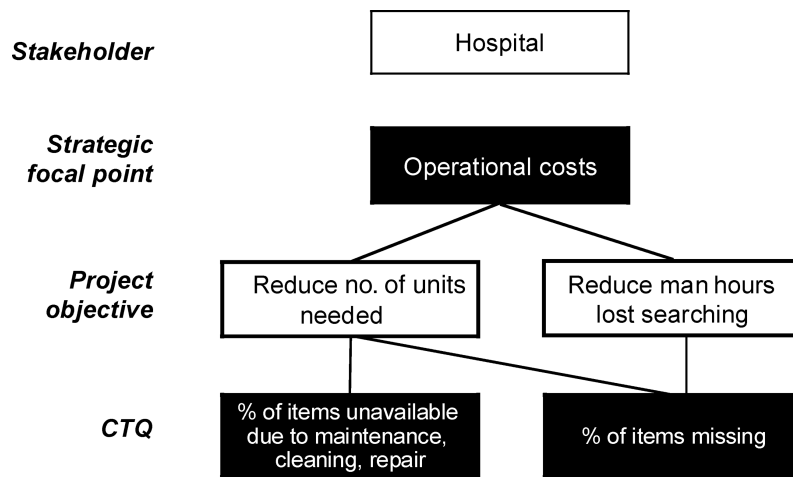


Figure 3. The CTQ flowdown for projects improving the utilization of equipment and facilities.

related to patient safety. The most important improvement actions were as follows:

1. Standardization of the pumps (resulting in a yearly reduction of depreciation of about €16 000); and
2. Introduction of a scan system for tracking and tracing the infusion pumps, resulting in an extra reduction of depreciation of about €16 000 yearly. Note that an additional benefit of the scan system is that employees are expected to spend less time searching. A similar black-belt project in the University Medical Center, Groningen demonstrated these track-and-trace costs to be about €175 000.

PROJECT TEMPLATE 3: REDUCE COSTS BY IMPROVING PURCHASING PROCESSES

Hospitals spend a lot of money acquiring goods, and services and hiring personnel. A revision of the purchasing process may result in savings due to cheaper purchase prices or more efficient manpower (Figure 4).

Example 3

In 2003, the Red Cross Hospital spent more than €1000 000 on temporary personnel. There was no

procedure for hiring temporary workers, and all departments had their own contacts with temporary agencies. Every agency used its own work sheet, and it was very hard to verify invoices. This situation led to a substantial administrative workload. Once reviewed, a substantial number of invoices turned out to have discrepancies, mostly to the advantage of the temporary agency. The project focused on both the cost of hiring temporary workers and the number of correct invoices.³⁴ The following actions were chosen to diminish the number of mistakes: a standardized work sheet for every temporary worker was introduced; requests for temporary personnel were centralized; an administrative system to check the irregularity bonus and the invoice was introduced; and the number of temporary agencies was reduced.

PROJECT TEMPLATE 4: REDUCE COSTS BY REDUCING UNNECESSARY USE OF RESOURCES

One of the drivers of operational cost is not only poor use of materials and energy but also unnecessary consults in, for example, diagnostics. Total cost of resources is determined by the used volume and the cost per unit. A typical CTQ in this template could be

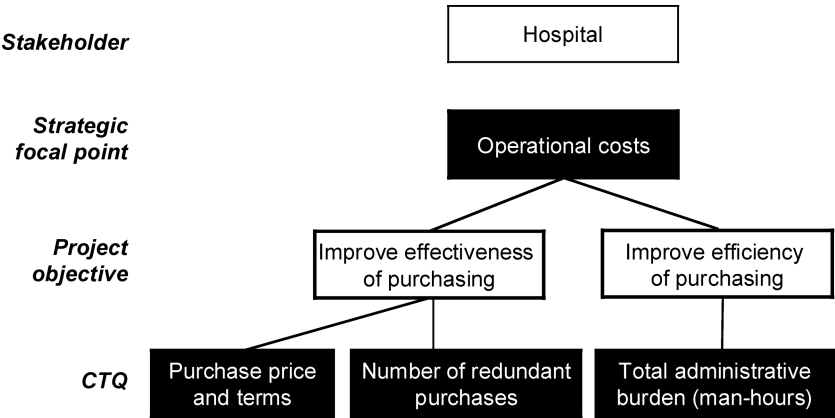


Figure 4. The CTQ flowdown for projects improving purchasing processes.

“Number of unnecessary used units (material/energy) or consults” (Figure 5).

Example 4

At the departments of internal medicine, pulmonology, urology, and orthopedics of the University Medical Center Groningen, about 1300 patients received intravenous antibiotics in 2008. Data showed that 40% of these patients could have switched to substantially cheaper oral medication earlier. A protocol was developed specifying when a patient could switch to oral medication; this new protocol resulted in annual savings estimated at €70 000.

PROJECT TEMPLATE 5: REDUCE COSTS BY REDUCING INVENTORY

Inventory brings about costs related to cost of capital, obsolescence, damages, and storage. While ensuring a reasonable low rate of out-of-stock occurrences, the number of items in stock can be reduced by avoiding the purchase of items, which are obsolete immediately or shortly after they have been purchased, by lowering the safety stock level (the number of items left when new supplies are ordered) and by rationalizing the cycle stock level (the quantity of items bought when resupplying) (Figure 6).

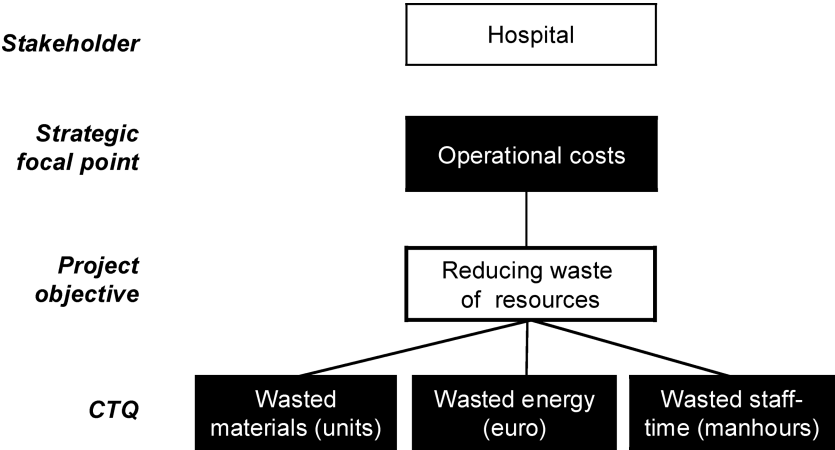


Figure 5. The CTQ flowdown for projects reducing unnecessary use of resources.

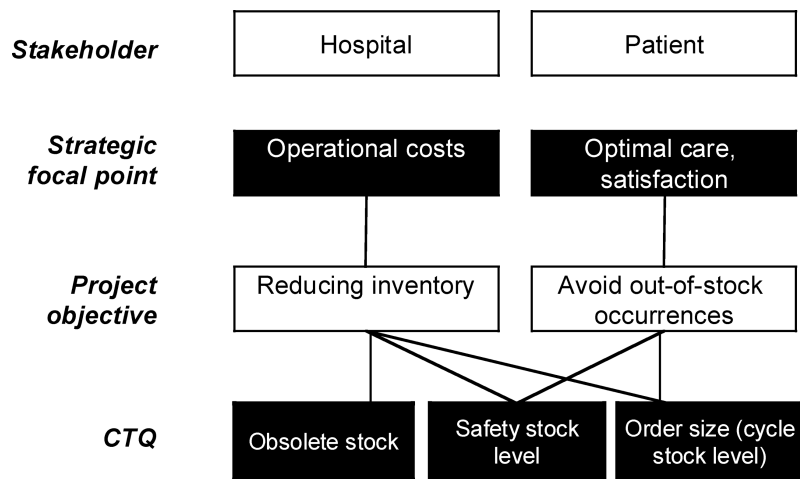


Figure 6. The CTQ flowdown for projects reducing inventory.

Example 5

Nursing departments of the University Medical Center Groningen are daily supplied with standard materials. Occasionally, there are special patients requiring nonstandard material. These are specially ordered, with opportunities to make mistakes. A project at the internal medicine nursing departments aimed at reducing wasted nonstandard materials. The minimum order size often exceeded the required number, leading to superfluous materials (about 20% of nonstandard material or €84 000 per year for the internal medicine wards). The data were collected in the wards, since the logistical software system was not up to the task of recording returned products. A benchmark study indicated that some nursing departments wasted hardly anything. Their strategy was not to order nonstandard products but to take (or buy) these from departments where such products are standard.

PROJECT TEMPLATE 6: IMPROVE SAFETY BY REDUCING COMPLICATIONS AND INCIDENTS

Complications and incidents affect patient safety, patient satisfaction, and financial losses incurred by the longer length of stay (LOS) (Figure 7).

Example 6

In 2007, the authorities announced 1700 potentially avoidable deaths per year in Dutch hospitals, and 76 000 patients suffering potentially avoidable permanent injury. Just to compare, fatal traffic accidents in the Netherlands were less than 800 in 2008. A black-belt project at the University Medical Center Groningen started in January 2008 with the goal of reducing the rate of postoperative wound infections (POWI) by 50%. Infections were registered in patient files, but summaries were rarely obtained. These summaries proved to be essential for creating awareness about the problem; POWI rates for some patient groups proved to be greater than 20%. Awareness is a key factor, as disregard of hygiene standards is a major cause of POWI. The black belt identified a large number of potential influence factors, and based on evidence from literature, measurements, and interviews with experts, the most important ones were selected. This resulted in the improvements of the air-conditioning in the operation theatres and storage rooms, better temperature control of patients, and better training for surgeons and operation personnel. A scheme was put in place for annual auditing of compliance with these standards.

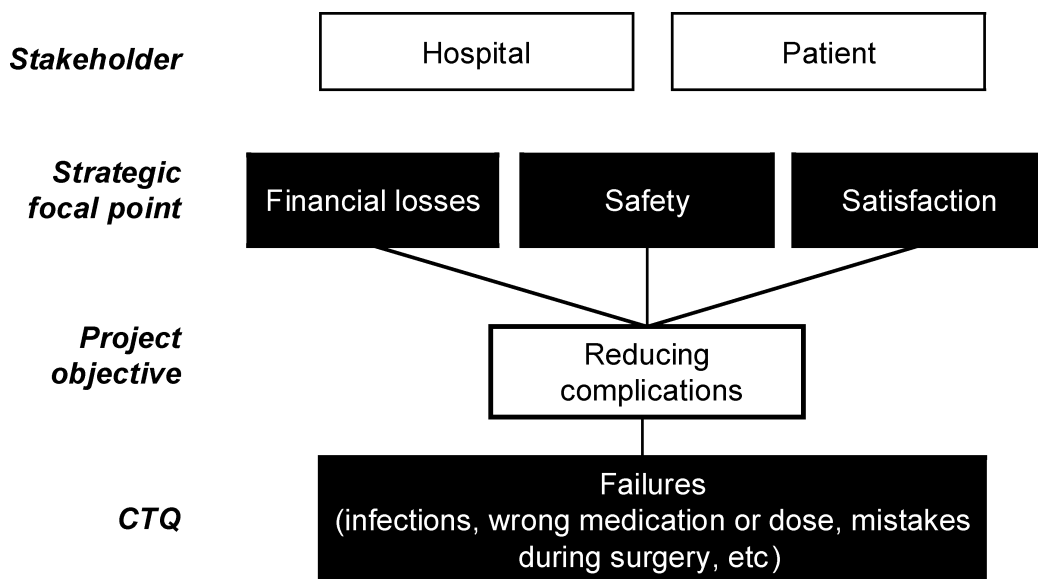


Figure 7. The CTQ flowdown for projects reducing complications.

PROJECT TEMPLATE 7: INCREASE REVENUE BY IMPROVING REGISTRATION

A hospital does not only receive invoices from its suppliers; it also issues invoices to patients and insurance companies. It may happen that some of the invoices are refused or delayed because of mistakes, resulting to missed or delayed revenue and increasing the administrative burden (Figure 8).

Example 7

The Red Cross Hospital issues approximately 250 000 invoices per year to patients and insurance companies. Of these, about 9% are refused and sent back because of mistakes by the hospital. After an in-depth study of the process by a green-belt team, a number of problems were identified and process improvements implemented. The team was able to reduce the defect rate by 90%. This translates into a saving exceeding €150 000 per year.

PROJECT TEMPLATE 8: INCREASE REVENUE BY INCREASING THE NUMBER OF ADMISSIONS

Hospitals earn money by admitting and curing patients. Treating more patients provides more income for a hospital and at the same time may reduce waiting times for patients before they are treated. Admissions can be increased by shortening the LOS (under the assumption that there is sufficient demand) (Figure 9).

Example 8

The University Medical Center Groningen is a level 1 trauma center in the northern part of the Netherlands. Seventy percent of all the admitted patients on the trauma-nursing department (TND) are acute patients who are admitted directly after trauma. Because of the relatively high bed occupation, in 2006 and 2007, it was not always possible to admit all trauma patients on the TND. The average LOS of the trauma patients at the beginning of the project on the TND was 10.4 days. Thirty percent of the LOS was

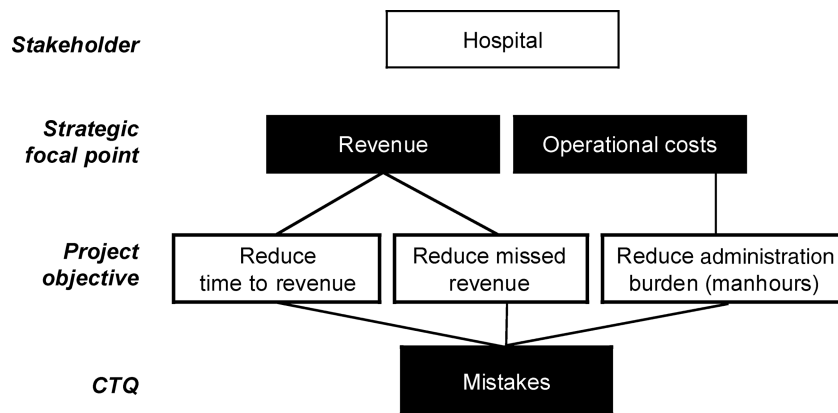


Figure 8. The CTQ flowdown for projects improving registration.

unnecessary. Causes for inappropriate hospital stay were waiting on a rehabilitation facility, delay in discharge planning, and waiting for an operation or diagnostic result. Implementation of the improvement actions reduced almost 50% of the inappropriate hospital stay and realized the possibility to admit almost every trauma patient on the TND. The average LOS after implementation was 8.5 days.³⁵ The financial benefits for the hospital are based on the 118 additional admissions, representing a value of €176 400. The nursing departments' costs were almost the same in 2007 and 2008, as was the staffing.

PROJECT TEMPLATE 9: INCREASE REVENUE BY INCREASING CAPACITY

The last template of projects aims to increase the revenues of a health care institution by increasing the capacity of resources. Part of this issue is often measured in terms of "throughput time," the time span from the request of a service to the moment the service is fully delivered. Throughput time can further be broken down into waiting time, processing time, and rework time, if certain steps have to be redone. To measure the resulting efficiency, we compute the

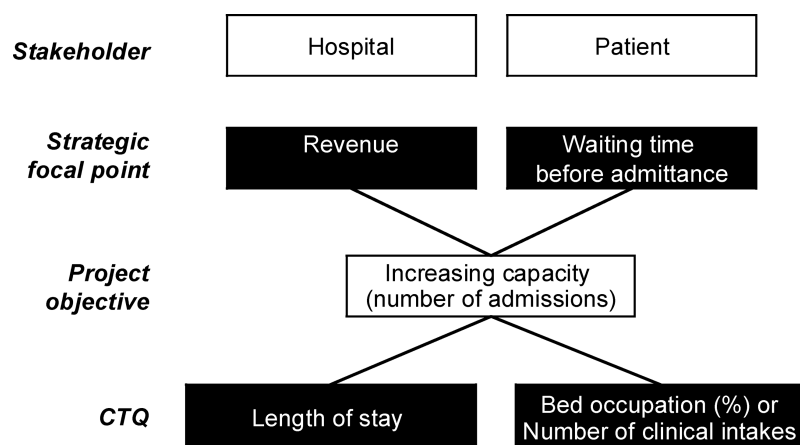


Figure 9. The CTQ flowdown for projects increasing number of admissions.

number of productive hours and the number of items produced (Figure 10). As in template 8, this kind of project is initiated because the entrance time is too long.

Example 9

Capacity problems are standard in hospitals. In our practice, we have run projects aimed at improving the usage of operating theatres, among others. Hospitals like the Canisius Wilhelmina in Nijmegen, the Red Cross in Beverwijk and the Virga Jesse in Hasselt participated in a benchmark study among 13 hospitals.³⁶ This study focused on starting on time in the morning and utilizing all available time. The official start time is most of the time around 8 am. Data collected in the “Measure” phase showed that the average start time was about 30 minutes. For a hospital with 20 operating rooms and an average of 250 days in a year, this adds up to 2500 lost hours that could be used for productive work. Operating theatres in a modern hospital are capital-intensive units staffed by highly skilled and, thus, expensive staff.

DISCUSSION

In the CBR paradigm, a profession may learn by organizing practical experience in such a way that it

provides useful guidance for future efforts. We contribute to the pursuit of ways to improve health care delivery by improving operating routines in hospitals. Project selection and definition are difficult but crucial tasks in this pursuit. We offer 9 generic themes for process improvement projects and provide standardized templates intended to provide useful guidance to project leaders.

Our sample of projects does not qualify as a representative sample. In the CBR pursuit, representativeness of the sample of cases is irrelevant, as one’s aim does not involve the extrapolation of sample results to conclusions for a population. Our sample is suitable as a basis for actionable and case-based guidance for practitioners, as long as one keeps in mind that we do not claim that the relative frequencies of the 9 templates can be generalized beyond our experience and that the proposed categories are not claimed to be unique or complete. Most of the projects were conducted in the specific context of the Dutch health care system; further research in other health care systems is likely to expand the knowledge base. On the contrary, the variety and size of our case base make it a rather unique collection. In an earlier analysis of Lean Six Sigma health care projects, Does et al³⁷ identified 6 templates, based on 100 projects (all of which are included in the current sample).

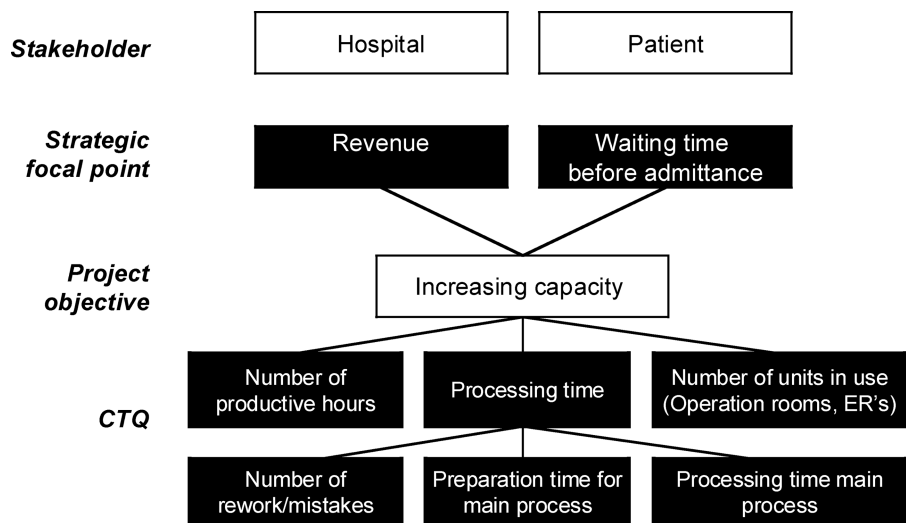


Figure 10. The CTQ flowdown for projects increasing capacity.

The 171 additional projects have greatly sharpened the templates, and they have expanded the scope of the case base. The authors continue updating the collection when needed. At the time of revision of this article, 53 new cases had been reviewed from 3 hospitals. No additional templates were added, since for each of these 53 new cases, a useful template was found among the 9 proposed in this article.

Another word of caution is that situations differ across hospitals, and although schemas for stereotypical situations are a powerful resource in problem solving and decision making, they should not be applied uncritically and without considering modifications to situational circumstances.

The Lean Six Sigma literature³⁸ suggests that process improvement projects should be conducted throughout the entire organization and led by professionals intimately involved in the processes. Problems in health care are numerous, highly detailed, and typically hinge on knowledge that is local in nature; these factors make it, for many problems, ineffective to entrust them to external specialists, staff functionaries, or consultants. This, however, means that health care providers, doctors, and, in particular, nurses need to assume a leadership role in executing Lean Six Sigma projects. For these professionals, the availability of tangible and actionable knowledge may substantially lower the threshold for embracing initiatives at improving health care delivery. This work offers case-based knowledge for project selection and definitions, in the form of templates for commonly encountered improvement opportunities, to complement the rule-based knowledge that the Lean Six Sigma methodology embodies in the form of guidelines and prescriptions such as the previously mentioned “Define-Measure-Analyze-Improve-Control” procedure. These generic project templates have clear and explicated rationales. Most are directly related to drivers of operational cost, while some are related to revenue, patient safety, and patient satisfaction.

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ERRATUM

No Payment for Preventable Complications: Reviewing the Early Literature for Content, Guidance, and Impressions: Erratum

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