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Can Six Sigma be the "cure" for our "ailing" NHS?

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Can Six Sigma be the “cure” for our “ailing” NHS?

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Abstract

Purpose – The purpose of this research is to analyse whether Six Sigma business strategy can be used to improve the financial and operational performance of the NHS. The paper will also look at some of the major challenges and barriers in the implementation of this powerful process improvement strategy within the healthcare sector.

Design/methodology/approach – This paper discusses whether Six Sigma DMAIC methodology can be a useful and disciplined approach to tackle process- and quality-related problems in the NHS.

Findings – The paper presents some key findings from other researchers in the field, followed by some comments on whether Six Sigma is a useful approach to be considered by the NHS for cost reduction and defect reduction strategies.

Originality/value – The paper illustrates the point that Six Sigma is not confined just to manufacturing industry, rather it is equally applicable to service industry, especially the healthcare and financial sectors. The application of Six Sigma in the UK health sector is relatively new and the purpose of the paper is to increase the awareness of this powerful business strategy in healthcare discipline.

Keywords Quality, Performance management, Six sigma, National Health Service, Health services

Paper type Research paper

Introduction

Six Sigma is a process-focused data driven methodology aimed at near elimination of defects in all processes which are critical to customers (Antony *et al.*, 2007). Six Sigma as a powerful business strategy has been around for almost twenty years and has grown exponentially in healthcare industry during the past five years mainly in the USA. Initially applied in manufacturing industry, it has now dispersed into service industries, most importantly to the healthcare sector. Sigma is a Greek letter used to describe process variability or in mathematical terms, standard deviation of a random variable. A number of times Sigma indicates the amount of defects that are likely to occur in a given process (manufacturing, service



or transactional). For example, a 3 sigma process has a defect rate of approximately 67,000 (6.7 per cent) whereas a Six Sigma process has less than 4 defects per million opportunities. Defects in processes cause increase in costs due to scrap, rework, repair, re-test and so on. For instance, the cycle time for reporting radiology results in a hospital as defined by physicians is 18 hours. This implies that if the turnaround time for any report produced by a physician is over 18 hours, then it may be viewed as a defect. We can calculate the defect per million opportunities (DPMO) and the corresponding Sigma Quality Level (SQL) once we know the number of patient visits per year to the radiology department.

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NHS challenges

Whilst improvements have been made within the NHS, services are still not good enough. Moreover the NHS is entering a very uncertain period through using market forces and promoting patient choice. The transformation of the whole system by making “big changes, very quickly” is now required as the NHS enters the latter part of the ten-year implementation plan (Hewitt, 2005). Many healthcare systems are now deeply dysfunctional and all require redesign with many indicating that this should be a radical redesign (Shalala, 2005). The challenges that face the NHS in order to respond to and meet the ever changing needs services need to be:

- well defined;
- co-ordinated;
- efficient;
- cost effective; and
- supported by core processes and systems and require multiple improvement strategies.

To achieve this, Six Sigma as a framework offers the NHS a realistic structured methodology for process improvements (Natarajan, 2006).

Overview of Six Sigma

Six Sigma allows for more careful analysis and more effective decision-making aiming for the optimal solution rather than what is simply “good enough”. It really takes TQM efforts to the next level and has a great future in healthcare (Lazarus and Butler, 2001). As a methodology for process and quality improvement, Six Sigma has demonstrated its ability to adapt to virtually any process – including healthcare. When appropriately implemented with uncompromising leadership support and the utilisation of change management tools to address cultural barriers and build acceptance, Six Sigma has achieved measurable success (Stahl *et al.*, 2003). Lean Thinking is a philosophy which requires the continuous elimination of waste and non-value-added elements from processes and is identified as being closely linked to Six Sigma.

Six Sigma made a beachhead in healthcare around the year 2000, although its growth was slow and steady. Two years after this, a number of hospitals in the USA have adopted Six Sigma as their core business process improvement strategy (Black and Revere, 2006). Throughout the last five years, many leading healthcare institutions in the USA have implemented Six Sigma with remarkable results in terms of reducing

ER cycle time, increasing timely completion of medical records, increasing bed availability, reducing medication errors, etc. (Lazarus and Stamps, 2002). The Red Cross Hospital in Netherlands (Europe) has successfully initiated Six Sigma programme with savings generated from a total of 44 Six Sigma projects amount to over €1.2 million (Heuvel *et al.*, 2005). Table I outlines outcomes and financial savings from the implementation of Six Sigma programmes. The fact that Six Sigma successfully combines quality improvement and cost reduction substantiates that it could be a solution to current financial problems in healthcare. An important motivation luring different healthcare organisations towards Six Sigma is its effectiveness in increasing customer satisfaction (i.e. patients, physicians and employees), provision of excellent service levels at minimal cost, effectively utilising existing resources and driving out non value added activities.

In service industries Six Sigma is proving its worth by improving transactional process performance with customer satisfaction in a wide range of sectors (Steele, 2004). Results from the UK service industry indicate that the majority of service organisations have been engaged in a six sigma initiative throughout the past three years with the average sigma quality level reached was around 2.8 (approximately 98,000 DPMO). Critical success factors cited for successful implementation according to (Anthony *et al.*, 2007) are: management commitment and involvement, customer focus, linking six sigma to business strategy, organisational infrastructure, project management skills, and understanding of the six sigma methodology. The benefits from the adoption of Six Sigma in service industries is in the form of considerable improvement in the bottom line result but it also increases customer satisfaction and employee morale, improves cross functional teams, increased awareness of problem solving tools and techniques leading to an improved consistent level of service.

In the manufacturing sector, it is quite possible to reduce or even eliminate (in some cases) most of human variability through automation. In the healthcare industry, the delivery of patient care is largely a human process, and hence the causes of variability are often difficult to identify and quantify. The challenge for the healthcare sector and staff is to find a way to leverage the data to drive human behaviour. Financial results and their validation continue to be a challenge in the healthcare industry. It is often a difficult task to place a dollar value on a faster test result that may yield a shorter length of stay or the value of a more satisfied patient.

The following are some of the typical characteristics of Six Sigma:

- emphasises a data-driven methodology rather than feeling and intuition in the decision making process;
- places a strong emphasis on customer needs and expectations such as service level, service cost, clinical excellence, patient satisfaction, etc.;
- focuses on elimination of defects or errors in processes due to unacceptable process variation;
- offers a structured approach to get into the root causes of problems using the DMAIC (Define-Measure-Analyse-Improve-Control) methodology; and
- Places a greater emphasis on hard-dollar savings from projects which are aligned with strategic objectives of organisation's business.

Company	Nature of the problem	Project	Outcome	Hard cash savings generated
CHC	Excessive patient waiting time	Radiology	Reduced patient waiting times, improved staff scheduling, 25 per cent increase in through-put	\$800,000 (approx.)
Scottsdale Healthcare	Overcrowded emergency department	ER	Reduced time to transfer a patient from the ER to an in-patient hospital bed	\$600,000 (approx.)
Commonwealth Health Corporation	Increased instances of wound integrity problems in small and large bowel surgical cases	Infection Control Group	Resulted in significant reduction in post-op infection, reduced infection rate by over 65 per cent	The annual savings generated from the project is over \$60,000
North Shore-LIJ Health System	Increased analytical errors in an automated lab		Reduced analytical errors by 35 per cent	Hard cash savings are not quantified in the case study
Decatur Memorial Hospital	Unacceptable number of hospital acquired infections in three key operational areas	Intensive care, intermediate care and the cardiovascular unit	Significant reduction in the number of hospital-acquired infections	Hard cash savings are not quantified in the project
Charleston Area Medical Centre	Excessive inventory levels, poor supplier relationships	Supply chain management for surgical supplies	Reduced inventory levels and improved supplier relationships	Estimated savings from the project are over \$500,000
Baptist Medical Centre	Inefficient hospital discharge process		The process mean (discharge order entry to patient leaving time) has been improved by over 70 per cent and process variation has been reduced by 60 per cent	Hard cash savings are not quantified in the case study
Virtua Health	Slower turnaround time in hospital lab results Low radiology through-put and unacceptable associated costs per radiology procedure in a hospital	Radiology	Reduced turnaround time by 40 per cent Significant improvement in radiology through-put (about 33 per cent) and reduction in cost per radiology procedure	Hard cash savings are yet to be quantified Approximately \$1.2 million

(continued)

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Table I.
Benefits of Six Sigma projects in healthcare services

Table I.

Company	Nature of the problem	Project	Outcome	Hard cash savings generated
Alaska Medical Centre	Poor patient safety due to high medication and laboratory errors	Emergency Department	Reduced medication and laboratory errors and thereby improved patient safety significantly Decrease diversions due to "critical care at capacity"	\$600,000/year in profit
LDS Hospital	Increase in the number of ambulance diversions (from 3 per cent to 24 per cent) Rapid treatment of painful conditions in the emergency department	Emergency Department	Time to pain management went from 67 minutes to 45 minutes and untreated pain dropped from 39 to 11 per cent. Overall patient satisfaction has significantly improved	Net revenue increase of \$1 million (US) per annum Hard cash savings are yet to be determined
Memorial Hermann Southwest Hospital	Unacceptable delays in admitting patients		Turnover time decreased from 325 minutes to less than 180 minutes, defects in the process have been reduced from 90 per cent to 55 per cent	Hard cash savings are not quantified for the project

An overview of Six Sigma methodology (DMAIC)

The Six Sigma methodology encompasses five stages:

- (1) *Define (D)* the problem within a process.
- (2) *Measure (M)* the defects.
- (3) *Analyse (A)* the causes of defects.
- (4) *Improve (I)* the process performance to remove causes of defects.
- (5) *Control (C)* the process to make sure defects do not recur.

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Define the problem

The problem statement should not contain its cause or prescribe a solution. The problem statement should describe what you want to accomplish from the Six Sigma project. A well defined problem leads to achieve the objective of the customer whereas inadequately defined problem might lead to an undesired outcome resulting in unhappy customers. In the define phase, it is important to determine the voice of the customer (VOC) and translate it into measurable critical-to-quality (CTQ) or critical-to-cost (CTC) or critical-to-delivery (CTD) parameters. The operational definition of a defect must be determined by the Six Sigma project team. Anything which is not acceptable in the eyes of the customer (patient or physician) can be treated as a defect. In the define phase, it is strongly advised to develop a project charter showing the nature of the project, team members involved in executing the project, key milestones of the project, project goals, business case, project sponsor, etc.

Measure the problem

In this stage, one should assess the baseline measure of the process performance. Once we determine what should be measured in a process, it is then important to link the data collection to key issues affecting the process. It is also vital to ensure that we have a valid and capable measurement system in place. This aspect is quite often overlooked in many service organisations. The following questions may be asked by the team during the measure stage of the methodology:

- (1) Who will be affected by the problem at hand? List all the departments, processes and the individuals, if possible.
- (2) How often is the problem occurring?
- (3) Where is the problem occurring?
- (4) What is the impact of the problem on our business?
- (5) What is the impact of the problem on customers?

Analyse the problem

In this phase, the team identifies the causal factors likely to impact the problem. In the context of Six Sigma, this is often represented as: $Y = f(X)$, where Y is the CTQ, CTC or CTD and $X = X_1, X_2, X_3, \dots, X_n$ represent the list of potential causal factors which affect Y . Many factors in healthcare are quite predictable, though uncontrollable such as arrival rate at the emergency room. Some useful tools which can be used to identify the causal factors are brainstorming, root cause analysis or cause and effect analysis, Pareto analysis and hypothesis testing.

Improve processes

The improve phase can be quite challenging in healthcare sector as it often involves changing human behaviour. It probably comes as no surprise to healthcare professionals that organisational structure can actually inhibit process thinking. In this phase, the team have to change the process to address the root causes identified in the analyse phase and thereby improve the process performance. Several rounds of improvement may be required to achieve the desired level of performance.

In a group environment, creative and innovative solutions can sometimes be suppressed by poor team dynamics and non-supportive environment. The choice of solution to a process problem can be determined by effectively employing an impact-effort matrix. Solutions that offer a high impact need to be examined to determine how much time, resources, budget, etc. will need to be invested for implementation.

Control processes

In the control phase, we generally determine the control plans that will assure that improved process performance is sustained over a period of time after the completion of the project. The most appropriate tool to use in the phase is control chart. The purpose of a control chart is to monitor the process and identify special causes of variation (e.g.: operator error, errors in recording of measurements, etc.) in processes. A root cause analysis can be carried out once the special causes of variation are identified. Having identified special causes of variation, appropriate remedial action plan should be developed.

Six Sigma projects and financial benefits

Projects are the primary vehicle used to drive product, process and service quality improvements in organisations. Using projects to improve process performance, yield, throughput, process capability and stability etc. that result in overall business performance are pretty fashionable in many organisations today which are engaged in a Six Sigma programme. The selection of right projects in the first place is quite critical in a Six Sigma initiative to gain the appreciation of top management personnel and many others interested in the survival of such an initiative. This section briefly outlines some guidelines of selecting projects, followed by illustrating the financial benefits of some healthcare related projects in a Six Sigma initiative.

Project selection:

The project selection process must incorporate three important voices: the voice of the process, the voice of the customer, and the voice of strategic business goals (Pande *et al.*, 2000). Snee (2001) identified the following as important criteria for improving project selection which can produce significant financial impact for the organisation:

- *Areas to improve.* Waste reduction, capacity improvement, downtime reduction, etc.
- *Effect on customer satisfaction.* On-time delivery and defect reduction
- *Effect on the bottom line.* Significant financial impact, doable in 4-6 months, and benefits realised in 6-12 months period.

Antony (2004) and Pyzdek (2003) accentuated the following guidelines in selecting any Six Sigma projects:

- linkage to strategic business plan and organizational goals;
- sense of urgency (how important the project is);
- project scope (doable within 4-6 months);
- project objectives must be clear, succinct, specific, achievable, realistic and measurable;
- project selection criteria must be established;
- project must have the approval and support of senior manager;
- focus on critical business process performance characteristics (CTQ, CTC; CTD); and
- project selection should be based on realistic and good metrics (defect per million opportunities, yield, process capability, etc).

The following table (see Table I) illustrates some of the Six Sigma projects with their key benefits obtained.

Critical Success Factors (CSFs) of Six Sigma deployment in healthcare sector

The idea of identifying the CSFs as a basis for determining the information needs of managers was popularised by Rockart (1979). In the context of Six Sigma, CSFs represent the essential ingredients without which the initiative stands little chance of success. Each one must receive constant and careful attention from management as these are the areas that must “go right” for the organisation to flourish. If results in these areas are not adequate then the efforts of the organisation will be less than desired. The leaders of health care industry should consider the application of Six Sigma from the perspective of improving the quality and capability of current processes as well as the ability of processes to deliver patient care and safety. The following CSFs are essential for the successful development and deployment of Six Sigma in a hospital environment.

Uncompromising top management support and commitment

Applying Six Sigma in a health care sector is not easy, and if the senior management team is not on board, it is almost certainly a formula for failure. The deployment of Six Sigma should begin with a two day broad overview of Six Sigma business strategy for the senior management team, ensuring buy-in and commitment for the implementation. Six Sigma project champions responsible for identifying and overseeing projects must be carefully chosen before the training program. In order to buy-in senior management support and commitment, it is also essential to select projects which are tied to strategic business focus.

Formation of Six Sigma infrastructure and the appropriate training

The selection of right people is crucial for the execution of Six Sigma projects. Once the Six Sigma infrastructure is defined with the assistance of person with adequate experience of Six Sigma in the service industry, training may begin. Project champions known as “Black Belts” should receive a good overview of Six Sigma fundamentals

and the skills required for project selection, project prioritisation, project scoping and project execution. The “Black Belts” must receive four weeks of intensive training, one week each month for four months. The focus of the training must be on the execution of Six Sigma projects and the required tools and techniques for statistical analysis, problem solving and project management. The Black Belts should work on two Six Sigma projects as part of their certification process with each black belt expected to spend at least 80 per cent of their time on Six Sigma projects.

Green Belts are the next level within the organisation and must receive two weeks of training on six sigma quality management and have the ability to execute and complete six sigma projects. Green Belts may work part-time and are expected to select a project from their own processes at the work place. They may also get involved with those projects which are executed by Black Belts but are also expected to complete at least 2-3 projects annually.

Project selection and the associated financial returns to the bottom-line

Potential Six Sigma projects within a healthcare setting may relate to operational processes such as billing, registration or work flow or they may involve clinical procedures such as medication administration. When identifying and prioritising projects in a healthcare industry, the first consideration should be the customer and knowing the Critical-to-Quality characteristics (CTQs) that drives the project. The customer in this context may be the patient, physician, nursing staff, department manager or other stakeholder, depending on the process being reviewed. The following tips may be useful while selecting potential Six Sigma projects in health care industry:

- projects must be aligned with critical hospital issues, patient care issues and strategic objectives of the business;
- projects must be feasible to execute from a resource and data standpoint;
- project objectives must be clear to everyone involved in the project;
- ensure that projects can be completed on time;
- ensure that a tollgate review must be performed at every stage of the Six Sigma methodology; and
- select those projects which have the ability to show measurable improvements in quality, cost and timeliness parameters.

Goldstein (2001) presented the following attributes of good projects:

- focus on critical to quality (CTQ) characteristics;
- the response variable can easily be measured;
- financial benefit to business;
- easy collection of data;
- high probability of success;
- project completion in four to six weeks;
- not to leave on black belt to select their own project; and
- use of correct approach.

Effective communication at all levels

Effective clear communication channels at all levels of the organisation is considered to be crucial to ensure active participation of team members and engagement of these members on projects. Lack of communication was a common cited implementation failure for many quality management initiatives in healthcare industry. Through effective communication, organisations can establish a common language for change and improvement.

Developing organisational readiness

A thorough assessment on cultural readiness to determine whether an organisation is ready or not to embark on Six Sigma initiative may be a worthwhile exercise. How successful an organisation has been with previous initiatives will reflect the culture and leadership of the organisation. The lack of sustainable, relevant and related quantifiable results will indicate whether or not an organisation is in a position to embrace the Six Sigma business strategy.

Effective leadership

Leadership is the key characteristic to keep in mind when selecting the people for launching the Six Sigma initiative. Achieving the desired results will require changing the way we work and changing the mindset of people. In other words, there is a need move people successfully from the old way of doing things to new way of working which demands supportive leadership. The following issues may be considered for measuring leadership commitment within a Six Sigma initiative:

- clear direction and guidance on deploying Six Sigma;
- commitment of both financial and personnel resources for the initiative;
- a clear strategic deployment plan showing the tangible objectives and goals of the initiative;
- development of a communication plan (i.e. need for the initiative, the benefits of implementation, roles and responsibilities of everyone in the new way of thinking, etc.);
- focus on tangible results; and
- reward and recognition system.

Some common barriers and challenges in the implementation of Six Sigma within the health care industry

There are several barriers and challenges lurking below the surface that healthcare organisations need to consider prior to the implementation and deployment of Six Sigma business strategy. The first and foremost challenge is the initial investment in Six Sigma Belt System training. Secondly the absence or difficulty of obtaining baseline data on process performance is another major challenge. There will be lots of data available in the health care sector, however, most of the time these data are not readily available for its analysis. For the health care industry, it is often a struggle to understand identify processes which can be measured in terms of defects or errors per million opportunities which can lead to poor analysis of problem situations.

Another barrier to Six Sigma deployment in health care industry is the psychology of the workforce. Compared to manufacturing processes, healthcare service processes

are subject to more noise or uncontrollable factors such as sociological factors, personal factors, etc. The measurement of patient satisfaction in a hospital environment is more difficult due to the human behavioural interaction associated with the delivery of service. Changing the machine parameter settings on a machine is quite a different matter than training staff or adjusting work procedures or tasks. Last but not the least, it is important to present recommendations and improvement report using the business language rather than the statistical language.

What does the future hold for Six Sigma in healthcare?

Six Sigma has maintained momentum for over 15 years now, much longer than many non-Six Sigma advocates expected. The question now remains how long can Six Sigma survive in leading organisations who are practising this strategy for solving business problems. In our opinion, the integration of Six Sigma with Lean thinking will be the next big step for such organisations. Although the integrated approach is widely accepted by many manufacturing organisations for the last few years, service industries are still far behind in the integration of Lean and Six Sigma strategies. In the authors' opinion, we will witness the introduction of Six Sigma principles in the design and development of new service processes and products within service industry. This is also referred to as Design for Six Sigma (DFSS). DFSS is more useful if new processes have to be designed for achieving world class capabilities. In the future, we will see the integration of Six Sigma within an holistic quality improvement strategy in an organisation rather than treating it as a separate initiative for improving process, product and service quality.

Conclusion

Although Six Sigma has been used by world class companies for several years with immense success, its application in healthcare sector is still in its infancy. Appropriately implemented, Six Sigma clearly produces benefits in terms of laboratory and medication error reduction, improved patient care, etc. Some of the early successful applications of Six Sigma in health care have resulted in a reduction of surgical inventory costs, reduction in length of stay at ER and an improvement in patient satisfaction. The success stories of Six Sigma are rapidly growing, all touting the impact of this powerful and rigorous methodology to problem solving. The authors believe that Six Sigma as a business strategy allows health care sector to deliver a truly high class service to patients. Think of the true impact that Six Sigma could have if we focus on the core issues of health care and improving the quality of lives of patients. In authors' opinion, the application of Six Sigma in health care industry will continue to grow, especially here in the UK over the next five years or so. This powerful business strategy could be something NHS should seriously consider in the next five years or so to tackle operational costs, inefficient process problems and enhance patient safety. We will witness the integration of Lean and Six Sigma methodologies in the next few years in Europe for reducing operational costs in health care and enhancing patient safety. Lean may be used to reduce waste and non-valued added steps in processes and thereby obtain a better flow and reduce cycle time whereas Six Sigma may be used to reduce process variation and achieve consistency in the quality of service and delivery parameters. As with all improvement strategies all it takes a couple of brave leaders willing to take the right course and confront resistance to core issues once and for all.

References

- Antony, J. (2004), “Six Sigma in the UK service organisations: results from a pilot survey”, *Managerial Auditing Journal*, Vol. 19 No. 8, pp. 1006-13.
- Antony, J., Antony, F.J., Kumar, M. and Cho, B.R. (2007), “Six Sigma in service organisations; benefits, challenges and difficulties, common myths, empirical observations and success factors”, *International Journal of Quality & Reliability Management*, Vol. 24 No. 3, p. 294.
- Black, K. and Revere, L. (2006), “Six Sigma arises from the ashes of TQM with a twist”, *International Journal of Healthcare Quality Assurance*, Vol. 19 No. 3, pp. 259-66.
- Goldstein, M.D. (2001), “Six Sigma program success factors”, *Six Sigma Forum Magazine*, Vol. 1 No. 1, pp. 36-45.
- Heuvel, J., Does, R.J. and Verver, J.P. (2005), “Six Sigma in healthcare: lessons learned from a hospital”, *International Journal of Six Sigma and Competitive Advantage*, Vol. 1 No. 4, pp. 380-8.
- Hewitt, P. (2005), “Hewitt warns managers of NHS reform challenges”, available at: www.societyGuardian.co.uk (accessed 17 July 2007).
- Lazarus, I.R. and Butler, K. (2001), “The promise of Six Sigma (Part 1)”, *Managed Healthcare Executive*, Vol. 11 No. 9, pp. 22-6.
- Lazarus, I. and Stamps, B. (2002), “The promise of Six Sigma (Part 2)”, *Managed Healthcare Executive*, Vol. 12 No. 1, pp. 27-30.
- Natarajan, R.N. (2006), “Transferring best practice to healthcare: opportunities and challenges”, *The TQM Magazine*, Vol. 18 No. 6.
- Pande, P., Neuman, R.P. and Cavanagh, R.R. (2000), *The Six Sigma Way*, McGraw-Hill, New York, NY.
- Pyzdek, T. (2003), *The Six Sigma Handbook*, McGraw-Hill, New York, NY.
- Rockart, J.F. (1979), “Chief executives define their own data needs”, *Harvard Business Review*, Vol. 57, March/April, pp. 81-93.
- Shalala, D. (2005), “Call to address ‘deeply dysfunctional’ healthcare systems”, available at: www.SocietyGuardian.co.uk (accessed 17 July 2007).
- Snee, R.D. (2001), “Dealing with the Achilles Heel of Six Sigma initiatives”, *Quality Progress*, March, pp. 66-72.
- Stahl, R., Schiltz, B. and Pexton, C. (2003), “Healthcare’s horizon”, *Six Sigma Forum Magazine*, Vol. 2 No. 2, pp. 17-26.
- Steele, A.D. (2004), “Six Sigma toolkit at your service”, *Six Sigma Forum Magazine*, February, p. 30.

Further reading

- Antony, J., Kumar, M. and Madu, C. (2005), “Six Sigma in small and medium sized enterprises: some empirical observations”, *International Journal of Quality & Reliability Management*, Vol. 22 No. 8, pp. 860-74.

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1. Shreeranga Bhat, E.V. Gijo, N. A. Jnanesh. 2016. Productivity and performance improvement in the medical records department of a hospital: an application of Lean Six Sigma. *International Journal of Productivity and Performance Management* 65:1. . [[Abstract](#)] [[PDF](#)]
2. Cindy S. Lee, Vibhor Wadhwa, Jonathan B. Kruskal, David B. Larson. 2015. Conducting a Successful Practice Quality Improvement Project for American Board of Radiology Certification. *RadioGraphics* 150024. [[CrossRef](#)]
3. Patrick D. Sutphin, Stephen P. Reis, Angie McKune, Maria Ravanzo, Sanjeeva P. Kalva, Anil K. Pillai. 2015. Improving Inferior Vena Cava Filter Retrieval Rates with the Define, Measure, Analyze, Improve, Control Methodology. *Journal of Vascular and Interventional Radiology* 26, 491-498.e1. [[CrossRef](#)]
4. Matthew Tickle, Dotun Adebajo, Robin Mann, Francis Ojadi. 2015. Business improvement tools and techniques: a comparison across sectors and industries. *International Journal of Production Research* 53, 354-370. [[CrossRef](#)]
5. Saja Albliwi, Jiju Antony, Sarina Abdul Halim Lim, Ton van der Wiele. 2014. Critical failure factors of Lean Six Sigma: a systematic literature review. *International Journal of Quality & Reliability Management* 31:9, 1012-1030. [[Abstract](#)] [[Full Text](#)] [[PDF](#)]
6. M. Prasanna, Sekar Vinodh. 2013. Lean Six Sigma in SMEs: an exploration through literature review. *Journal of Engineering, Design and Technology* 11:3, 224-250. [[Abstract](#)] [[Full Text](#)] [[PDF](#)]
7. J. Liberatore Matthew. 2013. Six Sigma in healthcare delivery. *International Journal of Health Care Quality Assurance* 26:7, 601-626. [[Abstract](#)] [[Full Text](#)] [[PDF](#)]
8. Mlungisi Masilela, Fenio Annansingh, Shaofeng Liu Striving for Market Dominance in UK's Private Healthcare Sector: A Case of Cygnet Healthcare 60-67. [[CrossRef](#)]
9. Thanos Papadopoulos. 2011. Continuous improvement and dynamic actor associations. *Leadership in Health Services* 24:3, 207-227. [[Abstract](#)] [[Full Text](#)] [[PDF](#)]
10. Svante Lifvergren, Ida Gremyr, Andreas Hellström, Alexander Chakhunashvili, Bo Bergman. 2010. Lessons from Sweden's first large-scale implementation of Six Sigma in healthcare. *Operations Management Research* 3, 117-128. [[CrossRef](#)]
11. Rodney McAdam, Shirley-Ann Hazlett. 2010. An absorptive capacity interpretation of Six Sigma. *Journal of Manufacturing Technology Management* 21:5, 624-645. [[Abstract](#)] [[Full Text](#)] [[PDF](#)]
12. Mohamed Gamal Aboelmagd. 2010. Six Sigma quality: a structured review and implications for future research. *International Journal of Quality & Reliability Management* 27:3, 268-317. [[Abstract](#)] [[Full Text](#)] [[PDF](#)]
13. Muthuswamy Shanmugaraja, Muthusamy Nataraj, Nallasamy Gunasekaran. 2010. Customer Care Management Model for Service Industry. *iBusiness* 02, 145-155. [[CrossRef](#)]
14. Franco M. Impellizzeri, Mario Bizzini, Michael Leunig, Nicola A. Maffioletti, Anne F. Mannion. 2009. Money matters: exploiting the data from outcomes research for quality improvement initiatives. *European Spine Journal* 18, 348-359. [[CrossRef](#)]