NHS
Institute for Innovation and Improvement

Lean Six Sigma: some basic concepts

Introduction

By Helen Bevan, Neil Westwood, Richard Crowe, Michael O'Connor.

The English National Health Service (NHS) is the largest healthcare system in the world. Its annual budget is more than £70 billion and it employs 1.3 million staff. Last year, there were 325 million patient consultations with primary care physicians and nurses. More than 13 million people attended a first specialty appointment in hospital and 14 million people attended the Accident and Emergency department (Chief Executive's report to the NHS, 2005).

The NHS is in the middle of a 10 year programme of transformational change. The aim is to provide a health and healthcare service that meets the life-long needs of the citizens of England. Ambitious goals have been set to reduce the burden of disease and improve outcomes of care: to reduce hospital admissions by supporting people with long term conditions in managing their own care and by providing preventative, community-based services; to improve clinical quality and safety; to improve access to care, remove health inequalities and eliminate delays.

This mission requires multiple improvement strategies on multiple fronts. On one level, it requires nothing less than fundamental redesign of the healthcare system. At another level, it needs on-going incremental improvement of existing services. We have tested and utilised a wide range of improvement strategies in our quest to create faster, more effective change. This has included Lean and Six Sigma, both of which have delivered promising results, particularly when combined with other tools and techniques. Pioneers are undertaking early testing of the approach. Our latest endeavour involves the integration of the two into an approach we have labelled 'Lean Six Sigma for healthcare'. This paper sets out some of the principles underpinning the approach.

Lean Six Sigma – an overview

Lean is an approach that seeks to improve flow in the value stream and eliminate waste. It's about doing things quickly.

Six Sigma uses a powerful framework (DMAIC) and statistical tools to uncover root causes to understand and reduce variation. It's about doing things right (defect free).

A combination of both provides an over-arching improvement philosophy that incorporates powerful data-driven tools to solve problems and create rapid transformational improvement at lower cost.

The key is to find the optimal combination of both approaches. For example, adopting the Lean idea of focusing on what adds value and then using Six Sigma tools to help understand and reduce variation, when the value stream is agreed.

This figure below shows the roots of Lean and Six Sigma and how they are converging.

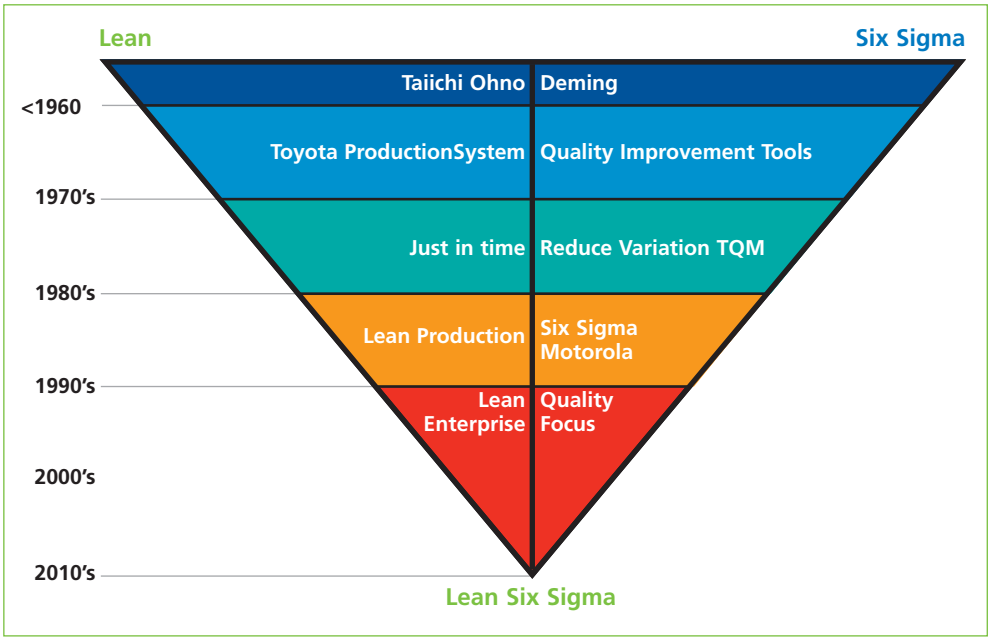

Figure 1
History of Lean and Six Sigma
adapted from LeanSigma.com

Discussion

Globally, organisations from many industries, including healthcare are adopting a 'Lean Six Sigma' strategy. This is particularly true of organisations that previously focused on Six Sigma. General Electric, one of the pioneers of Six Sigma, is now incorporating a Lean Six Sigma approach to achieving rapid transformational change at lower cost.

Introduction to Lean

Lean principles have been enhanced and developed by Toyota to create the Toyota Production System.

Toyota developed Lean in the 1950s based on the work of Frederick Taylor and W. Edwards Deming, both industrial engineers. (Note, Toyota does not refer to the word Lean, it uses the Toyota Production System. See Table 1.)

Stephen Spear's paper in Harvard Business Review (2005) says "If one asks the question, can the Toyota Production System be applied in healthcare? The quick answer is yes."

Industrial engineers invented both Lean techniques and the Six Sigma approach to process quality.

1980-90 Cell and Line	1990-mid 1990 Shop Floor	Mid 1990-1999 Value Stream	2000+ Value System
Highly prescriptive tool-based approach, disseminating the tools used by Toyota and others	Highly prescriptive best practice approach, with a focus on quality	Lean principles Value stream mapping. The concept of the Lean Enterprise with a focus on quality, cost and delivery. Concept of "one best way" still prominent – "what would Toyota do?"	Contingency involving customer value, policy deployment, size, industry, technology focusing on system-level capability and integrated processes

Table 1
Evolution of the Lean approach
Boaden, 2005

Lean is a strategic approach to change and improvement. Focusing just on the tools at an operational level and reducing costs, will not obtain the full benefits.

Lean means *"using less to do more"* by *"determining the value of any given process by distinguishing value added steps from non value added and eliminating waste so that ultimately every step adds value to the process"* (Miller, 2005).

It is relentlessly focused on the work and by definition the strategy becomes: focus on the work, learn from it and improve. That's your strategy. The strategy is simply to learn.

Not understanding Lean and applying tools in isolation leads it to be a cost-reduction exercise.

The main criticisms of Lean are summarised as (Hines et al., 2004):

- lack of consideration for human factors
- lack of strategic perspective (at least until recently)
- relative inability to cope with variability
- Lean means laying off people
- Lean is only for manufacturing
- Lean only works in certain environments – but it is more than manufacturing process design (a strategic approach).

Introduction to Six Sigma

Six Sigma is a process improvement methodology developed at Motorola in the 1980's to reduce defects in its processes. Its goal was to achieve a level of performance equal to a defect rate of 3.4 defects per million opportunities – this is a virtually defect free environment i.e. Six Sigma performance.

Similarly, Motorola Inc. Six Sigma methodology emerged in the 1980s from Total Quality Management, a core element of industrial engineering.

The roots of Six Sigma as a measurement standard can be traced back to Carl Frederick Gauss (1777-1855) who introduced the concept of the normal curve. Six Sigma as a measurement standard in product variation can be traced back to the 1920's when Walter Shewhart showed that three sigma from the mean is the point where a process requires correction. Many measurement standards (Cpk, Zero Defects, etc.) later came on the scene, but credit for coining the term "Six Sigma" goes to a Motorola engineer named Bill Smith.

The main criticisms of Six Sigma are summarised as (Hines et al., 2004):

- system interaction not considered – uncoordinated projects
- processes improved independently
- lack of consideration for human factors
- significant infrastructure investment required
- over detailed and complicated for some tasks
- it is the new flavour of the month
- the goal of Six Sigma (3.4 defects per million opportunities) is absolute – but this is not always an appropriate goal and does not need to be adhered to rigorously
- it is only about quality.

Lean and Six Sigma are process based improvement methodologies. Both were developed in manufacturing environments. Both have proven their effectiveness. Proponents of both can point to numerous, and dramatic success stories.

Current emerging trends are indicating that integrating the best elements of both methodologies could help healthcare deliver strategic and operational objectives.

Question: What are the advantages of integrating Lean and Six Sigma?

Answer: Integrating Lean and Six Sigma creates a win win situation. The philosophy of Lean provides the strategy and creates the environment for improving flow and eliminating waste. Empowered staff are encouraged to continuously improve to create value adding opportunities that otherwise would not be identified. Six Sigma helps to quantify problems, makes evidence based decisions (this prevents wasting time on anecdotal evidence), helps to understand and reduce variation and identifies root causes of variation to find sustainable solutions. Furthermore, it quantifies the financial benefits and savings. This helps to focus efforts in the areas that offer the most potential for improvement.

A combination of both can provide the philosophy and the effective tools to solve problems and create rapid transformational improvement at lower cost. Potentially, this could increase productivity, improve quality, reduce costs, improve speed, create a safer environment for patients and staff and exceed customer expectations.

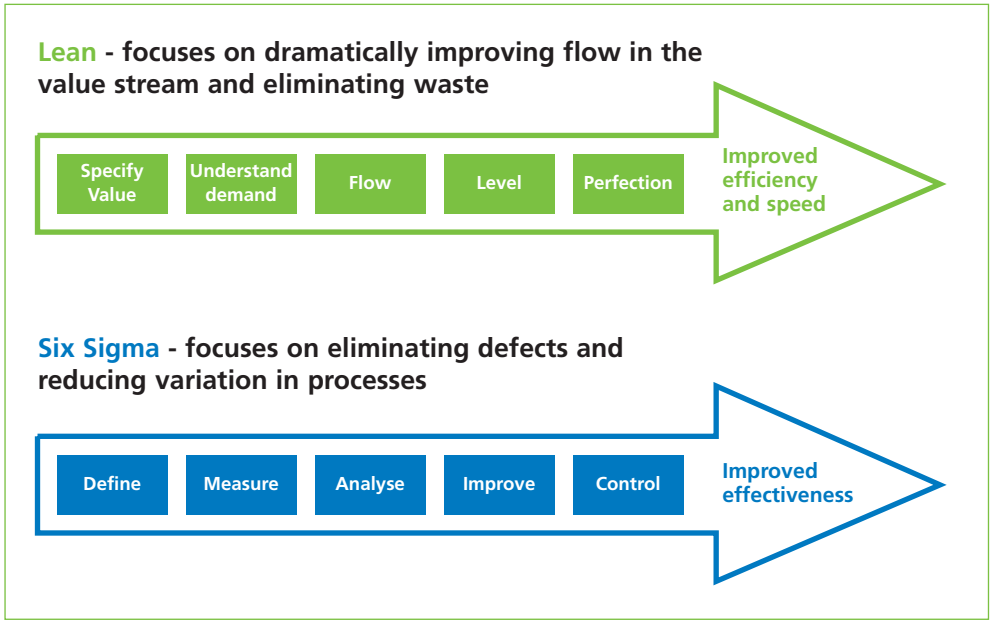

Figure 2
Integrating the two improvement approaches
Juran Institute

Question: How are Lean and Six Sigma similar?

Answer: Lean and Six Sigma are both customer-focused process improvement methodologies. They both follow the traditional quality improvement steps:

1. Identify the project
    a. Nominate projects
    b. Evaluate projects
    c. Select a project
    d. Ask: Is it quality improvement?
2. Establish the project
    a. Prepare a statement of goals
    b. Select a team
    c. Verify the statement of goals
3. Diagnose the cause
    a. Analyse symptoms
    b. Confirm or modify statement of goals
    c. Formulate theories
    d. Test theories
    e. Identify root cause(s)
4. Remedy the cause
    a. Evaluate alternatives
    b. Design remedies
    c. Design controls
    d. Design for culture
    e. Prove effectiveness
    f. Implement
5. Hold the gains
    a. Design for effective quality controls
    b. Foolproof the remedy
    c. Audit the controls
6. Replicate results and nominate new projects
    a. Replicate the project results
    b. Nominate new projects

As we can see in Table 2, both Lean and Six Sigma uncover similar issues.

Table 2
A comparison of common problems identified by Lean and Six Sigma

Lean	Six Sigma
Lack of customer focus	Lack of customer focus
Lack of staff empowerment	Inadequate measurement systems
Untidy, inefficient work spaces	Suboptimal processes
Suboptimal maintenance practices	Defect opportunities
Lack of cross-training	Outdated processes and metrics
Excess inventory	Lack of ownership of processes
Lack of visible controls	
Suboptimal processes	
Time traps	
Outdated processes and metrics	

Question: How are Lean and Six Sigma different?

Answer: At one level, both Lean and Six Sigma are improvement methodologies. But as you investigate further, the contrasting aspects of the two approaches becomes apparent.

Lean is often seen as an efficiency approach which focuses on improving flow in the value stream and eliminating waste. It is more than this.

Lean is a philosophy, not simply an exercise in eliminating waste. Lean is much more than episodic Kaizen (rapid improvement) events, it is a continuous improvement approach.

It asks the question, "Why does this process exist at all? What is the value and the value stream?"

Six Sigma, by contrast, is often considered an effectiveness approach which focuses on the elimination of defects and reducing variation. It is seen as working best in an environment where there is variation. Six Sigma starts with "How can we improve this process?" It does not ask "Why does it exist at all?

Six Sigma is not just statistics, in its best incarnation; one integrates experience, historical, prospective, and data to make decisions. Six Sigma projects can last from hours to months, the methodology is not designed to tackle every problem in a set amount of time, but it is designed so projects do not take any longer than necessary.

Lean needs Six Sigma because:	Six Sigma needs Lean because:
Lean does not explicitly prescribe the project set up and roles needed to achieve and sustain results	It identifies waste. Six Sigma sub-optimises processes (Lean applies a systems approach)
It provides a set of tools to understand problems and sources of variation	It improves process speed/cycle time
Lean does not recognise the impact of variation	It includes methods for rapid action (Kaizen)
Lean is not as strong in the measure and analyse stages of DMAIC	Six Sigma quality is approached faster if lean eliminates non value-added steps

Table 3
Why Lean and Six Sigma need each other
(George, 2003)

Nave (2002) has summarised the differences between the two approaches. See Table 4 – Six Sigma and Lean. Nave argues that it is the organisational culture that makes the difference about which method is appropriate and that many methods appear similar when their secondary effects are considered.

Methodology	Lean	Six Sigma
Theory	Reduce waste	Reduce variation
Application guidelines	Identify value Identify value stream Flow Pull Perfection	Define Measure Analyse Improve Control
Focus	Flow	Problem
Assumptions	Waste removal will improve performance. Many small improvements are better than systems analysis	A problem exists Figures and numbers are valued. System output improves if variation in all processes is reduced
Primary effect	Reduced flow time	Uniform process output
Secondary effects	Less variation Uniform output Less inventory New accounting system Flow metrics Improved quality	Less waste Fast throughput Less inventory Variation metrics Improved quality
Criticisms	Statistical or system analysis not valued	System interaction not considered Processes improved independently

Table 4
Six Sigma and Lean

The two methodologies follow different approaches. See Table 5.

Lean	Six Sigma
Specify Value What is important in the eyes of the customer?	Define What is important?
Identify the Value Stream What is the entire Value Stream?	Measure How are we doing?
Flow How will the material and information flow through our process?	Analyse What is wrong?
Pull How can we let the customer pull products, rather than pushing products?	Improve What needs to be done?
Perfect How can we optimise our processes?	Control How do we sustain the improvements?

Table 5
A contrast of the commonly taught approaches to Lean and Six Sigma

While the intent of the two approaches is similar the tools they use are different. See Table 6.

Area	Lean	Six Sigma
Process mapping	Value Stream Mapping	SIPOC Swim-lane diagrams Detailed process maps
Voice of the customer	Interviews	Interviews CTQ trees
Analysis	5 Whys Statistical Process Control (SPC) Takt time Overall Equipment Efficiency (OEE)	Statistical Process Control (SPC) Process capability Applied statistics Cause and Effect diagram Pareto Charts
Process improvement	Process redesign 5S TPM Visual controls	Process redesign

Table 6
A comparison of the commonly used tools of Lean and Six Sigma

Question: How are we integrating Lean and Six Sigma?

Answer: We have found that using around 20% of the tools achieves 80% of the benefits. We do this by focusing on the vital few things that will save time and maximise the impact gained. In healthcare settings, we have started to identify what value our customers are demanding and we have identified core value streams in healthcare. We have used Six Sigma tools to help us understand and reduce variation.

The Lean Six Sigma approach we are starting to develop is:
The Work Process Methodology, which includes the following, is protected by © NHS Institute for Innovation and Improvement:
1. Understand and Reframe
2. Develop Concepts
3. Test and Learn
4. Design the Delivery

Phase	Tools	Comments
Understand and Reframe	Interview Pareto charts Project Charter Voice of Customer Fishbone SPC 5 Why's Measures Value Stream Mapping	Here we go to *where the work happens* and interview staff and management about the present state of operations. Here we look at the "as-is" processes (observing and inquiring) and associated data to understand the nature and extent of the issue.
Develop Concepts	Brainstorming Affinity diagram Six Thinking Hats Pugh Matrix	Unlike traditional Six Sigma projects we look for any and all suggestions, not just suggestions that impact one dimension of the process. This is done in an effort to engage and empower staff while identifying quick win opportunities.
Test and Learn	Process redesign 5S Visual controls Trystorming Design of Experiments Failure Mode Effect Analysis Kaizan Kanban Visual Controls PokeYoke Rapid Prototyping	Perhaps this is the one step where the integration of Lean and Six Sigma into Lean Six Sigma is the most helpful. Lean Six Sigma offers us a comprehensive toolbox from which appropriate improvement plans can be developed.
Design the Delivery	Policies and Procedures Balanced Scorecards Standardisation Marketing Communication Plans Training Plans	By putting Balanced Scorecards in place it ensures that key metrics are scrutinised on a regular basis and by having metrics in place, it lays the foundation for sustaining the gains.

Table 7
Tools of Lean Six Sigma

NHS Experience

Lean techniques, such as value stream mapping, have been used in the NHS since the mid 1990s, largely through episodic Kaizen events or by combining Lean tools with other improvement approaches. Increasingly in the NHS, Lean is being utilised on a much more systematic basis, with a number of healthcare organisations stepping up to focus on organisation-wide value systems to achieve their strategic goals.

The starting point for the Lean Six Sigma initiative was a Six Sigma pilot programme which was set up on a countrywide basis. The programme was externally evaluated. This demonstrated that Six Sigma has both strengths and limitations as an improvement methodology for healthcare. We have had a lot of discussions about the positioning of Six Sigma, either as a comprehensive business strategy, or a toolkit. We have reflected on whether Six Sigma has validity as a stand alone approach to improvement.

One of the key issues has been whether the basic premise of Six Sigma works in healthcare. That is, to what extent we can take an existing clinical process, apply a variety of analytical, measurement and improvement techniques and improve its sigma score to a level where the process is virtually "defect free"?

We analysed the sigma scores in the projects that were undertaken as part of our Six Sigma programmes. We identified the baseline sigma scores for projects on a range of clinical processes across the whole country. The mean baseline sigma score of the projects was 2.0 and the median sigma score 1.9. This means that the clinical processes were defective more than 30% of the time. The lowest sigma score was 0.4 which meant that the process was defective 86% of the time. We concluded that this range of baseline sigma scores challenges the Six Sigma proposition that we can take an existing process and improve it to make it defect free.

Our hypothesis, based on these, and other Six Sigma projects in healthcare, is that many clinical processes are intrinsically ineffective. The latest large study in US healthcare (McGlynn (2003), *The quality of healthcare delivered to adults in the United States* NEJM; 348) concluded that the "defect rate" in the technical quality of American healthcare is approximately 45%. We conclude that it is unlikely that we can systematically improve clinical processes to get a higher sigma score. We need to redesign the basic process first.

This experience was a main driver in our decision to combine Six Sigma with Lean production methods. This combined approach is gaining credence in manufacturing and service sectors globally. If we can use Lean methods to identify our value streams at a macro level, we increase the potential to design better basic processes that are more likely to benefit from Six Sigma. It is too early to synthesize the data on the outcomes of the Six Sigma projects. However, the early results that we have seen so far indicate that the teams have had success in improving sigma scores by one or two, but nowhere near a "defect free" level of performance. Lean Six Sigma gives us the opportunity to get the basic processes right (through Lean) then take the variation out of the process (Six Sigma).

Question: What are the lessons learned so far?

Answer:

1. Lean and Six Sigma are complementary not competing
2. Start with goals and strategic intent – the quest for results should determine the improvement approach, not the other way round
3. Understand where Lean Six Sigma strategy is appropriate and where it is not
4. Test the approach
5. Focus on results
6. Engage staff and change agents
7. Senior Leadership must engage and actively participate
8. Resources are required to start improvement efforts
9. Use metrics to change behaviour for desired results
10. Educate, actively listen and encourage continuous improvement.

While Lean and Six Sigma were developed separately, they have similar goals and approaches. The approaches complement each other.

Lean Six Sigma is a strategic approach to change. It works best when it is used as a mechanism for achieving strategic improvement goals. Value streams and value systems transcend existing organisational and departmental boundaries.
The tools of Lean Six Sigma can be utilised for departmental specific improvement projects but the biggest gains can be made at an organisational or system-wide level.

Never brand an improvement initiative by its methodology. Ambitions to be a "Lean Six Sigma Hospital" won't be achieved. Methods and strategies need to be behind the scenes of the goal of better health and healthcare.

Focus on results. Success is contagious. Improvement methodologies lose their credibility if they take too long to produce results or if they are too difficult to implement. Lean Six Sigma allows us to get results quickly and to tackle difficult systemic issues as well.

Link Lean and Six Sigma approaches with other tools for change. Engage the staff and change agents. With 1.3 million employees the NHS has a lot of brain power, experience, and common sense. Engagement helps to achieve success.

No change process will work without active senior sponsorship, particularly by clinical leaders.

Some additional resources may be required in the short term to support the transition to this strategic and operational approach.

Measuring and understanding variation within a system has been a powerful way of influencing people's behaviour.

This is a continuous approach, we need to educate, listen and create an environment receptive to continuous improvement.

Conclusion

Lean Six Sigma combines two approaches which have synergy

Both approaches require a process focus, and both include customer drivers, either to define what needs to be improved (Six Sigma) or to define value (which then drive process improvement). Six Sigma focuses primarily on reducing variation, whilst Lean focuses on improving flow in the value stream and eliminating waste, although both may have similar secondary effects.

An effective combination of both approaches includes the value-maximising philosophy of Lean, underpinned by data-driven methods in decision making (from Six Sigma) focused on the customer (from Lean). All incentives and measures are reviewed (using Lean) to ensure global optimisation and minimisation of variation (from Six Sigma) would be a part of this.

The full benefits of Lean Six Sigma will only be realised when applied at both strategic and operational levels, with universal application only at the strategic level. Application at the operational level results only in cost reduction, whereas application at the strategic level results in wider benefits for the organisation.

The NHS has found Lean Six Sigma is a promising improvement methodology that incorporates the best of Lean and the best of Six Sigma. It is very rare that two approaches to enhancing value, eliminating waste and reduce variation can be used in a complementary rather than in a competing way. See Figure 3.

A pragmatic approach is required; use Lean and Six Sigma where necessary, or use Lean where Lean is necessary or Six Sigma where Six Sigma is necessary. Combining common sense (Lean) and common science (Six Sigma) offers the potential to achieve uncommon results.

We acknowledge the contribution of Ruth Boaden, and colleagues at Manchester Business School for researching and developing many of the concepts we have expressed in this paper.

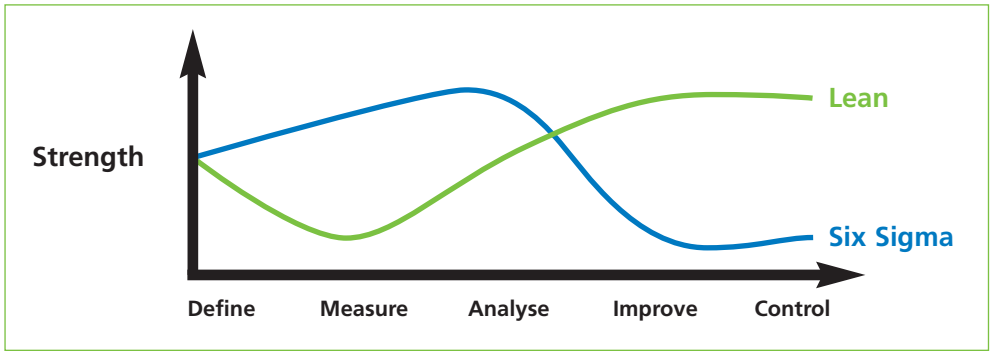

Figure 3
The relative strengths of the two approaches
GE Medical

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References

Department of Health (2005) Chief Executive's report to the NHS.
Nave, D (2002) "How to compare Six Sigma, Lean and Theory of Constraints", Quality Progress.
Miller (2005), Going Lean in Healthcare, IHI White Paper.
S Spear (2005), Fixing Healthcare from the Inside, today, Harvard Business Review
Dan Jones and Jim Womack, Seeing the Whole – Mapping the Extended Value Stream, (The Lean Enterprise Institute)
Mike Rother and John Shook, Value Stream Mapping to create value and eliminate muda, (The Lean Enterprise Institute, 2003).
Ruth Boaden (2005), Lean Six Sigma in the NHS, Manchester Business School.
Juran Institute (1993,2003), Quality Improvement Pocket Guide.
James P. Womack, Daniel T. Jones, and Daniel Roos (Macmillan, 1990). The Machine That Changed the World.
Mikel Harry Ph.D. and Richard Schroeder (Doubleday, New York, 2000).Six Sigma: The Breakthrough Management Strategy Revolutionizing the World's Top Corporations.
Mikel Harry Ph.D. (Sigma Publishing Company, Arizona, 1994).The Vision of Six Sigma: Tools and Methods for Breakthrough.
Peter S. Pande, Robert P. Neuman, and Roland R. Cavanagh (McGraw-Hill, 2000). The Six Sigma Way: How GE, Motorola, and Other Top Companies are Honing Their Performance.
McGlynn The quality of healthcare delivered to adults in the United States (NEJM 2003; 348)

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