

# A Summary of the Application Research of Six Sigma Management in the Field of Medical Health

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**Abstract:** The healthcare organization is the place where any defects and mistakes cannot be tolerated, even the smallest mistake can cost a human life and therefore defects or mistakes must be eliminated in healthcare service processes. With zero defects in processes as a goal, Six Sigma appears to be the best choice in the healthcare environment. Six Sigma often succeeds in combining quality improvement with cost reduction. It can significantly contribute to improving process performance. At the same time, these also reduce operating costs and inventories, which translate into significant savings for hospitals, thereby creating a win-win situation. This provides an effective and feasible method for the continuous improvement of service quality in healthcare organizations. This paper reviews the application of Six Sigma Management in the field of healthcare, mainly discusses its application effect in healthcare organizations, analyses the existing problems in the current application process, and puts forward the prospect of future research trend.

## 1. Introduction

Today's medical institutions are a complex dynamic system. They have made amazing progress in technology and treatment, but they are often troubled by inefficiency, resource constraints and medical safety [1]. Medical institutions are also increasing their operating costs due to the demand for advanced technology, new medical tools in diagnostic and interventional processes and the impact of population ageing [2]. In addition, in the process of medical services, besides being patients of customers, their family and friends also need to be considered, because the results of services affect the lives of all those concerned. A mistake or mistake in this field may be devastating to individuals and groups. As a result of these potential risks, medical institutions must focus on improving the quality of medical services and continuous improvement of their processes [3]. Improving patient satisfaction is essential for the long-term good operation of medical institutions.

With the successful implementation of Six Sigma Management in many manufacturing enterprises, the medical and health departments are increasingly interested in the methods adopted in this industrial sector to improve quality and organizational efficiency [4]. Six Sigma provides a scientific and effective management method for medical institutions that reduces ineffective repetitive services and reduces patient waiting time so that they can diagnose and treat patients, thereby continuously improving the quality of medical services, and by reducing unnecessary Medical expenses and inventory to reduce the cost of various expenses and help medical institutions achieve efficient and long-term development.

## 2. The theoretical basis of Six Sigma management

### 2.1 The meaning of Six Sigma management

In 1987, Motorola's  $6\sigma$  level was proposed to control product quality within  $6\sigma$ , which is the source of Six Sigma management [5]. Motorola's success has led other companies to try Six Sigma management, which is really popular and developed, thanks to General Electric Company (GE), when GE CEO Jack Welch used Six Sigma as one of GE's three strategies. In the four years of

implementation, the company's savings reached more than 2 billion US dollars. Six Sigma management is directly linked to financial benefits and is one of the main reasons why  $6\sigma$  continues to be considered an important quality improvement tool [6].

Six Sigma Management is a statistical assessment method that pursues zero-defect production, guards against product liability risks, reduces costs, increases productivity and market share, and improves customer satisfaction and loyalty. Six Sigma management focuses on products, service quality, and process improvement. Sigma ( $\sigma$ ) is used statistically to indicate the degree of dispersion of data, to describe the deviation of the final result from the standard value, and in the field of quality management, to indicate the level of quality management. The general quality requirements of traditional companies have been raised to  $3\sigma$ , that is, the product qualification rate is 99.73%, and only 0.27% is a defective product. However, as people's requirements for product quality continue to increase, companies increasingly need high-quality management standards like  $6\sigma$  to maintain their dominant position in the fierce market competition. In fact, Japan has used  $6\sigma$  as an indicator of their quality requirements. From  $3\sigma$  to  $6\sigma$  is a process of continuous improvement. First, standards should be formulated. The deviation between assessment operations and standards should be tracked at any time in management, and continuous improvement. Now, a simple process model for continuous improvement of each link has been formed: definition and measurement, analysis, improvement, control. When the final result is  $6\sigma$ , the product pass rate is as high as 99.99966%, which is only 3.4 chances of error per million chances.

## **2.2 Six Sigma management method**

Six Sigma is a set of scientific tools and management methods, using the process of DMAIC (improvement) or DFSS (design) to design and improve the process. DMAIC is a process improvement method consisting of five stages: definition, measurement, analysis, improvement and control. It is generally used to improve existing processes, including manufacturing process, service process and working process [7].

DFSS refers to the Six Sigma design. It is a generalized concept evolved on the basis of the early Six Sigma improvement method. It is suitable for dealing with the inherent limitations of the six sigma model of DMAIC. It contains a package of methods which are widely used in the design of new products or new service processes. DFSS also has its own process, but it has not yet formed a completely unified model, commonly used are: DMADV: Define, Measure, Analysis, Design, Verify and IDDOV: Identify, Define, Develop, Optimize, Verify [8].

## **3. Application of Six Sigma management in the field of medical health**

### **3.1 Application of Six Sigma management and its main achievements**

Like other service operations, healthcare organizations need systematic innovation to remain competitive, cost-effective, and advancing with the times. A case is presented to illustrate how to effectively apply Six Sigma management methods to the health care sector to control the growth of medical costs and improve the quality of care [9]. Six Sigma management The five most commonly used departments in medical institutions are: (A) surgery; (B) administration and operations; (C) imaging and radiology; (D) pharmacy; (E) emergency and trauma. Although cases can be distributed within the same hospital department, there are differences in outcomes and improvements as each department has its own goals.

A major improvement in surgery is shortening the length of hospital stay, which is an important quality of service indicator, especially for hospitals. In a case study aimed at improving air leaks in patients with lung intervention, Bertolaccini et al. found that after six sigma, the number of hospital stays decreased from 7.1 days to 6.5 days [10]. Another application focused on reducing the cost of joint replacement surgery, resulting in a 36% reduction in hospital stay [11]. Niemeijer et al. described a process improvement in hip fracture surgery, with a 31% reduction in hospital stay from 13.5 days to 9.3 days [12]. According to Cima, patient waiting time is also an important improvement in surgical applications [13]. In addition, despite an increase of 26% of employees,

surgical improvements have reduced personnel costs by 14% [14]. Preoperative outpatient visits were reduced by 39% and device use was reduced by 32% [15].

In terms of administration and operations, patient waiting time is shortened, which is the biggest improvement. Fischman reduced patient waiting time from 14 minutes to 5 minutes (64%) by applying the LSS method to the medical residency clinic. Shreeranga, Gijo, and Jnanesh described similar improvements with an average patient waiting time reduction of 94% [16]. Gijo and Antony reduced patient waiting time from 56.95 minutes to 24.5 minutes, a reduction of 57% [17]. Some specific applications have also been identified in this department, as described by Taner and Sezen, where the Six Sigma method can reduce the rate of 11% of doctors in addition to improving procedures and increasing patient satisfaction [18]. The case described by Breslin, Hamilton and Paynter aims to improve the readmission rate of the health insurance population. After 30 days of pilot projects, the readmission rate dropped from 16.2% to 6.5%, which was significantly improved [19].

The most common improvement in imaging and radiology is the increase in the number of patients admitted and the reduction in repeated examinations. The increase and decrease rates are 9.5% and 84.12%, respectively. Aakre and Valley improved patient flow in clinical radiology and determined that the daily patient capacity increased from 65 to 71 by 9% without the need for any additional personnel and equipment [20]. Bahensky, Roe and Bolton described a 31% increase in patient throughput through an improvement program. In addition, improvements related to reducing patient waiting time and shortening of walking distance of hospital staff were also found [21]. In the pharmacy department, the application of Six Sigma management methods is improving and reducing prescription errors, reducing inventory and shortening patient waiting time [22].

### **3.2 Six Sigma management implementation method**

In terms of implementation methods, DMAIC is selected in most cases, there is no example of applying PDCA alone, and there is no example of simply applying PDSA. Since DMAIC is the Six Sigma language for PDCA in all improvement programs related to the Six Sigma project, these findings are expected. The successful implementation of Six Sigma in the health care field is largely due to the structured approach provided by DMAIC, which defines a logical sequence that links statistics to other tools found to be effective in the improvement process.

Gayed et al. implemented their own framework approach using the Vision-Analysis-Team Objective-Map-Measure-Maintenance (VA-TAMMCS) model. The VA-TAMMCS process improvement approach focuses on systems rather than on individual inefficiencies, improved purchases, and sustainability. They point out that VA-TAMMCS is an effective tool for improving Lean and Six Sigma processes in surgical practice, and their previous findings have fully demonstrated this conclusion.

Cima describes three phases: the first phase holds a meeting that focuses on reviewing existing literature on the subject and process mapping. The second phase focuses on improving current process steps to reduce the differences between surgeons. The final phase is to build infrastructure to support process reform and staff education.

### **3.3 Quality tools in the Six Sigma project**

Process mapping is the most commonly used tool, followed by statistical analysis tools and Ishikawa (fishbone) maps. The SIPOC chart also plays an important role in the applied research of Six Sigma management. It is usually applied to the DMAIC "definition" phase. According to Shreeranga, Gijo, and Jnanesh, it is important to understand/defining the process being evaluated before starting any process management or improvement activities. The SIPOC diagram summarizes the input and output of the process in tabular form. The SIPOC process definition was developed to help process owners and process personnel agree on the scope of the project before rushing to draw the flowchart.

Chiarini believes that Failure Mode and Effects Analysis (FMEA) is the basis for nurses and physicians to calculate and analyze safety and health risks in cancer drug management programs [23]. Taner, Sezen, and Atwat (2012) use FMEA to analyze potential failure patterns, impacts,

possibilities, and causes to allow team members to view key drivers in the process. Based on research by Breslin, Hamilton and Payenter, the team used FMEA to score the severity, probability, and detectability of the redesigned emissions process. However, further research is still needed to verify whether it is the best tool for managing such risks with LSS.

The limited data available in these cases highlights the importance of using basic quality tools. Bertolaccini et al. and Niemeijer et al reported that their project was not statistically significant due to the small number of samples [24]. Gijo and Antony report that because team members are unfamiliar with these activities, data collection, analysis, and interpretation of results are more complex. Shreeranga, Gijo, and Jnanesh emphasize that statistical tools and techniques can be successfully applied to the service industry for root cause analysis, well-prepared data collection programs, and properly trained people to use these tools and technologies. Gijo and Antony identified extensive data collection and use of software packages as agents of process improvement. Lifvergreen et al. pointed out that these difficulties make the basic improvement tools such as Ishikawa, Affinity, Histogram, Time Series, Scatter, Pareto and Control Charts more important [25].

In the case studied, almost all improvements use process mapping to better understand the process flow and get an overview of what is going to be improved. In addition, value stream mapping (VSM) is used, especially for case studies based on lean methods. As pointed out by Warner et al., VSM helps to describe the care process and determine the specific goals of quality improvement. Applying VSM to the auditory mechanics scheduling process helps identify and eliminate waste steps [26]. Niemeijer pointed out that the VSM provides valuable information about workflow (process time) and waste (including waiting time and other inefficiencies) from a patient perspective.

#### **4. Current application challenges and future research prospects**

Similar to businesses, medical institutions also have their own workflow. Due to the complexity of the medical environment, the application of Six Sigma management in the medical and health field may face unique challenges compared with other industries.

##### **4.1 Research involves fewer fields**

In order to investigate the research institutions and related scholars on which areas of research on the application of Six Sigma management methods in medical health are concentrated, and whether there is little or no research in the field, the relevant literature is analyzed, and the results of Table 3 are obtained. It can be seen that Six Sigma Management The most widely explored area of medical health is the emergency department, which published 16 (13.6%), followed by hospital wards and outpatient departments, each publishing 15 (12.7%) [27]. Most of these studies aim to reduce patient waiting time in the emergency room, improve the efficiency of bed turnover and reduce waste in patient mobility [28]. There are few publications in some areas, such as the Intensive Care Unit (ICU), the Materials Purchasing Center, and the Disinfection Center (CMS) [29]. In ICU cases, the purpose of the study is mostly to improve patient safety, while in CMS cases, the goal is to reduce hospital infection indicators in clean surgery. In addition, there are still some areas that are not even mentioned, such as billing and nutrition.

##### **4.2 Stakeholders are more complex**

Although the fundamentals of process improvement are the same regardless of the environmental settings of different industries, medical projects differ from other industries in terms of participant relationships, as shown in Figure 2 [30]. In medical services, there is no clear supplier or customer. For example, employees in medical institutions are suppliers, and in some processes they can be customers. In addition, many processes involve many different stakeholders.

In medical services, many overlapping but contradictory relationships need to be considered. For example, if we only focus on the recovery of patients, it will have a negative effect on the income from insurance institutions. So we need to care more about patients, but measures to improve

patients' experience and satisfaction may increase doctors' efforts. In process improvement, stakeholder analysis tools should not be overemphasized.

### **4.3 Doctors are more difficult to participate in projects**

It is reasonable for doctors to control or influence many processes in the medical system, which is also the key reason for doctors to participate in improving decision-making from the very beginning. To integrate doctors into the project, learn the theory of Six Sigma Management and how to apply it to medical institutions, and work with other doctors to focus on the whole process and the impact of part on the whole [31]. Emphasis should also be placed on the potential for improved quality of work and its impact on individuals and organizations.

It is very difficult for all doctors to participate in the project, but step by step, try to find doctors who are willing to serve as consultants for the pilot project, and demonstrate with the results of the pilot project that they can save more time on patient care and other related benefits. Pilot projects should be representative in solving some problems, such as reducing management matters or simplifying these processes, making life and work easier. Once doctors realize the effectiveness and benefits of quality improvement programs, they become loyal supporters.

### **4.4 Other related challenges**

Initial investment in Six Sigma system training is also a major challenge in the implementation process. In addition, the lack of or difficulty in obtaining basic data on process performance is also a challenge in the application of Six Sigma in the medical field. Although there are a lot of relevant data in the medical field, most of the time these data are not easy to use for analysis. Finally, another challenge in deploying Six Sigma in the medical industry is the psychological awareness and acceptance of employees [32].

According to Taner et al.'s research, the implementation of Six Sigma management method is obviously beneficial to WHO, because it can bring better operational efficiency, cost-effectiveness and higher process quality [33]. In addition, they also mentioned that the application of Six Sigma has a positive impact in clinical areas such as infection control and drug delivery. However, due to the following reasons, the application of Six Sigma may also fail in medical services: A. lack of financial support; B. scarcity of human resources; C. lack of time; D. lack of leadership; E. lack of training; F. lack of project selection; g. internal resistance. So we can see that there is a long way to go to apply Six Sigma management method in the field of health care.

### **4.5 Future research prospects**

It is very important to study the impact of the sustainability of Six Sigma management on the medical environment [34]. Ninety-six (81.4%) published empirical articles on Six Sigma Management in the medical field did not even mention any indicators of improved sustainability that had been achieved. Eighteen articles (15.3%) described some sustainability indicators and attempted to show the organization within 1 to 12 months of project implementation improvement. Four other articles (3.4%) described improvement sustainability in 12 to 24 months. A few articles describing sustainability did not describe improvements 24 months after implementation. This also provides a very good direction for future research [35].

Through literature analysis, we can see that some researchers try to find out the key factors that affect the success of Six Sigma management in hospitals [36]. Communication, management support, commitment and organizational culture are identified as key factors in working in these environments. Future research may attempt to analyze the extent to which these positive impacts on employees affect sustainability. In addition, there is no article describing how to create a culture of sustainable development. Similarly, most of the articles describing sustainability remain in the tool area. These are the new space for future empirical research.

## 5. Conclusion

Due to the advancement of modern social technology and the aggravation of population aging, it is more important for medical institutions to provide high-quality medical services for patients to meet their expectations. When the quality of service is improved, patient satisfaction will also be improved, so that medical institutions can achieve the highest level of patient retention and loyalty. To achieve these goals, medical institutions need to continuously improve service processes and quality through Six Sigma management.

With regard to Six Sigma Management, the medical and health industry is still at an early stage of development. Therefore, medical staff should actively receive training and implement it with the support of the top management. Successful implementation of simple projects will enable relevant personnel to deal with more difficult projects in the future and achieve clinical changes on a larger scale. The implementation of Six Sigma management is very beneficial to the development of medical institutions, because it can bring better operational efficiency, better cost-effectiveness and higher process quality, and its application in clinical fields such as infection control and drug delivery has a positive impact.

However, at this stage, financial, human and time factors are also hindering the implementation of Six Sigma Management in medical institutions. In addition, in view of the application of Six Sigma Management in the field of health care, the following research directions are worth considering in the future: combining it with lean thinking to form lean Six Sigma Management; considering the sustainability of Six Sigma Project in terms of improvement, such as the effect after 24 months of implementation; exploring the overall development of medical institutions based on Six Sigma Management, rather than Focus only on specific departments or areas. It is believed that due to the great superiority of Six Sigma management method, its application in the medical industry will be more and more extensive.

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