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Six Sigma in a Dutch Hospital: Does It Work in the Nursing Department?

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The Red Cross Hospital is a medium-sized general hospital with 385 beds, located in Beverwijk, The Netherlands. It also has a freestanding National Burn Care Centre. The Red Cross Hospital was the first hospital in The Netherlands with a quality system based on ISO 9000. At the end of 2001 the hospital started implementing Six Sigma. The process began with Executive Training for management and Green Belt (GB) training for 16 middle managers and other staff. Seven GB projects were started in the areas of accounts receivable, patient logistics, invoicing, medication, temporary workers, and length of stay in hospital. In February 2003 the final review of the first group was done and savings appeared to be three times higher than estimated beforehand. At present (May 2004) the fourth group of Green Belts has been trained. In this paper we briefly explain that Six Sigma was the next logical step in the quality approach of the hospital. We also discuss how it was implemented and we describe some case studies in the nursing departments. Copyright © 2004 John Wiley & Sons, Ltd.

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INTRODUCTION

In the past the Six Sigma approach has predominantly been used to improve manufacturing processes. However, Six Sigma is now increasingly applied to a wide variety of non-manufacturing operations (cf. Does *et al.*[1]). In this article, we discuss the application of Six Sigma in a healthcare environment (cf. also Barry *et al.*[2]). Most recently, Merry[3] pleaded for a change in thinking, structures and processes in healthcare. In our opinion, Six Sigma might be this new way of thinking.

The Red Cross Hospital is a medium-sized general hospital with 385 beds located in Beverwijk, The Netherlands. A National Burn Care Centre with 25 beds is also part of our hospital. In 2002 the Red

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Cross Hospital had about 12 000 admissions, 8300 day-care treatments, 190 000 visits in the ambulatories of which 72 500 were first contacts. The annual budget of the hospital is €64 million and the hospital employs 930 full-time equivalent employees. During the past four years management and employees have put a lot of effort into implementing quality management in the hospital. A quality system was designed and implemented to support quality assurance. At the end of 2000, an external audit resulted in an ISO 9002 certification for the entire quality system of the hospital. In addition to quality assurance, a project organization was set up to support quality improvement.

Initially quality improvement seemed to work reasonably well at our hospital. We were able to run quality improvement projects and were successful in completing a number of them. There were, however, some deficiencies.

1. Most of the time, we had no accurate way of determining the relevance of a given project and its contribution to our goals.
2. We did not have a standardized procedure to evaluate the cost effectiveness of a project in advance.
3. Once a project was started we had no reliable information about the progress.

Employees who had to implement improvement projects also experienced some problems. For them the fact that there was no standardized project management approach was a major problem. A lot of time was wasted initiating and running a project because the project approach, the project documents, the planning, etc. had to be developed each and every time. Another problem for our employees was the fact that they rarely had the opportunity to be relieved of other tasks, so they had to carry out their project in addition to their other activities.

THE IMPLEMENTATION OF SIX SIGMA

Six Sigma is a scientific method used to solve problems in business and industry. It gives a methodological framework to tackle quality problems, but it also offers an organizational structure to implement the required change. Six Sigma is an integrated approach best characterized by its emphasis on data and by its focus on financial results (cf. Harry[4]).

Originally developed at Motorola in 1987, Six Sigma became well known in the U.S.A., with use in important multinationals such as American Express, Boeing, Citibank, Dow, Ford, and General Electric. These companies were able to produce multibillion dollar savings by utilizing this program. In recent years Six Sigma has been implemented in Europe within companies such as DAF Trucks, Nokia, and Philips.

As Juran[5] stated some years ago, 'All quality improvement takes place project by project and in no other way'. Chronic problems will linger unless they are put on the agenda and scheduled as projects for improvement by upper management. To make sustained progress it is widely recognized that projects should follow a logical sequence of steps: first define the project, then diagnose the problem followed by a proposed remedy, check that the remedy is effective and finally institute controls to hold on to the gains. This structure is incorporated in the Six Sigma DMAIC sequence of Define, Measure, Analyse, Improve, and Control.

Six Sigma projects are conducted by individuals who are thoroughly trained in the Six Sigma approach, statistical tools, and techniques for problem solving, called Black or Green Belts. Typically, Black Belt training consists of four modules of four days each, which are taught within a six-month period. Green Belt training has two modules each of three days, within the same period.

For several reasons we had to customize the Six Sigma concept when we decided to implement it in our hospital. The main reason was that companies using Six Sigma are mainly large multinationals. Therefore, we used Green Belts instead of Black Belts to perform the projects. Our Green Belts may spend one to two days a week on their project. As a financial threshold, we chose €20 000 for each project. Some people felt uncomfortable about the explicit focus of Six Sigma on financial results. Fortunately, we were able to convince these people that lower costs for our hospital is also in the best interest of our patients. It turned out that our approach was comparable with the implementation of Six Sigma in Thibodaux Regional Medical Center in southern Louisiana, U.S.A. (see Stock[6]). A full account of the decision process to implement Six Sigma in the Red Cross Hospital may be found in Van den Heuvel *et al.*[7].

At the end of 2001, we started the implementation of Six Sigma with a one-day training course for our management team, which consisted of two directors and the managers of the four divisions. Then our quality manager started the intensive Black Belt training in January 2002. In September 2002, 16 employees started an in-company Green Belt training. During the Green Belt training, teams of two or three Green Belts worked together on one Six Sigma project. Every team had to produce the specific results that characterize a Six Sigma project. No one was allowed to go to the next phase until the preceding phase has been completed. Teams had to perform two progress presentations before the entire group. In the second presentation, they demonstrated the results of their project. When the first group completed their projects in February 2003, we immediately started a second and, in September 2003, a third group of Green Belts. A fourth and fifth group of Green Belts is scheduled for 2004. Participants are very enthusiastic about the Six Sigma approach. It supports them very well during the entire project.

Furthermore, the scientific 'data driven' approach is helpful in dealing with resistance during the implementation of the results. Data appear to be very convincing and on many occasions, leave little room for resistance driven by emotions. Our Black Belt performed the role of Master Black Belt. Two experienced trainers from a consultancy agency supported her. Most of the projects had to deal with problems in the areas of accounts receivable, patient logistics, invoicing, medication, temporary workers, and length of stay in the hospital. Three projects, all concerning the nursing departments, are presented in the following sections as case studies. They all show that Six Sigma, despite its origin from industry, can work equally well in healthcare. One project aimed to shorten the length of stay of gynaecology patients, another project dealt with reducing preparation time of intravenous medication, and the third project focused on reducing costs for temporary workers. In the description of the projects we follow the DMAIC cycles as proposed by Harry[4].

SHORTENING THE LENGTH OF STAY OF GYNAECOLOGY PATIENTS

In The Netherlands, hospitals receive, as part of their budgets, a fixed amount of money for every admission. Therefore, reducing the length of stay of patients has a direct impact on the financial results of the hospital because more patients can be admitted. The head of the Department of Gynaecology, one of the participants of the second Green Belt group, chose this project.

Define phase

The objective of this project was to shorten the stay of gynaecology patients who had to undergo an abdominal uterus extirpation (AUE) or a vaginal uterus extirpation (VUE). The financial benefits of this project were estimated to be €57 800. An additional benefit was the possible reduction in the waiting lists for these types of gynaecological procedures. The duration of the project was estimated to be six months. The project was carried out by two Green Belts in training. Both Green Belts had one day per week available to spend on the project. Before starting the project a contract was made in which the appointments between the Green Belts and the Champion (in this project, the managing director) were formalized. The Green Belts, the Champion, and the Controller signed this contract.

Measure phase

The so-called critical to quality (CTQ) characteristic is the length of stay of patients with AUE or VUE. This CTQ was defined as the length of the stay measured in days. Only patients who had to undergo an AUE or VUE were included. The requirement on the CTQ was to shorten the length of stay as much as possible with no additional discomfort to the patients. The measurement of the length of stay by means of the computer system had to be validated. This was done by comparing the length of stay measured using 30 patient dossiers with the results from the computer system. There were no differences found in this sample. Based on these observations we concluded that the measurement system was valid.

Analyse phase

Data for the year 2002 were used. There appeared to be a few outliers, which were analysed and excluded from the data by performing a capability analysis. The average stay in the hospital of patients with VUE or AUE was 7 days, and the standard deviation was 2 days. Based on the current performance, the Green Belts decided that the objective of this project was to reduce the length of stay for AUE or VUE patients to 4.5 days with a standard deviation of 0.6 days. This objective should result in a financial benefit of €63 520. Factors influencing the length of stay were listed by using a cause and effect diagram and a failure mode and effect analysis (FMEA).

Improve phase

The most relevant factors influencing the length of the stay were found to be:

- treatment protocols of patients with AUE or VUE; and
- situation at home, i.e. whether there are relatives who can take care of the patients after discharge.

Changes in the protocols of AUE or VUE patients, such as skipping the pre-surgery day, directly reduced the length of stay of the patient. The other most fruitful improvements were:

- an out-patient clinic to prepare the patient for the operation (this action reduces the length of stay of patients by one day);
- improved protocols;
- check on the situation at home and offer home care if needed; and
- information about the length of the stay given to the patient in advance.

Control phase

All of the above-mentioned improvements were implemented in March 2004. At present (May 2004) the average length of stay is 5.2 days and the standard deviation is 0.9 days (based on 15 patients). Further reduction in the length of stay is expected after this initial phase.

SHORTEN THE PREPARATION TIME OF INTRAVENOUS MEDICATION

In our hospital, every nursing department has facilities to prepare intravenous medication. When a patient needs intravenous medication, it is prepared in the nursing department by a registered nurse. The medication is administered by means of an intravenous drip. This procedure was found to be rather inefficient.

Define phase

The objective of this project was to shorten the preparation time of intravenous medication. The financial benefit of this project was estimated to be around €20 000. Furthermore, in the near future, due to new Dutch legislation, it will be necessary to prepare intravenous medication under strict controlled conditions in a flow closet. An additional one-time benefit of €21 000 could be realized when the installation of flow closets is minimized. The duration of the project was estimated to be six months. The project was carried out by two Green Belts in training—a nurse and an employee of the pharmacy department. Both Green Belts had one day a week available for the project. A contract was drawn up whereby the appointments between the Green Belts and the Champion were formalized. This contract was signed by the Green Belts, the Champion (in this case, the managing director) and the Controller.

Measure phase

The CTQ characteristic was the preparation time of one dose of intravenous medication. The total preparation time of the dose was measured using a stopwatch. A Gauge R&R study on the stopwatches was successfully carried out in an earlier Black Belt project. The unit was a medication order and the population consisted of all medication orders. The requirement on the CTQ is that the preparation time has to be as small as possible.

Analyse phase

Data analysis revealed that the in control process had a mean preparation time of 165 s and a standard deviation of 50 s. The objective of this project was to reduce the mean and the standard deviation of the preparation time as much as possible. Brainstorming techniques were used to find the relevant factors that influence the preparation time.

Improve phase

The most important factors influencing the preparation time of the injection in the nursing department are:

- interruptions;
- absence of a supervisor;
- number of injections to be prepared; and
- workload in the department.

An experiment was carried out to prepare intravenous medication in the pharmacy department. Eight runs of 30 doses were prepared. This resulted in a mean preparation time per injection of 104 s and a standard deviation of 12 s. Based on these results it was decided to transfer the preparation activities from the nursing departments to the pharmacy. The new approach also solved the problems of interruptions, workload within the nursing department, and the absence of the supervisor. Improvement actions were also set up to further reduce the preparation time at the pharmacy.

Control phase

New instructions to the nurses were introduced. A training program was scheduled and executed. In the pharmacy department the medication is injected directly into infusion fluid. The annual saving compared with the procedure being carried out in the nursing departments is €33 600.

IMPROVED CHECKS ON INVOICES OF TEMP AGENCIES

The Red Cross Hospital spends more than €1 000 000 a year on hiring temporary personnel. There was no circumscribed procedure for hiring temporary workers. The different departments all had their own contacts with temp agencies. Every temp agency used its own worksheet and it was very hard to verify the corresponding invoices. This situation led to a substantial administrative workload. Once reviewed, we discovered a significant number of invoices that contained discrepancies. Most of the time these mistakes were in favour of the temp agency (reasons unknown).

Define phase

The objective of this project was to reduce the number of mistakes on the invoices. The CTQ characteristic was the number of invoices we received from the temp agency that were correct. The financial benefits of this project were estimated to be €20 000. The expected duration of the project was six months. The project was carried out by two Green Belts in training. Both Green Belts had one day per week available for the project. Both Green Belts were involved in hiring temporary workers. The Green Belts, the Controller and the Champion (the managing director) signed a contract.

Table I. Results of the analysis of declaration
forms and corresponding invoices

Category	Percentage
I	15
II	21.5
III	15
IV	26.5
V	22

Measure phase

A declaration form is used by the temp agency to produce an invoice. The project has focused on both the accuracy of declaration forms and invoices. To make the CTQ—the number of correct invoices—operational the Green Belts used the following criteria to check the declaration form.

- Are the breaks registered?
- Are the total working hours in accordance with the agreement?
- Are there any other obvious mistakes?

The invoices were checked on the following.

- Is the number of hours spent by the temp worker correct?
- Is the irregularity bonus applied correctly?
- Are there any arithmetical mistakes?

With these checks, five categories of the CTQ can be distinguished.

I. Both the declaration form and the invoice are correct.
II. The declaration form is correct and the invoice is incorrect.
III. The declaration form is incorrect and the invoice is correct.
IV. The declaration form is incorrect and the invoice may be easily corrected (i.e. the mistakes in the declaration form are corrected in the invoice).
IV. The declaration form is incorrect and the invoice is incorrect (i.e. in addition to the mistakes in the declaration form, additional mistakes have been made in the invoice).

The validation of the measurement system is achieved by executing an experiment. Two operators independently judged 25 declaration forms on two separate occasions. The results of the experiment found that every declaration form was judged four times in exactly the same way. We could conclude that the measurement system was precise enough to meet our expectations.

Analyse phase

Declaration forms for the previous three months (117 forms) were analysed. Table I gives an overview of the results.

It was found that only 15% of the declaration forms and the corresponding invoices were correct. The objective was to improve this percentage to 100%. This would have a financial impact of €36 000 annually.

Influence factors were found using specific knowledge, an exploratory study and brainstorming. These three methods delivered a variety of possible influence factors. Based on an exploratory analysis it was discovered that the irregularity bonus did not fit with the collective wage agreements because the temp agencies did not use the maximum allowed percentage. So the amount on the invoice was often too high.

A brainstorming session led to the following influence factors:

- signature of the head of the department is missing;
- no check on the hours worked;
- breaks not registered;
- mistakes made by the temporary worker with respect to hours worked and travelling costs;
- no check on the number of years experience of the temporary worker; and
- the hourly wage on the invoice is incorrect.

Improve phase

The relation between the influence factors and the CTQ characteristic appeared to be very close. The following actions were chosen to diminish the number of mistakes.

- A standardized worksheet 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.
- The number of temp agencies was reduced.

With these improvements the majority of mistakes can be eliminated.

Control phase

A new procedure has been introduced for hiring temporary personnel. Heads of departments are required to use the new standard worksheet. With this worksheet all the relevant data can be easily checked. The corresponding invoice can be made in advance and compared with the invoice sent by the temp agency to establish any discrepancies.

CONCLUSIONS

Six Sigma has been introduced in the Red Cross Hospital as a quality improvement system in addition to our ISO 9000 quality management system. We have chosen to run the projects with Green Belts. Employees were very enthusiastic about the Green Belt training itself, as well as how the training supported them during their projects. We have described three projects in the nursing department, all rendering more savings than were estimated at the beginning. Until recently, Six Sigma was predominantly used in industry. Based on our experience, it can be concluded that Six Sigma is also applicable in healthcare.

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Authors' biographies

Jaap van den Heuvel became a MD at the University of Leiden in 1984. In 1988 he obtained his MBA degree at the Erasmus University of Rotterdam. He worked for three years as a house officer and after that he became IT consultant specializing in electronic medical records. In 1992 he became manager of the radiology department in the academic hospital in Utrecht. In 1997 he became managing director of the Red Cross Hospital in Beverwijk. In this hospital, he introduced an ISO 9001 quality management system and Six Sigma.

Ronald J. M. M. Does obtained his MS degree (*cum laude*) in Mathematics at the University of Leiden in 1976. In 1982 he defended his PhD entitled 'Higher order asymptotics for simple linear rank statistics' at the same university. From 1981 to 1989 he worked at the University of Maastricht, where he became Head of the Department of Medical Informatics and Statistics. In 1989 he joined Philips Electronics as a senior consultant in Industrial Statistics. Since 1991 he has been Professor of Industrial Statistics at the University of Amsterdam. In 1994 he founded the Institute for Business and Industrial Statistics, which operates as an independent consultancy firm within the University of Amsterdam. His current research activities lie in the design of control charts for non-standard situations and the improvement of statistical methods in Six Sigma.

M. B. (Thijs) Vermaat obtained a Master's degree in Econometrics and Operations Research at the University of Groningen in 2002 and a Master's degree in Statistics at the same University in 2003. Currently, he is a PhD student at the University of Amsterdam and a consultant in industrial statistics at the Institute for Business and Industrial Statistics. His research interests are control charts, extreme-value theory, Bernstein approximations, and Six Sigma.