

Quality Improvement in Healthcare: Six Sigma Systematic Review

ABSTRACT

Six Sigma has been widely used in the healthcare sector as a management tool to improve patient quality and safety. The objective of this study is to identify opportunities for its implementation through literature analysis. A literature review has been carried out since the first publication of Six Sigma in the sector appeared until 2017, 20 years in all. To this end, it has been used three databases: MEDLINE, Web of Science (Core Collection) and Scopus. Accordance with the 196 articles of our database, it is found that: (1) Six Sigma publications in healthcare sector have been carried out mostly in the USA, (2) multiple specialities and services have used this tool, among them, we can emphasize the operating room and radiology service, (3) the case study has been the most used methodology and, (4) the objectives are focused mainly on achieving reductions of time, costs and errors, for the improvement of the quality and the satisfaction of the patients. This review seeks to serve healthcare professionals to know the benefits that Six Sigma can generate in processes that take place in a health center, hospital or other organizations in the sector.

Keywords: Six Sigma; quality improvement; literature review; bibliometric; healthcare

1. Introduction

Six Sigma is a management system that seeks to improve the efficiency of processes, reducing defects [1] to achieve improved quality and customer satisfaction. Since Motorola implemented it in the mid-1980s, it has become a powerful management tool whose objective is to achieve a quality level of 99.99996% [2]. For this purpose, it uses a stepwise process called DMAIC, whose acronym means Define, Measure, Analyze, Improve and Control. These stages allow improving the quality of any process at the project level or throughout the organization.

Six Sigma gradually was extended successfully to other industrial sectors and later on to the service sector [3]. It is noteworthy the strong impact on the healthcare sector, considering the large number of case studies published, which are focused on hospitals and improving medical procedures [4,5]. In healthcare, it is crucial the use of quality management systems for ensuring efficiency because the commission of errors may seriously harm patients. This is what the Six Sigma philosophy pursues by taking advantage of the application of the most innovative digital technologies for reducing the inefficient use of resources and not-optimized service processes [6].

The main purpose of this article is to break down the Six Sigma literature, applied to the healthcare sector through a bibliometric analysis. With this, we want to let academics and practitioners in

the sector know who, where, how and what has been done regarding Six Sigma in the sector and secondly, what can be done in the future, i.e. identify opportunities for continue applying this method in healthcare.

2. Method

A systematic review is characterized by being objective since it summarizes the previous research through searches carried out in steps and in a replicable way [7]. This review has been carried out according to the proposed design of Tranfield et al. [8], based on three stages. The first corresponds to the planning of the review, the second to the realization and finally, the third stage is the presentation of the results.

Planning is detailed in this section and entails different sub-stages among which are the choice of databases and keywords (2.1) and, the inclusion or exclusion criteria of the identified articles (2.2). To visualize the process used to obtain the final sample of research, the flow chart of the PRISMA guide (Preferred Reporting Items for Systematic Reviews and Meta-Analyzes) [9] has been applied (Figure 1).

2.1 Data Source

Using different databases guarantees greater coverage of the searched literature [10]. For this reason, it is quite common to use multiple databases in the bibliometric analysis [4,11,12]. Therefore, three databases have been chosen: Web of Science (WOS) core collection and Scopus for their relevance at the management level, as well as MEDLINE, for its relevance at the medical level.

Three levels of descriptors or keywords were used to find the relevant articles: first, the word Six Sigma written in any of its forms, such as "six sigma" or "six-sigma"; second, terms related to quality processes such as: "quality systems", "quality improvement", or "quality management"; and finally, to narrow the activity sector, we add the keyword "health*". In the case of WOS and MEDLINE, these terms had to appear looking for "Topic", while in Scopus, they should be in the "Title, Abstract or Keywords" sections.

2.2 Study Selection

The first article on Six Sigma in healthcare appears in 1998 in the Milbank Quarterly, therefore our analysis focuses on the period 1998 – 2017, considering only research articles (including conference proceedings, letters, notes and reviews) but not editorials, summaries or other types of publications [13]. To be included they must have at least the title and summary in English.

2.3 Data Processing

Before carrying out the review, we conducted a homogenization of the data to increase the consistency of the results. We ensure that the names of the authors were always written in the same way as well as the journals, affiliations or any other data analyzed. Finally, we verified that the citations received for each article were not duplicated when considering the three databases. Two of the authors worked independently in this revision process to reduce the risk of error. Only articles commonly agreed between them were included in the review.

3. Results

Figure 1 shows the results of the review process carried out. We finally reviewed 196 publications, including articles, conference proceedings, letters, notes and reviews.

INSERT FIGURE 1 ABOUT HERE

This results section is divided into five subsections corresponding to the questions aforementioned in the introduction.

3.1 Who has researched about Six Sigma in healthcare?

The literature on Six Sigma in the healthcare field begins in 1998 with the document entitled "Is Health Care Ready for Six Sigma Quality?" [14]. Since then numerous authors, especially North Americans, have written on the topic. 128 out of 196 articles of our database come from the United States of America, which represents 65% of the total number of publications. Among the health centers that have paid more attention to implement quality control strategies, it should be mentioned the Mayo Clinic (Rochester, Minnesota) and Mount Sinai Hospital (New York, NY), with 11 and 5 studies, respectively. Among the different universities, Texas University is the one with more published records on Six Sigma applied to healthcare, with a total of 9.

Figure 2 shows the increasing importance of publications on Six Sigma in healthcare disaggregated according to their authorship (academic, professional or joint). As can be seen, firstly, papers were written by professionals, as Six Sigma is a philosophy coming from practitioners. Later, academics became interested in its study and the literature in regards to the implementation of Six Sigma in the healthcare sector began to grow faster.

It is worth emphasizing the involvement of medical professionals in academic and research activities, as well as joint authorship, that is to say, collaborations between professional and academics are more frequent in medicine than in others areas.

INSERT FIGURE 2 ABOUT HERE

3.2 Where has this research been published?

From an academic point of view, analyzing the journals where these articles have been published, we found 127 sources, among proceedings and journals, which represent a great dispersion. 80% of the journals have only published one article about Six Sigma on healthcare. This fact is due to the transversal nature of this approach that can be applied to different areas and, therefore, both specialized and non-specialized journals in quality issues, have been interested in papers that apply the methodology to healthcare. In our database, among journals with more than 5 documents published in relation to the topic of study are the *International Journal of Health Care Quality Assurance* (13), *Quality Management in Health Care* (11), *Joint Commission Journal on Quality and Patient Safety* (8), *Journal of Healthcare Management* (6) and *Radiology Management* (6). The most important journals according to the number of publications and citations are shown in Table 1. As expected, most of the journals address aspects of quality management in the healthcare sector, with the exception of the *International Journal of Six Sigma and Competitive Advantage*, which is specialized in articles from different sectors that apply Six Sigma as a quality approach.

INSERT TABLE 1 ABOUT HERE

3.3 Where has its implementation been carried out?

From a professional perspective, Six Sigma has been implemented to improve patient care and safety in different services or specialties. 42% of the articles used Six Sigma as a conceptual methodology and/or do not specify in which part or processes of the organization this tool has been applied. On the other hand, the case studies that indicate where Six Sigma has been implemented, stand out especially those carried out in the operating room and in the radiology service (Figure 3).

Within the category of others, we have included specialties with less than five cases of study on quality improvements applying the Six Sigma method, for example, in oncology, pediatrics or ophthalmology.

Some examples of improvements carried out are the optimization of waiting times (in both, appointments or reports of results [15,16]), improvement in the administration of medications [17,18], reductions of errors or complications in the operating rooms [19,20], among others.

INSERT FIGURE 2 ABOUT HERE

3.4 How has this research been made?

Six Sigma applied to the healthcare sector has been carried out basically through case studies (Table 2). 65.3% of the papers considered in the review used this methodology. Surveys, i.e. papers that gather statistical data for conducting some analysis, are the most important quantitative research option but only represent the 9.2% of the Six Sigma research.

On the other hand, theoretical papers represent a small proportion of the research. It is the case of conceptual papers developing concepts, new processes or applications theoretically, i.e. without testing them, literature reviews analyzing previous literature, and overview papers giving a global vision of some aspect of the Six Sigma research through authors observation and experience. And, finally, it has to be said that it is irrelevant the research that used secondary data as Six Sigma needs data that are difficult to find in external databases.

Considering other quality management methods, it should be noticed the influence of Lean [21] in the Six Sigma research. Its combination has been recurrent and it is found that 26.5% of the articles analyzed used both approaches.

Analyzing the tools used during the DMAIC phases [22], there are many techniques that appeared in the literature, but the most relevant in the sector according to our data have been: (1) process maps and flow charts, (2) diagrams cause-effect and Pareto, (3) the technique of failure mode and analysis of effects (FMEA) and (4) the analysis of statistical data.

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3.5 What has been achieved with the application of Six Sigma?

The analyzed articles, especially the case studies, have addressed different problems related to quality in healthcare. Overall, the main purpose has been to improve the medical and management processes to offer patients an improvement in care. Its applied nature to specific problems justifies the proliferation of such case studies in the literature on Six Sigma in the healthcare sector.

Table 3 shows the most relevant results of the analyzed papers that include some Six Sigma applications that have allowed to improve some medical processes or services. Particularly, three

major categories or objectives to be achieved have been identified through the improvement of processes in the sector, depending on their approach, which may be aimed at reducing time, costs or errors.

Firstly, 21% of articles refer to time reduction in processes or services. This optimization in waiting time has a great impact on patient satisfaction. Secondly, 17% of the actions pursue a cost reduction through reducing failures that make services more expensive. Thirdly, 32% of articles are related to errors reduction and the detection of problems that can damage the service quality perceived by the patient. Finally, 30% of the articles in the database did not identify the specific objectives achieved with the implementation of the method since they are more theoretical or follow a general approach.

INSERT TABLE 3 ABOUT HERE

4. Conclusions

Six Sigma has been widely used in the healthcare sector as a quality management system [203]. In fact, with the areas of engineering and business, healthcare constitutes one of the three main research domains where the method has been applied [214]. This has been proved through the number of publications on Six Sigma in the sector which shows a continuous growth over the years, especially using case studies as methodological approach. This large number of articles detailing implementation processes shows an interest in the transmission of knowledge to achieve higher quality levels addressing specific cases or situations.

We found that Six Sigma implementations have occurred especially in countries like the United States, where it does not exist a universal health system, therefore, the sector addresses other objectives, like maximizing economic benefits, which is not a priority in public healthcare systems applied in other countries. In addition, the US health market is characterized by being highly fragmented and the costs associated with treatment, medical care, medications, etc. are higher than in other countries according to recent studies [215]. Therefore, it is where this method has been most developed seeking an increase in its efficiency and quality.

Among the published articles, several literature reviews have been carried out, although not systematic ones, to address aspects such as the identification and evaluation of the effectiveness of Six Sigma in the sector, as well as its main objectives and future challenges [11,207]. These revisions have used multiple databases but their time horizon ends in 2013, as in the case of that carried out by Dellifraigne et al., or that of Liberatore in 2010. The consideration of more recent works until 2017, represents an update of the previous results. In addition to these general reviews, there are three whose analyses are focused on two of the services that in this study have been identified as those that have applied more frequently this quality management system: radiology

[203] and surgery [204,205]. According to these reviews, in surgery, the risk reductions derived from complications in the operating room (infections, delays, etc.) appear as the main motivation for the application of the method. On the contrary, in radiology, the main objectives of the implementation consist of reducing costs and waiting times, since very long waiting times for testing and obtaining results limit the ability to offer a service of quality [69]. The results of this work coincide with the motivations found by other authors for the use of Six Sigma: time reduction [15,20,69], costs [89,102,189] and errors [19,211]. In addition, through the analysis of the 196 articles found, we provided a summary of the actions carried out to achieve these efficiency objectives, which could serve as a starting point for future research and/or implementations.

With the review of Six Sigma studies on healthcare during the last 20 years, we intend to convey the potential of implementing Six Sigma in the healthcare sector, like a quality management system widely used in the United States but barely applied outside.

Despite the contributions of this study, there are also some limitations that should be mentioned. The review only covers documents written in English. This may lead to an underestimation of research which uses other languages. On the other hand, we ran the search algorithm only in the topic or in the Title-abstract-keywords sections, which could represent a limitation in the obtained results. As has been mentioned several times throughout the review, we focused on Six Sigma in healthcare. Therefore, we did not want to lose the topic attention by adding works no directly related to the field by conducting a wide search, e.g. in all text. Nevertheless, some other methodologies as Lean have been widely applied in healthcare also [216]. Its study could represent an interesting research line for the future. To address these opportunities in future research will contribute to advance in the management of quality in the health sector.

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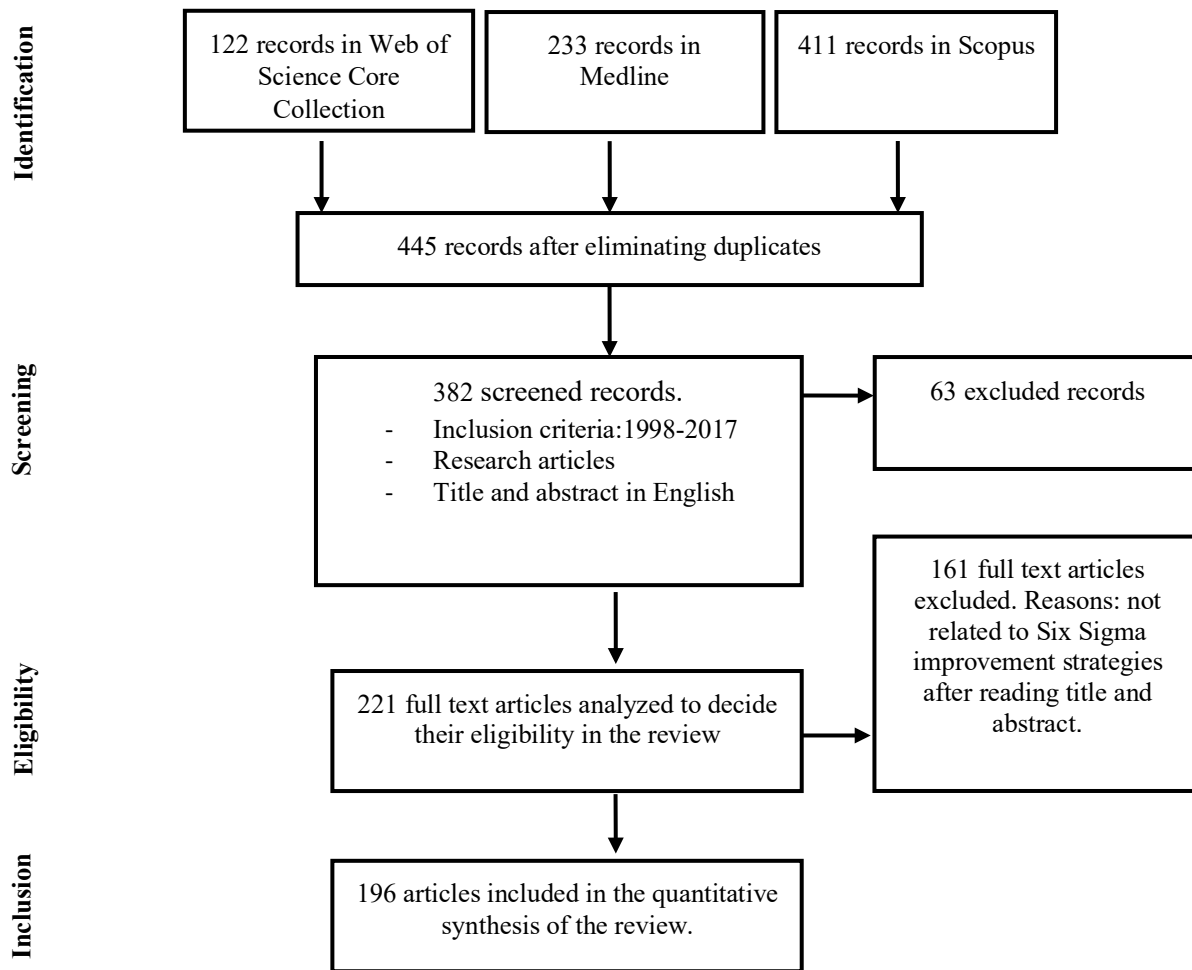
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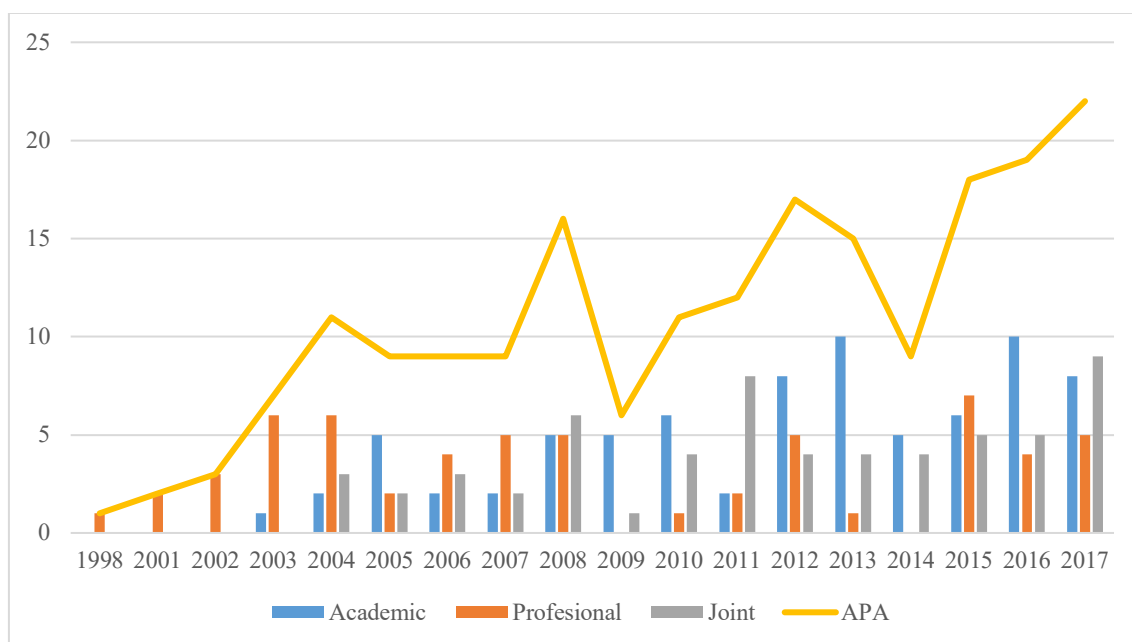
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Figure 1. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)



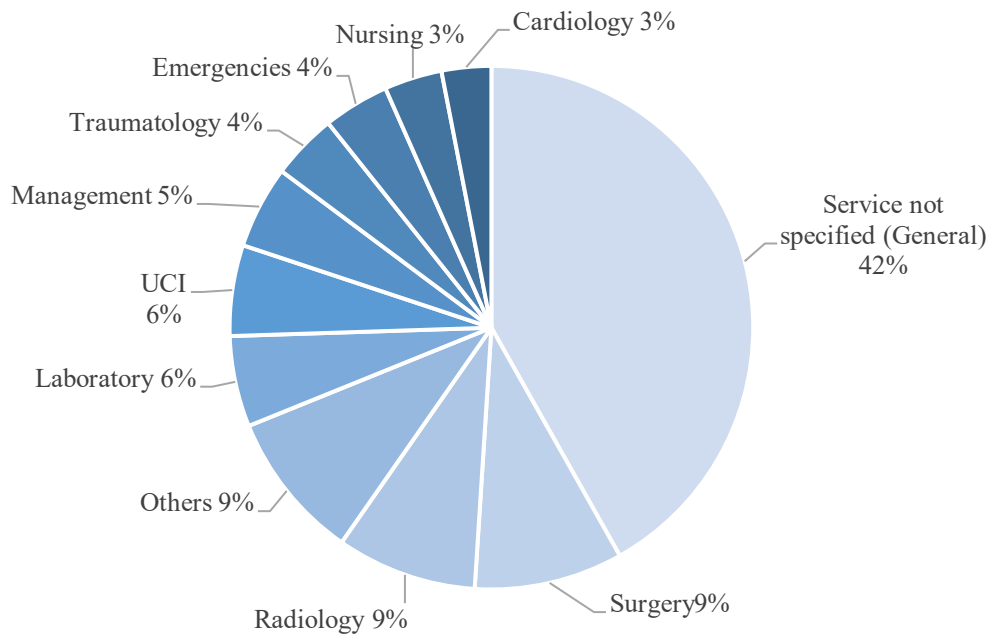
Source: Adapted from Moher et al. (2010)

Figure 2. Evolution of articles published per year (APA) according to authorship.



Source: Own elaboration

Figure 3. Specialties where Six Sigma has been applied.



Source: Own elaboration

Table 1. Most relevant journals on Six Sigma in healthcare

	Number of Publications	Number of Citation
International Journal of Health Care Quality Assurance	13	185
Quality Management in Health Care	11	242
Joint Commission Journal on Quality and Patient Safety	8	133
Journal of Healthcare Management	6	204
Radiology Management	6	51
International Journal of Six Sigma and Competitive Advantage	5	55
Journal for Healthcare Quality	5	192

Note Most important journals according to the number of publications and citations (including citations registered in WOS, MEDLINE and Scopus).

Source: Own elaboration

Table 2. The methodological approach for the study of Six Sigma in health

	Publications	Percentage	References
Case study	128	65.3%	[15,17,19,20,23–146]
Survey	18	9.2%	[147–164]
Conceptual	17	8.7%	[14,165–180]
Overview	16	8.2%	[181–196]
Case Study with interviews	6	3.1%	[197–202]
Literature review	6	3.1%	[11,203–207]
Literature review with a case study with interviews	2	1%	[208,209]
Conceptual with case study	1	0.5%	[210]
Secondary data	1	0.5%	[211]
Case Study with Interviews and survey	1	0.5%	[212]

Source: Own elaboration

Table 3. Where has Six Sigma been applied and for what purpose? Actions and improvements
Some actions carried out to achieve the main efficiency objectives.

Objective	Service/Process	Actions/Improvements
Time reduction	Hospitalization	Improve evaluation processes. [108] Decrease patients' length of hospital stay. [104,138,139,176] Minimize infections derived from long stays. [98]
	Waiting list	Improve collaboration between different doctors and specialists. [140,142]
	Medical consultation	Improve patient flow (Reorganization). [103]
	Medical tests	Reduce length of notification process and delivery of results. [62,160]
	Surgery	Avoid underutilization of spaces. [114] Reduce steps' duration. [113,146]
	Emergency	Differentiate urgent from non-urgent queries. [159] Improve coordination between different hospital areas or different centers during transfers.[27]
	Cost reduction	Laboratory
Surgery		Improve the programming of interventions to reduce extra hours of the staff. [114] Reorganize operating rooms processes. [38] Improve procedures to avoid incidences or infections. [115]
Unnecessary process or test		Improve the programming of interventions to reduce extra hours of the staff. [72] Decrease orders of excessive daily laboratory tests and X-rays. [116]
Management		Improve the use of resources. [32,70,122] Reduce falls rates. [119]
Error reduction	Laboratory	Improve protocols that avoid erroneous values. [213] Improve workflow, sample handling. [56] Improve the billing process (avoid unbilled tests). [123]
	Surgery	Reduce complications arising from the administration of anesthesia or other aspects of interventions. [33,57,136]
	Medication administration	Improve medical prescriptions. [121] Guarantee the correct administration of medications. [18,47,79,164]
	Measure	Use digital measurement systems. [58,127]
	Hygiene	Improve protocols to avoid infections. [68]
	Information system	Improve information system in favor of the effectiveness of the processes. [78]

Note Objective: motivation for applying Six Sigma. Service/Process: where Six Sigma has been applied. Actions/improvements: improvements made or actions carried out for the achievement of the main objectives

Source: Own elaboration