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Article

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Enhancing Quality across Industries: A Systematic Literature Review on the Impact of Six Sigma

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ABSTRACT

Purpose: The objective of this study is to conduct a systematic literature review on the impact of Six Sigma in various industries.

Design/methodology/approach: A total of 83 articles from respected international journals published between 2015 and 2020 were selected and analyzed. The inclusion criteria ensured that the articles focused on quality improvement using the Six Sigma approach and were published by reputable publishers.

Findings: The findings of the study reveal that manufacturing emerged as the most prevalent sector, with 17 studies dedicated to it. Among the selected articles, case studies were the most employed research method, accounting for 59 studies. Moreover, the study highlights the primary benefits associated with implementing Six Sigma. The most notable benefit is the reduction of defect rates, followed by improvements in efficiency and cost reduction. The primary benefit of Six Sigma is the reduction of defects (52 cases or 42.75%), followed by improvement in efficiency (49 cases or 37.40%), and then cost reduction (26 cases or 19.85%).

Research limitations/implications: Based on the results, the study recommends that organizations adopt Six Sigma to enhance the quality of their processes, increase efficiency, and minimize costs.

Originality/value: This recommendation is particularly relevant for the manufacturing sector, which showcased the highest concentration of research studies in the literature.

Keywords: Six Sigma, Lean Six Sigma, Operations Management, Lean Manufacturing, Systematic Literature Review (SLR), Total Quality Management (TQM), Quality Improvement

I. Introduction

Today's globalization and rapid technological advancements have led companies to low-cost competition and increased consumer awareness of

quality (Alkunsol et al., 2019). The demand for higher-quality products at lower prices has increased, and market competitiveness and consumer pressure have forced many companies to rely on global sources (Moin et al., 2018). Quality has been a universal concern for a long time, and to improve the quality of products, it is necessary to identify defects in a structured manner and eliminate them (Sreedharan, Gopikumar, et al., 2018). Several principles, methods, and tools were established to improve quality,

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including statistical quality control (SQC), zero defects, total quality management (TQM), quality circle, cellular manufacturing, and Six Sigma (Adebanjo et al., 2016; Alkunsol et al., 2019; Sharma et al., 2018; Yook & Kim, 2017). Both manufacturing and service industries have undergone significant changes in the last four decades, and getting a sustainable competitive edge in the present global market is becoming a daunting task for all organizations (Ding et al., 2018; Guvenli & Sanyal, 2002; Kim & Lee, 2020; Modgil & Sharma, 2016).

Six Sigma is an approach created by Motorola in 1986, which focuses on process- and quality-related improvements by identifying the causes of errors and reducing variability (Hadidi et al., 2017), (Sreedharan, Rajasekar, et al., 2018). The Six Sigma methodology is applied to companies of various sizes, from small and medium-sized enterprises to large enterprises (Amitrano et al., 2016). Doshi and Desai (2019) argued that implementing the Six Sigma framework for small and medium-sized enterprises is an important step in the right direction to improve quality. Understanding the factors that affect the success and failure of implementation and sustainability is necessary in SMEs (Stankalla et al., 2019). For example, the failure modes effect analysis (FMEA) is considered the standard approach representing a universal quality tool that is typically applied at the design stage of products (Lolli et al., 2016). Companies strive to achieve excellence, and management is committed to producing and delivering flawless products, solutions, or services and promoting first-time-right production (Makwana & Patange, 2021). They also need to propose a production strategy that integrates aspects necessary to manage production systems: transformation (T), flow (F), and value generation (V).

Wang et al., (2016) argued that the number of defects is a critical factor because defects not only lower manufacturing yields and the quality of products but can also cause potential reliability problems. The key to achieving near-zero or even zero-defect manufacturing (ZDM) is by concentrating not only on the quality of the products and the product

conditions but also on the conditions of the equipment and the degradation of performance (Chongwatpol, 2015). All assessment reports regarding facility defects must use an 'Assessment Form' to avoid difficulties of creating it due to a lack of knowledge of technical terms and expertise in performing it (Bin Ismail, 2018). Six Sigma has been a continuous improvement strategy in quality and has successfully increased companies' operational efficiency, and productivity, and reduced costs (Gijo et al., 2019; Vijaya-Sunder, 2016; Vijaya-Sunder & Kunnath, 2020). Six Sigma is a project-based, customer-focused, and data-driven approach that makes use of a structured and systematic methodology (Marques & Matthé, 2017).

In the Six Sigma methodology, improvement activities are done using the define-measure-analyze-improve-control (DMAIC) framework (Hakimi et al., 2018; Makwana & Patange, 2021). The first phase of DMAIC defines which production process will be chosen to apply Six Sigma to. The 'measure' phase aims to determine the status of the stated implementation of Six Sigma and the potential sources of variables in the production process. The 'analysis' phase has the objective of identifying problems resulting from the production of a given product and their causes based on the collected data. The 'improvement' phase is intended to remove the errors caused and seek to present a performance within acceptable limits. Amitrano et al. (2016) argued that the 'control' phase was the last phase of the DMAIC. It consists of the identification of ways to maintain the improvement(s). The cultural and managerial aspects of Six Sigma cannot be ignored or underestimated. The key to success in Six Sigma lies behind rigorous utilization of the tools. Therefore, keeping in mind that Six Sigma, in essence, is a large toolbox, having a sufficient understanding of this large bulk of tools and properly selecting and implementing the most suitable among these tools are critical to maintaining progress in the Six Sigma initiative (Uluskan, 2016).

Despite the great objectives of having Six Sigma implemented in companies, there are a few challenges in implementing them (Ahuja & Khamba, 2008;

Coronado & Antony, 2002; Kokkranikal et al., 2013; Yaduvanshi & Sharma, 2017), that might lead to hesitation in implementing it even though the need is there. This paper aimed to provide a summary of case study literature that provided, firstly, information related to how Six Sigma was implemented, as well as the results and benefits of implementing it in companies across multiple industries. This research reveals the impact that the Six Sigma method brings and what kind of Six Sigma-related intervention in companies is useful.

The novelty of this article can be summarized as follows:

1. Broad Cross-Sector Analysis: While previous systematic literature reviews (SLRs) on Six Sigma might have focused on its application and benefits in specific industries or sectors, this article has conducted a wide-ranging analysis across multiple sectors. This broad scope offers a more holistic understanding of Six Sigma's impact and is a significant contribution to the field.
2. Emphasis on Universal Appeal: The article not only presents findings from various industries but also emphasizes the universal applicability and effectiveness of the Six Sigma methodology. This suggests that the benefits of Six Sigma aren't confined to a particular sector but are relevant across diverse industries. Such a perspective can be particularly valuable for practitioners and policymakers seeking to implement quality improvement initiatives across varied contexts.
3. Corroboration with Existing Literature: The article doesn't just present new findings; it also aligns its results with existing literature, validating the benefits of Six Sigma mentioned in previous studies. This corroboration strengthens the reliability of the article's conclusions and reinforces the established understanding of Six Sigma's advantages. In essence, the novelty lies in the article's approach to presenting a comprehensive, cross-industry perspective on Six Sigma, emphasizing its widespread relevance

and effectiveness. This expansive view is a departure from previous research that might have had a narrower or sector-specific focus.

II. Literature Review

A. Quality

One of the factors that influence consumers' decisions in buying a product is quality, which is the main theme of Six Sigma. Quality is the overall features and nature of the products or services that affect the ability to satisfy customer needs. Improvements such as the reduction of defective products, inventory, and waste can improve a production plant's performance. Many companies are working hard to increase productivity and quality and reduce costs to be competitive in the business, which is a characteristic of world-class manufacturing organizations where they manage their quality effectively (Modgil & Sharma, 2016).

B. Quality Control

Quality control involves the activities of engineering and management with the purpose of measuring the characteristics of product quality and comparing them with specifications or requirements and taking action to restructure them. Six Sigma can reduce variability in key product quality characteristics (Goyal et al., 2019). There are seven basic tools of quality that are often used, such as a diagram of causation, sheet check, diagrams of control, histogram, Pareto diagrams, charts spread, and stratification. These tools are very effective in reducing the inefficiency of the process (Shivajee et al., 2019). Six Sigma creates many possibilities to improve the process and quality of products radically. The literature and case studies have covered the implementation of Six Sigma for quality improvement in manufacturing settings (Vijaya-Sunder, 2016; Marques & Matth  , 2017;

Hakimi et al., 2018; Karout & Awasthi, 2017; Kankariya & Ravichandran, 2017; Contreras, 2018).

In the past few years, sustainable quality improvement has been playing a key role in delivering sustainable business and the operation of manufacturing companies. Many researchers argue that quality management has a purpose to achieve a company's objective through support from top management, customer relationships, supplier relationships, employee relationships, product design, and process management. However, only several articles suggest that quality improvement is part of sustainable manufacturing. This shows a lack of literature on quality management systems for sustainable operations. An exception is given by de Freitas et al. (de Freitas et al., 2017), who found that the reduction of the level of defects is one of the important impacts of Lean Six Sigma in the sustainability of operations.

Furthermore, Uluska (2016) emphasizes the need for research to unlock the benefits of Six Sigma beyond cost savings and defect rate reduction. Some practitioners and researchers have begun to recognize that the application of total quality management (TQM) principles, tools, techniques, and systems often fail to help manufacturing organizations achieve high profitability (Goyal et al., 2019).

C. Previous Systematic Literature Reviews on Six Sigma

This article focuses on Six Sigma articles published since 2015 in renowned international journals. Therefore, it is logical for this article to examine previous Six Sigma systematic literature reviews in prominent international journals from 2015 onward.

Some authors focus on specific industries or sectors. For example, Qayyum et al. (2016) collected and reviewed literature on Six Sigma in construction, focusing on critical success factors (CSFs). The review covered papers published between 2000 and 2015, aiming to identify CSFs for successful implementation. Antony et al. (2018) undertook a

review specifically centered on Six Sigma in healthcare, underscoring its role in enhancing the quality of healthcare services. They pinpointed opportunities for the successful deployment and growth of Six Sigma in the healthcare domain. Sunder et al. (2018) performed a morphological analysis of research literature on Lean Six Sigma for services. The study reviewed 175 papers published from 2003 to 2015 and constructed a framework to pinpoint research gaps and future research avenues. Rodgers & Antony (2019) reviewed Lean and Six Sigma practices in the public sector. The review evaluated the applicability of these methodologies to the public sector and discussed various perspectives on their suitability.

Several researchers focus on a specific country. For instance, Muraliraj et al. (2018) presented an annotated methodological review of Lean Six Sigma, specifically focusing on critical success factors (CSFs) in manufacturing and service industries in India. The authors conducted a systematic literature review to identify and analyze the CSFs for Lean Six Sigma implementation. The review offers significant insights into the key factors contributing to the success of Lean Six Sigma initiatives in India.

Other authors focus on specific aspects of Six Sigma. For example, Laureani & Antony (2017) conducted a systematic literature review on the relationship between leadership and Lean Six Sigma. Their review sought to consolidate existing knowledge and offer guidance to researchers and practitioners. Uluskan (2016) offered a comprehensive insight into the Six Sigma DMAIC toolbox, emphasizing the importance of understanding the entire toolbox rather than focusing on specific tools. Chugani et al. (2017) executed a systematic literature review to explore the green impact of Lean, Six Sigma, and Lean Six Sigma. The study reviewed articles published between 1997 and 2015, investigating the intersection of environmental sustainability and process improvement methodologies. Padhy (2017) undertook a critical review of Six Sigma project selections, pinpointing research opportunities in areas such as project risk management and portfolio selection. Laureani & Antony (2017) carried out a systematic literature

review on leadership and Lean Six Sigma. The review aimed to consolidate existing knowledge on the subject and provide insights for researchers and practitioners. Singh & Singh (2020) executed a systematic literature review to discern critical success factors (CSFs) for Six Sigma implementation. They analyzed numerous research articles and case studies to propose a categorized list of essential CSFs.

In summation, these systematic literature reviews furnish valuable insights into various facets of Six Sigma. These encompass its applications in healthcare, the interplay between leadership and Lean Six Sigma, critical success factors, project prioritization and selection techniques, and the comprehensive toolbox of Six Sigma. These reviews augment the existing knowledge reservoir and offer directives for future research and deployment of Six Sigma methodologies.

The main differences between this article and the previous systematic literature reviews (SLR) on Six Sigma are as follows.

1. Time Frame

This research specifically emphasizes Six Sigma articles published since 2015 in renowned international journals, while the previous SLR on Six Sigma encompasses a broader time frame with some going back to 2000 or even 1997.

2. Focus and Scope of the Reviews

This article provides a review from various focal areas. In contrast, the previous reviews have authors focusing on:

- Specific industries (e.g., construction, healthcare, services, public sector).
- Specific countries (e.g., India).
- Specific aspects (e.g., leadership, DMAIC toolbox, environmental sustainability).

3. Methodological Approaches

This article undertakes a cross-sector analysis, emphasizing the universal appeal of Six Sigma. The

previous reviews, in contrast, have more specialized approaches, such as morphological analysis, methodological reviews, or critical reviews.

4. Depth and Breadth of Analysis

While this article provides a broader perspective by exploring Six Sigma's impact across sectors, the previous reviews dive deep into specific areas, offering detailed insights into their chosen focal points.

5. Contributions to Knowledge

The enclosed article emphasizes the cross-sectoral benefits of Six Sigma, underscoring its broader implications. The previous reviews, on the other hand, delve deep into their chosen themes, providing nuanced insights and contributions to specific areas of Six Sigma knowledge.

6. Practical vs. Theoretical Implications

Depending on their focus, the previous reviews might offer more direct practical implications (e.g., CSFs for implementation, project selection techniques) or theoretical insights (e.g., relationships between leadership and Lean Six Sigma).

In summary, while there's an overlap in the areas covered, the main difference lies in the scope, depth, and specific focal points of this article versus the previous SLR. This article offers a more comprehensive view of Six Sigma's impact from 2015 onward in renowned international journals, while the previous reviews provide deep dives into specific areas, industries, or themes.

D. Literature review of Lean and Six-Sigma Integration

The integration of Lean and Six Sigma was first promoted by the George Group in the United States in 1986. However, the term Lean Six Sigma (LSS) was first introduced to academic literature around

Table 1. The Characteristics of Six Sigma and Lean Operations

Six Sigma	Lean
<ul style="list-style-type: none"> • Eliminates defects • Reduces variations in processes • Improves quality • Demonstrates hard cash savings to the bottom-line • Uses data analytics • Project-based approach 	<ul style="list-style-type: none"> • Removes waste • Improves efficiency • Improves flow • Determines value-added and non-value-added activities • Uses statistical tools • Continuous improvement

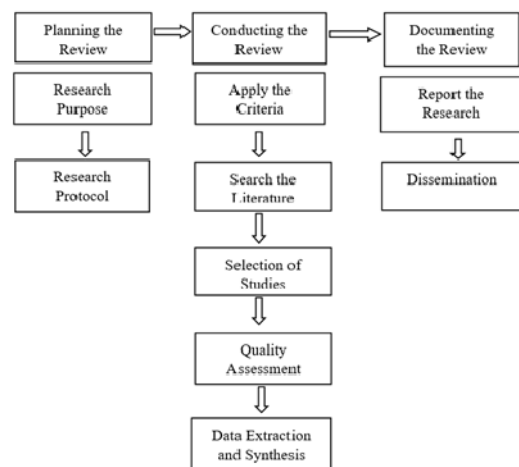
2000. Lean Six Sigma has a powerful strategy for optimizing processes with the purpose of reducing waste in the process and defects in products that lead to cost reduction, quality increase, and customer satisfaction improvement. Lean Six Sigma attempts to combine the characteristics of both Lean and Six Sigma, as shown in Table 1 (Karthik Bharathi et al., 2017; Albliwi et al., 2015).

III. Research Method

To achieve the overall objectives of this study, we conducted a systematic review of the scientific literature. According to Thomas et al. (2016) and Alexander et al. (2019), a systematic literature review is a methodology for systematically examining work in a particular field and for evaluating and synthesizing findings in a reproducible manner. By using this method, we were able to provide more reliable results and evidence when making conclusions (Albliwi et al., 2015).

One of the advantages of a systematic review approach is the awareness of the breadth of research and theoretical background in certain fields. We believe that there is a clear need for a more systematic review of quality improvement in various industries using the Six Sigma method to bridge the gap in the previous literature. Therefore, this paper aims to present a systematic literature review of all articles in top journals from 2015 to 2020.

In this study, we reviewed various research articles and case studies to investigate the implementation of Six Sigma in various industries around the world.

**Figure 1.** Summary of Research and Process

The main purpose of this research is to identify the impacts of Six Sigma methods in various industries.

A. Approach and Phases

literature review, which were grouped into three stages (Stankalla et al., 2019; Albliwi et al., 2015). The stages and processes are shown in Figure 1 below, along with the following explanations:

This SLR follows nine fundamental steps described below.

1. Research Purpose

Before embarking on the review, it's crucial to identify the primary goals and objectives. In this paper, the purpose was determined after assessing common gaps found in the existing literature. This step ensures that the research addresses unmet needs

or unanswered questions.

2. Research Protocol

A research protocol serves as a structured plan detailing how the review will be conducted. This paper's protocol included the scope of studies to be considered, strategies for searching and selecting literature, criteria for inclusion and exclusion, quality assessment procedures, and data extraction methods. Adhering to a protocol ensures consistency and rigor in the review process.

3. Apply the Criteria

Clearly defined criteria are vital to ensure the relevance of the studies included in the review. By applying these criteria, the researchers ensured that only pertinent papers were considered, filtering out unrelated or less relevant studies.

4. Search the Literature

An exhaustive search of academic and specialist journals was carried out to identify potential articles for inclusion. This step often involves multiple databases and may also include manual searches to ensure comprehensiveness.

5. Selection of Studies

Once potential studies are identified, they need to be evaluated against the research criteria to determine their relevance and suitability for the review.

6. Quality Assessment

Not all studies are of equal quality. This step involves assessing the rigor, validity, and reliability of the selected studies. Tools or scales may be used to rate the quality of each article, ensuring that the review's findings are based on sound research.

7. Data Extraction and Synthesis

This step involves pulling out relevant data and information from the selected studies. The extracted data might include study methods, populations, outcomes, results, and more. Synthesis involves combining or comparing the extracted data to draw broader conclusions or identify patterns.

8. Report the Research

After completing the review, the researchers documented their methods, findings, and conclusions in detail. This step ensures transparency and allows other researchers to understand, replicate, or build upon the work.

9. Dissemination

Publishing the findings in academic journals ensures that the broader academic and professional community can access, evaluate, and utilize the insights from the systematic review.

In essence, the research method described in the paper follows a structured and systematic approach to reviewing the literature. This approach ensures that the review is comprehensive, unbiased, and based on high-quality studies, providing a reliable overview of the current state of knowledge on the topic.

B. Inclusion and Exclusion Criteria

The study established criteria that were utilized to filter out members of the entire population, thus obtaining an appropriate sample. In this regard, two types of criteria were utilized to determine the sample that would be the object of research, namely inclusion and exclusion criteria. The criteria were stated to explain to the reader why some of the articles they might be familiar with had been excluded from the review. As argued by Albliwi (2015), researchers could save time and effort by simplifying their research using criteria, starting with reviewing the title and then abstracting it when necessary.

Table 2. Inclusion and Exclusion in Journal Selection

Inclusion	Exclusion
<ul style="list-style-type: none"> Articles published between 2015 and 2020 Articles published in renowned international journals Articles on the topics of operations management and related issues. Articles on improving quality with a Six Sigma approach in various industries Scopus- indexed journals. Case studies, literature reviews, or survey-based articles, 	<ul style="list-style-type: none"> Any publication before 2015 Low-ranking journal Irrelevant journals Papers related to unrelated sectors or themes Books, online sites (conferences, proceedings, procedia, reports, and technical reports)

The study utilized two criteria to select the articles. Firstly, the articles were required to cover topics related to quality improvement based on the Six Sigma approach, and secondly, they had to be internationally published by renowned and trusted publishers. The requirements for selecting articles are further explained in Table 2 below.

A total of 83 articles (n=83) were chosen from distinguished journal publishers, including Elsevier, Emerald Insight, Taylor & Francis, Inderscience, Growing Science, Sage Journal, and Omnia Science, for further review. During the journal search, the following keywords were utilized: (Lean) and (Six Sigma) or (Lean Six Sigma) or (Lean Sigma) or (quality improvement) and (manufacture) and (case study). Articles were searched using search engines such as Google Scholar and major renowned journals' search engines with the selected keywords.

After completing the selection process, the chosen articles were stored and maintained in a database for further review and descriptive analysis. Subsequently, the collected articles were compiled, focusing on specific information related to the impact of Six Sigma application on companies, as well as improvement domains such as business processes, tools, and personnel. The type of industry served as an additional filtering criterion.

IV. Results and Discussion

A total of 83 articles were selected and reviewed.

Table 3. Number of Articles Based on Publication

Elsevier	15
Emerald Insight	40
Growing Science	1
Inderscience	1
Omnia Science	1
Sage Journal	1
Taylor & Francis	24
Total	83

Table 4. Number of Research Articles by Year

Year	Amount
2020	6
2019	16
2018	17
2017	16
2016	22
2015	6
Grand Total	83

Table 3 displays the categorization of articles according to the journals examined in this study. Initially, the articles were assessed based on their abstracts; if they aligned with our subject matter, the articles underwent a thorough review.

In Table 3, it is evident that the top three publishers of articles were Emerald Insight with 40 articles (48%), followed by Taylor & Francis with 24 articles (29%), and Elsevier with 15 articles (18%).

Table 4 presents the number of articles published from 2015 to 2020, with 22 articles issued in 2016, followed by 17 articles in 2018. Sixteen articles were published in 2019 and 2017, while the lowest number

of published articles was in 2020 and 2015, with six articles each.

Table 5 shows that a majority of the articles reviewed in this study were published in journals with a high indexed quartile in Scopus. Specifically, 62 journals were in the 1st quartile (Q1), 15 journals were in the 2nd quartile (Q2), and 6 journals were in the 3rd quartile (Q3). This indicates that the articles selected for this study came from high-quality journals that are recognized in the academic community.

Table 6 displays the descriptive analysis of the journal names. The majority of journal publications came from the International Journal of Lean Six Sigma, with ten articles. Production Planning and Control had nine articles, and the International Journal of Quality & Reliability Management had seven articles. The remaining articles were from various journals.

Table 7 presents the number of research articles by industry, indicating 17 sectors were covered in this study. The manufacturing sector had the highest

number of studies with 17 articles, including those related to printing, carpet production, furnace production, aluminium production, and valve production. The general industry had nine studies; however, it does not specifically mention the industries studied. Additionally, there were seven

Table 5. Number of Articles with Scopus-Indexed Journals per Quartile

No	Scopus Indexed Journal Quartile	Quantity
1	1st Quartile (Q1)	62
2	2nd Quartile (Q2)	15
3	3rd Quartile (Q3)	6
Total		83

Table 7. Number of Published Articles by Industrial Sectors

No	Industry	Amount
1.	Aviation	5
2.	General	9
3.	Electronic Industry	4
4.	Small and Medium Industry	7
5.	Chemical Manufacturing Industry	1
6.	Textile Industry	2
7.	Services	4
8.	Construction	4
9.	Manufacture	17
10.	Medical	6
11.	Automobile	7
12.	Plate	2
13.	Dairy Products	3
14.	Banking	3
15.	Petroleum & Mining	2
16.	Technology	4
17.	Transportation	3
Total		83

Table 6. Journal Publication

Journals	Articles
International Journal of Lean Six Sigma	10
Production Planning and Control	9
International Journal of Quality & Reliability Management	7
TQM Journal	5
Journal of Cleaner Production	4
Quality Engineering	4
Benchmarking: An International Journal	3
Business Process Management Journal	3
Total Quality Management and Business Excellence	3
Others	35
Total	83

Table 8. Method Used for Six Sigma Studies

Method	2015	2016	2017	2018	2019	2020	Total
Case study	4	12	14	14	9	6	59
Literature Review	1	6	0	3	3	2	15
Survey	1	4	2	0	2	0	9
Total							83

Table 9. Impact of the studies

Year	Defect Rate Reduction	Efficiency Improvement	Cost Reduction
2015	3	3	0
2016	7	14	6
2017	5	13	5
2018	16	9	7
2019	15	8	6
2020	10	2	2
Total	56	49	26

studies conducted in small and medium industries.

Table 8 indicates the types of research categorized into three groups: case studies, literature reviews, and surveys. It can be observed that case studies were the most widely used method in 59 studies, followed by literature review with 14 studies, and surveys with nine studies.

Table 9 also shows that the majority of the studies indicate that the primary benefit of Six Sigma is the reduction of defects (52 cases or 42.75%), followed by improvement in efficiency (49 cases or 37.40%), and then cost reduction (26 cases or 19.85%).

V. Discussion

The systematic literature review revealed several intriguing findings regarding the Six Sigma methodology and its impact across various industries. Here, we discuss the broader implications, compare our findings with existing literature, and shed light on the potential future trajectory of Six Sigma

applications.

Prevalence of Six Sigma: The study emphasized the widespread application of Six Sigma across 17 sectors, with a dominant presence in manufacturing. This is in line with the foundational principles of Six Sigma, which originated in the manufacturing domain. However, its applicability across diverse sectors underscores its versatility and relevance in today's dynamic business environment.

Publication Trends: This research highlighted that the majority of articles came from renowned publishers like Emerald Insight, Taylor & Francis, and Elsevier. This not only speaks to the academic rigor of the research on Six Sigma but also suggests that the methodology remains a focal point in quality management discussions in reputable academic circles.

Research Methodologies: The dominance of case studies in the reviewed articles signifies the real-world applicability and success of Six Sigma. This is likely because case studies provide a detailed look at how Six Sigma was implemented in a specific organization and the

results that were achieved. While case studies provide in-depth insights, the prominence of this methodology might indicate a gap in diverse research approaches, offering avenues for future researchers to explore experimental or mixed-method designs.

Benefits of Six Sigma: The research underscored defect reduction as the paramount benefit of Six Sigma. This aligns with the core objective of the methodology: reducing variability and defects. The additional benefits of efficiency improvement and cost reduction further highlight the holistic value proposition of Six Sigma, extending beyond mere defect management.

Comparison with Existing Literature: While the findings corroborate much of the existing literature on Six Sigma's benefits, the broad cross-sector analysis provides a more comprehensive view of its impact. Previous studies often focused on specific sectors, whereas our review underscores the universal appeal and effectiveness of the methodology.

Quality of Articles: The emphasis on high-tier, Scopus-indexed journals for article selection underscores the quality and academic rigor of our review. However, this also brings forth the question of potential insights from lesser-known journals or grey literature, which could be a consideration for future reviews.

The benefits of the findings to business practitioners can be detailed as follows:

Holistic Value Proposition of Six Sigma: Beyond defect reduction, practitioners can leverage Six Sigma for efficiency improvements and cost reduction, offering a more comprehensive approach to quality management.

Customization Opportunities: The article provides practitioners with insights into how Six Sigma has been applied across various industries. Those in underrepresented sectors can draw inspiration and tailor the methodology to fit their specific contexts.

Reinforcement of Six Sigma's Relevance: By showcasing its impact across industries, the research reiterates the enduring relevance of Six Sigma. This can bolster confidence among practitioners considering adopting or continuing with Six Sigma initiatives.

Quality Improvement and Operational Efficiency: At its core, the findings emphasize that Six Sigma remains a potent tool for driving quality enhancements and boosting operational efficiency, essential for businesses aiming for excellence in their operations.

To determine the benefits of the proposed research findings to society, this section might need to infer and extrapolate from the findings and their broader implications:

Improved Product and Service Quality: One of the primary benefits of Six Sigma is the reduction of defects and enhancement of efficiency. When businesses across various sectors adopt and successfully implement this methodology, consumers and end-users benefit from higher-quality products and services. This can lead to increased consumer satisfaction and trust in industries that adopt these quality improvement practices.

Economic Growth: As industries become more efficient and reduce costs through Six Sigma initiatives, they can potentially grow and expand, leading to economic benefits. This can result in job creation, increased investments, and overall economic growth.

Environmental Benefits: Efficient processes can lead to reduced waste, optimized resource usage, and minimized environmental impact. As industries adopt Six Sigma for quality improvement, there's potential for positive environmental outcomes, contributing to a more sustainable society.

Safety and Well-being: In sectors like healthcare, manufacturing, or transportation, the reduction of defects and errors can directly translate to

enhanced safety for consumers and the general public. For instance, fewer defects in the manufacturing of vehicles or medical devices can prevent accidents or medical complications.

Educational and Knowledge Dissemination: The publication of systematic reviews like the enclosed article contributes to academic knowledge. This knowledge can be used in educational settings, training future professionals about best practices and the benefits of methodologies like Six Sigma. An informed workforce can then contribute positively to society.

Standardization and Benchmarking: The findings from such research can set benchmarks and standards for industries, leading to more uniform quality levels. This standardization can be beneficial for regulatory bodies, policymakers, and consumers.

While this article may not explicitly detail all societal benefits, the above points are inferred from the broader implications of Six Sigma's impact across industries. The positive outcomes for businesses, in turn, have cascading benefits for society at large.

Theoretical implications often relate to how research can influence, modify, or contribute to existing academic theories or frameworks. Based on the content and findings that have discussed, the theoretical implications are as follows:

Broadening of Theoretical Scope: The article's cross-sector analysis of Six Sigma's impact expands the theoretical understanding of the methodology's applicability. While prior studies might have focused on specific sectors, this article's comprehensive approach can influence how Six Sigma's theoretical framework is viewed in academic circles, emphasizing its universal applicability.

Reinforcement of Six Sigma Principles: The findings corroborate many benefits of Six Sigma from existing literature, reinforcing its core theoretical principles related to defect reduction,

efficiency improvement, and cost-saving.

Potential for New Theoretical Models: The article's emphasis on the universal appeal of Six Sigma across sectors might pave the way for the development or refinement of theoretical models that account for its broader applicability.

Contribution to Quality Management Theory: The article's findings, especially regarding Six Sigma's benefits and its impact across industries, contribute to the broader body of knowledge in quality management theory. It provides empirical evidence that can influence theoretical discussions on quality improvement methodologies.

Gap Identification for Future Research: By highlighting areas less represented in the review, the article potentially identifies gaps in the current theoretical landscape. These gaps can guide future academic inquiries, leading to further theoretical advancements.

The implications, benefits, or recommendations for managers or practitioners from these findings are:

Customization and Application of Six Sigma:

Managers in industries that are less represented in the review should consider tailoring and implementing Six Sigma methodologies in their operations. The article provides a wealth of information and success stories that can inspire and guide managers in their Six Sigma initiatives.

Universal Relevance of Six Sigma: The article emphasizes the broad and deep impact of Six Sigma across different industries. Managers can take this as a testament to the methodology's versatility and effectiveness, reinforcing its adoption as a valuable tool for quality improvement and operational optimization, irrespective of their industry.

Quality Improvement and Operational Efficiency:

One of the core findings is the significant role Six Sigma plays in enhancing quality and boosting operational efficiency. Managers can

leverage these insights to prioritize and drive quality-focused initiatives in their organizations, leading to better products/services and potentially higher customer satisfaction.

Learning from Success Stories: The article highlights various success stories related to Six Sigma implementations. Managers can derive practical lessons and best practices from these cases, potentially avoiding pitfalls and ensuring more successful implementations in their own contexts.

Strategic Decision-Making: Given the evidence of Six Sigma's benefits across sectors, managers can use the findings to inform strategic decisions, be it in resource allocation, training, process redesign, or technology adoption related to quality improvement.

In essence, the article provides managers with both a theoretical understanding and practical insights into the benefits of Six Sigma, emphasizing its relevance across industries. By integrating these findings into their management practices, managers can drive quality-focused transformations that yield tangible benefits for their organizations.

VI. Conclusion and Recommendation

In conclusion, this systematic literature review aimed to investigate the impact of Six Sigma on various industries. The study found 83 articles published in renowned international journals between 2015 and 2020 that met the inclusion criteria. The majority of the articles were published in Emerald Insight, followed by Taylor & Francis and Elsevier. The International Journal of Lean Six Sigma was the most frequently cited journal. Manufacturing was found to be the most prevalent industry with 17 studies. Case studies were the most commonly used research method, and the primary benefits of Six Sigma were found to be defect rate reduction, followed

by efficiency improvement, and then cost reduction. Some research limitations are:

- The study predominantly relied on articles from renowned publishers, which might introduce a bias as potentially valuable insights from lesser-known journals or conferences might have been overlooked.
- The majority of the reviewed articles were case studies, which means the findings are heavily reliant on real-world, context-specific scenarios. While case studies provide in-depth insights, they may not always be generalizable.
- The review might have been limited to articles published in English and from specific geographical regions, possibly excluding relevant studies in other languages or from different cultural contexts.

It is important to note that these limitations do not undermine the study's findings, but rather provide a context in which they should be interpreted. Future research can address these limitations by expanding the scope, diversifying sources, and incorporating more varied methodologies.

Based on the findings and limitations of this systematic literature review, the following future research agenda is proposed:

- Future studies should focus on the long-term impact of Six Sigma on organizational performance, culture, and employee engagement. By focusing on the long-term impact of Six Sigma, future studies can offer valuable insights for industries considering the implementation of this methodology. These insights can inform decision-making processes, help organizations assess the sustainability and long-term benefits of Six Sigma, and guide the development of strategies to maximize the positive impact of this intervention on organizational outcomes and employee well-being.
- There is a need for more comparative studies that compare the effectiveness of Six Sigma with

other business methodologies such as the Theory of Constraints, Business Process Reengineering, TRIZ (Theory of Inventive Problem Solving), Business Process Management, Agile methodology, and Design Thinking. This would help industries choose the most appropriate methodology for their specific needs.

- To effectively implement Six Sigma in diverse cultural contexts, future studies must explore the cultural ramifications of adopting this methodology, especially in international and multicultural organizations. By examining the cultural implications, organizations can gain insights into navigating and successfully implementing Six Sigma in various cultural settings, potentially using experimental or mixed-method designs.
- Another area of future research can focus on the impact of integrating Six Sigma with Industry 4.0 on organizational climate and employee commitment to the company. The integration of Six Sigma with Industry 4.0 can require new skills and competencies from employees. Future research can investigate the impacts of this integration and identify strategies to manage the change process effectively.

Overall, this study provides valuable insights for practitioners, researchers, and academicians interested in the application of Six Sigma in various industries, highlighting its potential benefits and areas for further studies.

This systematic literature review reveals the expansive and profound impact of the Six Sigma methodology across various industries and academic discussions. The findings underscore the enduring relevance of Six Sigma in driving quality improvements and operational efficiency. As the business landscape continues to evolve, the principles of Six Sigma offer a steady compass for organizations aiming for excellence.

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