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Adoption and Impact of Six Sigma Methodology on Operational Efficiency in Afghanistan with a Focus on Food and Medicine Industry

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ABSTRACT

Manufacturing and industrial processes are dynamic in nature, and sustaining operational excellence while securing long-term competitive advantages involves continuous innovation. Six Sigma and its updated version Lean Six Sigma (LSS) are among the various approaches developed to address these challenges and are proven to be effective. This study aimed to explore the adoption and impact of the Six Sigma methodology on operational efficiency in Afghanistan, focusing specially on the food and medicine industries. The data was collected through online survey and physical distribution of the questionnaire. The main tool was a self-administered questionnaire containing 24 questions divided into seven sections. The collected data was analyzed using SPSS 26, which enhanced the reliability of the results and facilitated accurate calculation of statistical measures. Although Six Sigma has shown significant success worldwide, its adoption in Afghanistan remains limited, with only 42.3% of surveyed organizations formally implementing the methodology. Notable improvements were observed among those applying Six Sigma, in areas such as faster production cycles, cost reduction, and better resource utilization. Conversely, challenges including low awareness, inadequate training, and limited use of Six Sigma tools continue to limit its broader impact. The findings of this study suggest that overcoming these obstacles and fully realizing Six Sigma's potential in Afghanistan requires tailored approaches, leadership support, and easily accessible training programs. This study provides valuable insights to encourage the adoption of Six Sigma, supporting sustainable development and recovery in Afghanistan's industries.

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INTRODUCTION

Manufacturing and industrial procedures are dynamic in their nature, maintaining operational excellence and securing long-term competitive advantages necessitates

persistent innovation. Six Sigma and its revised version, Lean Six Sigma (LSS), have been especially successful among the Methods developed to solve these issues Six Sigma employs LSS emphasizes. Though, LSS focuses on reducing waste to streamline operations, Six Sigma uses a structured problem-solving framework called Definition, Measurement, Analysis, Improvement, and Control (DMAIC) to identify and eliminate process inefficiencies. When these methodologies are combined, they offer a synergistic strategy that blends operational efficiency with data-driven decision-making, making them essential tools for handling complex industrial problems (George, 2002).

The success of Six Sigma in handling customer complaints is clearly shown through its application in an Indian chemical company. By using the DMAIC approach, researchers pinpointed crucial manufacturing factors — like post-grinding temperature, holding time, and work shift — that directly impacted product quality. Once these were optimized, customer complaints dropped significantly from around 5% to just 1%, leading to yearly savings of INR 4 million (Patyal et al., 2021). In the telecom sector, Lean Six Sigma has played a major role in boosting service quality. Its success heavily relies on factors such as strong support from senior leadership, careful selection of strategic projects, and a company culture deeply committed to quality. However, challenges like lacking a clear strategic direction and poor awareness often hinder its full adoption. These findings highlight how tough it can be to apply Lean Six Sigma in service industries and underline the importance of aligning company culture with quality objectives (Psychogios et al., 2012).

In addition, combining Lean and Six Sigma principles has shown great success in addressing various operational challenges. A study examining this integration highlights how important it is to tailor strategies based on the complexity of each project. By blending larger, well-established projects with continuous, small-scale improvements, organizations can significantly boost their efficiency. This flexible yet well-structured framework enables the effective cross-application of both Lean and Six Sigma, allowing them to complement each other optimally (Assarlind et al., 2013). A great example of Six Sigma's versatility can be seen in the dairy industry, where it was used to optimize plain yogurt production. By fine-tuning factors like the incubation time and fat content, researchers identified optimal conditions — 12 hours and 1.5% fat — which led to noticeable improvements in product quality, showcasing the method's value in elevating food production standards (Hakimi et al., 2018).

Beyond manufacturing, Lean Six Sigma has also made a notable impact in other sectors, like the railcar industry. By applying tools such as Kaizen, Value Stream Mapping, and 5S, companies achieved major efficiency improvements — including a 27.9% reduction in lead time and a 71.9% cut in non-value-added activities — clearly demonstrating the method's power in minimizing waste and optimizing operations (Daniyan et al., 2022). In the biopharmaceutical field, Lean Six Sigma interventions like enhanced equipment layouts and improved cooling capacities led to a 54% reduction in non-value-adding processes by streamlining production cycles and lowering operating costs (Ismail et al., 2012).

Across various industries, both Six Sigma and Lean Six Sigma have shown remarkable potential to boost operational efficiency, elevate product quality, and lower expenses. Lean principles focus on reducing waste and creating value, while the DMAIC framework provides a structured path for tackling problems. Key success factors include a continuous improvement mindset, tailored implementation strategies, and strong leadership support. Despite these successes, challenges such as limited awareness, resistance within organizations, and narrow implementation scopes remain. To fully harness the power of these methodologies, future research should aim at developing holistic, integrative strategies that factor in employee engagement and supply chain dynamics (Manufacturing Continuous Improvement 2015).

Afghanistan has enormous potential for agricultural competition, especially in high-margin exports such as processed vegetables, meat, fruits, and dairy. However, inadequate infrastructure, restricted financial resources, antiquated food safety procedures, and disjointed regulatory supervision hamper growth. Controls over food safety are still based on procedures from the 1970s, and businesses deal with overlapping inspections from several organizations, such as the Ministry of Public Health, the Ministry of Agriculture, and municipalities. Adoption of HACCP-based self-inspection models, enhanced inspector training, risk-based inspection systems, and legislative harmonization are important areas that need improvement. To increase production and unleash Afghanistan's export potential, these deficiencies must be filled. (Rathi et al., 2024)

The study investigates the effects of the DMAIC (Define, Measure, Analyze, Improve, and Control) phases on industry performance using a quantitative methodology and data from 382 managers of pharmaceutical factories in Indonesia. The results demonstrate that Six Sigma significantly and favorably affects operational efficiency. Being the first quantitative study to use Six Sigma in this way, it provides insightful information for comparable applications in other nations and sectors. (Purwanto, 2020)

Key flaws were divided into three categories using the DMAIC framework: volume problems, sealing flaws, and empty vials. The most important issue was determined to be volume flaws, with a sigma level of 3.80 and a projected DPMO of 10,630. Using Fishbone and FMEA methods, root causes were examined, and the main contributing factor was found to be insufficient supervision. To improve production quality, improvement actions were suggested utilizing the 5W+1H method and standardized for execution. (Haekal, 2023)

Given Afghanistan's economic challenges and reconstruction efforts, implementing Six Sigma and Lean Six Sigma could significantly improve regional businesses. Manufacturing and service sectors face inefficiencies, supply chain disruptions, inadequate infrastructure, and limited management expertise. Six Sigma techniques can enhance product quality, reduce waste, and streamline operations, boosting competitiveness locally and globally. Data-driven decision-making can further increase productivity and profitability. Overly assertive without evidence this approach has the potential to improve operational efficiency

in industries and ultimately support the economic growth and future success of Afghanistan (Desai & Patel, 2009).

This study focuses on understanding how the Six Sigma methodology is being adopted and used to improve operational efficiency in Afghanistan, particularly within the food and pharmaceutical industries. It aims to explore the current level of awareness and application of Six Sigma practices, as well as their impact on process efficiency, quality improvement, and defect reduction. At the same time, the study seeks to identify the key challenges organizations face when implementing Six Sigma in Afghanistan, taking into account the country's specific socioeconomic and political conditions. Based on these aims, the study addresses two main questions:

1. How widely has Six Sigma been adopted in the food and pharmaceutical sectors in Afghanistan, and what effect has it had on operational efficiency?
2. what barriers limit its effective implementation, and what practical measures can help organizations successfully adopt Six Sigma in this context?

METHODS AND MATERIALS

This study followed a quantitative research design to better understand how Six Sigma is being adopted in Afghanistan's regional industries. To reach professionals working across different parts of the country, the study used both online surveys and printed questionnaires. This was important because not all regions have reliable access to digital tools, and using both methods made it possible to gather information from a wider group of participants. This approach helped the study collect measurable insights into how Six Sigma is understood, implemented, and experienced in different industrial settings (Sekaran & Bougie, 2016; Tavakol & Dennick, 2011).

Sampling Technique

The study aimed to include 110 industry professionals from various sectors. Out of these, 104 completed the survey fully and were included in the analysis, while 6 responses were incomplete and therefore not used. Convenience sampling was chosen simply because it allowed the researchers to reach individuals who were available, willing to participate, and actively working in industries where Six Sigma practices might be applied (Creswell, 2014). Participants came from manufacturing, service, and healthcare industries, providing a broader picture of how Six Sigma is viewed and utilized in different areas.

Inclusion Criteria

- Industry professionals currently working in Afghanistan
- Individuals with some exposure to Six Sigma, either through training or direct involvement
- Respondents who voluntarily agreed to participate and understood that their information would be kept confidential

Exclusion Criteria

- Individuals with no exposure to Six Sigma
- Any incomplete responses

Survey Design

The survey was developed specifically for this study, keeping in mind the unique conditions of Afghan industries. It was designed as a self-administered questionnaire divided into seven key sections:

- Demographics: Basic background details
- Awareness of Six Sigma: Understanding of concepts and tools
- Process Inefficiencies: Ability to recognize problems in existing processes
- Implementation and Effectiveness: Experiences with applying Six Sigma methods
- Benefits and Quality Improvements: Perceived improvements and outcomes
- Operational Efficiency and Customer Satisfaction: Broader organizational impacts
- Challenges and Future Outlook: Difficulties encountered and expectations for the future

To ensure that the questionnaire was reliable, its internal consistency was tested using SPSS version 26. The Cronbach's alpha value of 0.73 showed that the questions were dependable and measured the concepts consistently (Sekaran & Bougie, 2016; Tavakol & Dennick, 2011).

Data Collection

Data were collected over a period of three months. Printed questionnaires were distributed directly through trusted industry contacts, while an online version was created using Google Forms for participants with easier internet access. This combination allowed the study to reach individuals from different regions and backgrounds. Out of all the responses received, 104 were complete and included in the final analysis. The six incomplete forms were removed because they did not provide enough information for proper interpretation (Fowler, 2014).

Data Analysis

After collecting all responses, the data were entered into SPSS version 26 for analysis. Descriptive statistics were used to understand the major patterns in the findings. Frequencies and percentages were calculated to explore:

- How aware respondents were of Six Sigma
- How they recognized inefficiencies in their workplaces
- How Six Sigma was implemented and how effective it appeared
- The benefits they observed, including improvements in quality and operations
- The impact on customer satisfaction and overall performance
- The challenges they faced and their views on the future of Six Sigma in Afghanistan

The results were displayed in tables so that patterns and trends could be easily identified and clearly understood.

RESULT AND DISCUSSOIN

Table 1 and Figure 1 provide an overview of the respondents' industry affiliation, organizational experience, and professional roles. As shown in Figure 1, the majority of respondents are from the Food sector (30%), followed by Pharmaceutical (20%), Medicine (10%), and Other industries (40%). This demonstrates the prominence of food-related sectors in the Afghan industrial landscape.

In terms of organizational experience, 50.0% of respondents represent organizations functioning for 10–20 years, 30.8% for 5–10 years, 8.7% for less than 5 years, and 10.6% for over 20 years. Regarding professional occupations, 31.7% work in Quality Assurance/Control, 26.0% in management, 15.4% in operations, and 26.9% hold other roles. These data imply a diversified pool of respondents, covering a broad spectrum of industry sectors, organizational maturity, and functional responsibilities.

Table 1. *Distribution of Respondents by Industry Sector, Years of Operation, and Organizational Roles*

Variable	Category	n	%
Industry Sector	Manufacturing	95	91.3
	Service	1	1.0
	Retail	2	1.9
	Other	6	5.8
Years of Operation	Less than 5 years	9	8.7
	5–10 years	32	30.8
	10–20 years	52	50.0
	More than 20 years	11	10.6
Position Role in the Organization	Management	27	26.0
	Quality Assurance/Control	33	31.7
	Operations	16	15.4
	Others	28	26.9

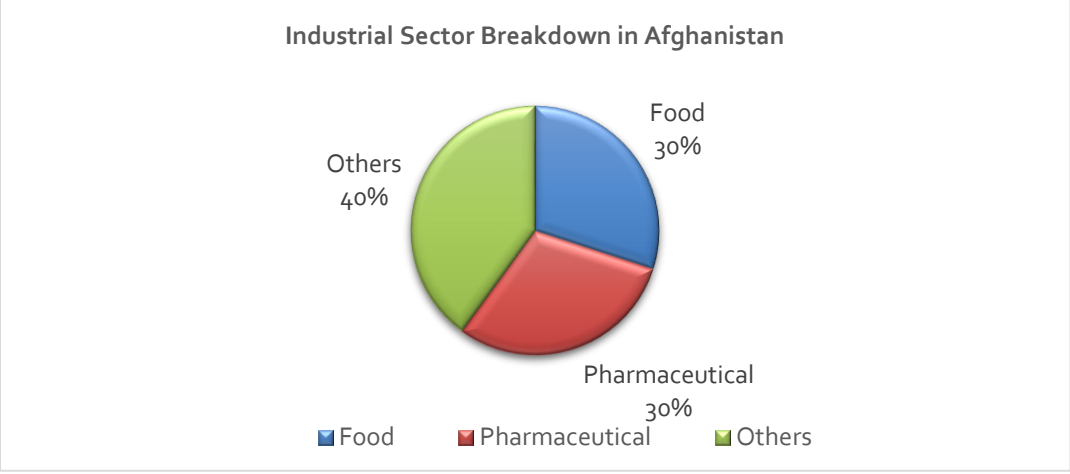

Figure 1. *shows industrial sector breakdown in Afghanistan*

This figure shows the Industrial Sector Breakdown in Afghanistan, based on data I personally collected during my research. I engaged with professionals and businesses across the Food, Pharmaceutical, and other industrial sectors to understand their scale and contribution. As shown, both the Food and Pharmaceutical sectors each make up 30% of the industrial activity, while the remaining 40% includes various other industries such as textiles, construction, and small-scale manufacturing. This breakdown gives a clear picture of how industrial efforts are distributed and helps set the stage for deeper analysis in the following sections.

The table 2 highlights respondents' familiarity with Six Sigma, its adoption in organizations, and how inefficiencies are identified and addressed. While 40.4% of respondents are familiar with the concept of Six Sigma, the majority (59.6%) are not. Similarly, only 42.3% of organizations have formally adopted Six Sigma practices, leaving 57.7% without it. Among organizations using Six Sigma, 23.1% have implemented it for less than a year, 31.7% for 1–3 years, 34.6% for 3–5 years, and 10.6% for over five years.

When it comes to inefficiencies, quality control is the most commonly cited area (38.5%), followed by production/manufacturing (30.8%), supply chain management (15.4%), customer service (10.6%), and other processes (4.8%). The most frequently used method to identify inefficiencies is customer feedback, reported by 60.6% of respondents. Other methods include employee suggestions (19.2%), regular internal audits (12.5%), and Six Sigma tools (6.7%), with 1.0% using alternative approaches.

In terms of effectiveness, only 16.3% of respondents rated their current methods for identifying inefficiencies as "Excellent," while most (59.6%) described them as average. Additionally, 14.4% rated their methods as slightly above average, and 9.6% felt they were "Very Poor." These results show a wide range of familiarity with Six Sigma and its practices, as well as significant room for improvement in addressing inefficiencies effectively.

Table 2. *Familiarity with Six Sigma, Its Adoption, Implementation Duration, Areas of Inefficiencies, Methods for Identifying Inefficiencies, and Perceived Effectiveness*

Variable	Category	n	%
Familiarity with Six Sigma	Yes	42	40.4
	No	62	59.6
Formal Adoption of Six Sigma	Yes	44	42.3
	No	60	57.7
Duration of Six Sigma Implementation	Less than 1 year	24	23.1
	1–3 years	33	31.7
	3–5 years	36	34.6
	More than 5 years	11	10.6
Processes with Most Inefficiencies	Production/Manufacturing	32	30.8
	Quality Control	40	38.5
	Supply Chain Management	16	15.4
	Customer Service	11	10.6

Variable	Category	n	%
Methods Used to Identify Inefficiencies	Other	5	4.8
	Regular internal audits	13	12.5
	Customer feedback	63	60.6
	Employee suggestions	20	19.2
	Use of Six Sigma tools (e.g., SIPOC, Pareto analysis)	7	6.7
	Other	1	1.0
Perceived Effectiveness of Current Approach	Very poor	10	9.6
	Poor	17	16.3
	Good	62	59.6
	Excellent	15	14.4

The table 3 gives an insight into how organizations implement Six Sigma, including the methodologies they use, the level of training they invest in, the tools they apply to reduce defects, and the results they see in terms of defect reduction. The majority of organizations (65.4%) primarily use the DMAIC methodology (Define, Measure, Analyze, Improve, Control), while 19.2% use DMADV (Define, Measure, Analyze, Design, Verify), and 15.4% follow other methodologies. When it comes to Six Sigma training, more than half of organizations (53.8%) have not invested in any formal training. Among those that have, Green Belt training is the most common (21.2%), followed by Yellow Belt (12.5%), Black Belt (6.7%), and Master Black Belt (5.8%).

In terms of tools used to reduce defects, Cause and Effect (Fishbone) Diagrams (30.8%) and Control Charts (27.9%) are the most frequently used, with other tools like Statistical Process Control (SPC) and Process Mapping also being applied by 19.2% and 15.4% of organizations, respectively. As for the impact of Six Sigma on defect reduction, 43.3% of organizations reported seeing measurable improvements, while the same percentage indicated no significant change, and 13.5% were unsure.

Regarding defect rates, 39.4% of organizations do not track them at all. Of those that do, 24.0% report a defect rate of less than 1%, 31.7% fall between 1% and 3%, and 4.8% report rates between 3% and 5%. No organization reports defect rates above 5%. This data reflects a strong reliance on DMAIC methodology, a general lack of advanced Six Sigma training, a variety of tools in use, mixed outcomes regarding defect reduction, and a significant number of organizations not tracking their defect rates.

Table 3. *Six Sigma Methodologies, Training Levels, Tools for Defect Reduction, and Defect Rate Tracking in Organizations*

Variable	Category	n	%
Primary Six Sigma Methodology Used	DMAIC (Define, Measure, Analyze, Improve, Control)	68	65.4
	DMADV (Define, Measure, Analyze, Design, Verify)	20	19.2
	Other	16	15.4
Level of Six Sigma Training Invested In	Yellow Belt	13	12.5
	Green Belt	22	21.2
	Black Belt	7	6.7
	Master Black Belt	6	5.8
	None	56	53.8
Six Sigma Tools Used to Reduce Defects	Control Charts	29	27.9
	Cause-and-Effect (Fishbone) Diagrams	32	30.8
	Process Mapping	16	15.4
	Statistical Process Control (SPC)	20	19.2
	Other	7	6.7
Measurable Reduction in Defects After Six Sigma Implementation	Yes	45	43.3
	No	45	43.3
	Not sure	14	13.5
Organization's Defect Rate	Not tracked	41	39.4

The table 4 outlines the benefits organizations have experienced from Six Sigma implementation, how they measure product or service quality, the extent of quality improvements, and the areas most impacted. The benefit reported is improved product or service quality, experienced by 43.3% of organizations. Other notable benefits include reduced operational costs (24.0%) and enhanced operational efficiency (21.2%), while improved customer satisfaction was noted by 10.6%. Only 1.0% of organizations reported enhanced employee skills and engagement as a benefit.

When it comes to measuring quality, the most common method is customer satisfaction surveys, used by 56.7% of organizations. Quality inspection reports and market feedback are both used by 18.3% of organizations. Fewer organizations track quality using warranty or return claims (5.8%), and only 1.0% use other methods. Regarding the quality improvements achieved through Six Sigma.

In terms of specific areas of improvement, the most noticeable change has been in product consistency, cited by 47.1% of organizations, followed by service reliability at 30.8%. Improvements in the durability and performance of products were also reported by 12.5% of organizations, and 9.6% saw improvements in general durability or performance. Overall, the data shows that Six Sigma has brought about significant quality improvements, particularly

in product consistency, with customer satisfaction being the key method for measuring success.

Table 4. *Benefits of Six Sigma Implementation, Methods for Measuring Quality, and Areas of Quality Improvement in Organizations*

Variable	Category	n	%
Benefits Experienced from Six Sigma Implementation (1–5 Rating)	Improved product/service quality	45	43.3
	Enhanced operational efficiency	22	21.2
	Reduced operational costs	25	24.0
	Improved customer satisfaction	11	10.6
	Enhanced employee skills and engagement	1	1.0
Methods Used to Measure Product/Service Quality	Customer satisfaction surveys	59	56.7
	Quality inspection reports	19	18.3
	Market feedback	19	18.3
	Warranty/Return claims	6	5.8
	Other	1	1.0
Quality Improvement Achieved Through Six Sigma (Rating)	1	14	13.5
	2	20	19.2
	3	46	44.2
	4	21	20.2
	5	3	2.9
Most Noticeable Areas of Quality Improvement	Product consistency	49	47.1
	Service reliability	32	30.8
	Improved durability/performance	10	9.6
	Improved durability/performance of product	13	12.5
	Other	0	0.0

The table 5 provides insights into how organizations gather customer feedback, the effects of Six Sigma on customer satisfaction, and improvements in operational efficiency. The most common method for collecting customer feedback is through surveys, used by 62.5% of organizations, followed by online reviews (20.2%) and customer service interactions (17.3%). When it comes to customer satisfaction since adopting Six Sigma, the results are mixed. Most organizations (43.3%) rated customer satisfaction as average (3 out of 5), while 23.1% rated it below average, and 14.4% rated it very low. Smaller proportions gave higher ratings, with 16.3% rating satisfaction as slightly above average and just 2.9% rating it as excellent.

Regarding operational efficiency, 45.2% of organizations feel that Six Sigma has helped streamline their operations, while 39.4% have not seen significant improvements, and 15.4% are unsure. The areas where operational efficiency has improved the most are faster

production cycles (39.4%), followed by lower operational costs (22.1%) and better resource utilization (11.5%). A smaller number of organizations (7.7%) reported improvements in other areas. This data suggests that while Six Sigma has had a notable impact on efficiency, particularly in speeding up production and reducing costs, the effects on customer satisfaction have been more varied, The table 5 provides a breakdown of the areas where organizations have seen the most significant improvements in operational efficiency. The most noticeable improvement has been in faster production cycles, which 39.4% of organizations identified as a key area of progress. Following that, lower operational costs have been reported by 22.1% of organizations, with another 19.2% also mentioning cost reductions, emphasizing the financial benefits of operational efficiency. Better resource utilization has been an area of improvement for 11.5% of organizations, while 7.7% cited other areas of improvement not specified in the table. These results suggest that organizations are primarily seeing improvements in production speed and cost management, with some focusing on more effective use of resources.

Table5. *Customer Feedback Collection Methods, Impact of Six Sigma on Customer Satisfaction, and Operational Efficiency Improvements*

Variable	Category	n	%
Customer Feedback Collection Methods	Surveys	65	62.5
	Online reviews	21	20.2
	Customer service interactions	18	17.3
Customer Satisfaction Since Adopting Six Sigma (Rating)	1	15	14.4
	2	24	23.1
	3	45	43.3
	4	17	16.3
	5	3	2.9
Six Sigma Helped Streamline Operational Efficiency	Yes	47	45.2
	No	41	39.4
	Not sure	16	15.4
Areas with Greatest Operational Efficiency Improvement	Faster production cycles	41	39.4
	Lower operational costs	20	19.2

Variable	Category	n	%
	Reduced waste/defects	23	22.1
	Better resource utilization	12	11.5
	Other	8	7.7

The table 6 presents the future plans of organizations regarding the continuation or expansion of Six Sigma practices. A majority of organizations (57.7%) do not plan to continue or expand Six Sigma practices. In contrast, 34.6% of organizations intend to expand or continue using Six Sigma in the future. A smaller percentage, 7.7%, are unsure about their plans regarding Six Sigma practices. These findings indicate that while a significant portion of organizations may be moving away from or have not fully embraced Six Sigma long-term, there is still a notable group considering its continued use or expansion in the future.

Table 6. *Organizations' Plans to Expand or Continue Six Sigma Practices in the Future*

Variable	Category	n	%
Plans to Expand or Continue Six Sigma Practices	Yes	36	34.6
	No	60	57.7
	Not sure	8	7.7

The findings show a clear gap between awareness and adoption of Six Sigma in Afghanistan, especially in the food and medicine industries. More than half of the respondents (59.6%) were unfamiliar with the methodology, and 57.7% of organizations had not formally implemented it. This suggests that Six Sigma is still relatively new in these sectors, which aligns with studies showing that low awareness and limited organizational readiness can hinder adoption of process improvement methods in resource-constrained contexts (Albliwi et al., 2014; Antony et al., 2012).

Among organizations that have adopted Six Sigma, most (89.4%) reported less than five years of experience, which may explain the limited use of key tools such as SIPOC and Pareto analysis, used by only 6.7% of respondents. Research has highlighted that adequate training and leadership support are crucial for effective use of these tools, and without them, organizations may see only limited improvements (Alsaadi, 2024; Singh et al., 2020).

The main areas of inefficiency identified—quality control and production/manufacturing—emphasize the need for structured methodologies to improve operational outcomes. While 43.3% of organizations reported measurable reductions in defects, an equal proportion reported no significant change, and 39.4% did not track defect rates at all. These findings indicate that Six Sigma's effectiveness depends heavily on proper training, consistent tool usage, and organizational commitment, which has also been noted in previous studies (Antony et al., 2012; Albliwi et al., 2014).

DMAIC was the most commonly used methodology (65.4%), reflecting global trends, but over half of organizations (53.8%) had no formal training, which likely limits deeper integration and more significant quality improvements. Previous research confirms that lack of training and leadership support are key barriers to successful Six Sigma implementation, affecting both tool utilization and sustainability of results (Chakravorty, 2010; Alsaadi, 2024).

Respondent demographics further reveal a strong manufacturing sector presence, constituting 91.3% of participants, with smaller representations from other sectors (5.8%). This distribution is consistent with Six Sigma's traditional focus on manufacturing, which emphasizes process optimization and quality enhancement. Supporting this, Alghamdi et al. observe that Lean Six Sigma is most effective within manufacturing contexts (Alghamdi et al., 2023). Within Afghanistan's industrial landscape, the food industry leads respondents at 30%, followed by pharmaceuticals at 20%, medical sectors at 10%, and other industries at 40%. The significant presence of food and pharmaceutical sectors underscores Six Sigma's importance, particularly in industries where quality, safety, and regulatory compliance are critical.

The data also shed light on respondents' knowledge and implementation of Six Sigma techniques to reduce inefficiencies. While 59.6% report familiarity with Six Sigma, a substantial 40.4% remain unfamiliar with the methodology. This limited awareness aligns with other studies, such as those by Alghamdi et al., which emphasize the constrained adoption of Six Sigma, particularly outside specialist industries (Patyal et al., 2021). Correspondingly, 57.7% of organizations lack formal Six Sigma integration, with only 42.3% formally adopting its practices. This finding concurs with research identifying barriers like insufficient training and lack of organizational support as key impediments to wider utilization (ICFQ, 2024).

Regarding defect reduction tools, Cause and Effect (Fishbone) Diagrams (30.8%) and Control Charts (27.9%) are the most commonly applied. Other methods, including Statistical Process Control (SPC) (19.2%) and Process Mapping (15.4%), are used less frequently. This distribution mirrors industrial studies that highlight the effectiveness of these tools in visualizing and addressing root causes of inefficiencies (Industrial Trainer, 2023). However, the limited use of more advanced tools indicates a missed opportunity for gaining deeper insights and achieving more substantial improvements.

In terms of outcomes, 43.3% of organizations report measurable defect reduction, while an equal proportion note no significant change, and 13.5% remain uncertain. This variability reflects challenges in consistent implementation and reinforces the importance of comprehensive training and organizational commitment. The Henry Harvin study similarly highlights that Six Sigma's success heavily depends on sustained effort and appropriate resource allocation (Henry Harvin, 2024).

Further analysis shows that many organizations do not monitor defect rates rigorously; 39.4% of organizations do not track defects at all. Among those that do, defect rates of less

than 1% are reported by 24.0%, rates between 1% and 3% by 31.7%, and between 3% and 5% by 4.8%. This widespread lack of tracking represents a lost opportunity for continuous improvement, a gap frequently underscored in Six Sigma literature (Kumar et al., 2008).

The benefits of Six Sigma are also apparent in quality and cost outcomes. A notable 43.3% of organizations identify improvements in product or service quality as the most significant gain, consistent with research demonstrating Six Sigma's role in streamlining processes and reducing defects (Antony et al., 2016). Cost reduction is reported by 24.0%, and enhanced operational efficiency by 21.2%, matching prior findings that Six Sigma improves quality while identifying inefficiencies and waste, leading to savings (Chiarini & Bracci, 2013).

Customer feedback mechanisms predominantly involve surveys (62.5%), followed by online reviews (20.2%) and customer service interactions (17.3%). The preference for surveys corresponds with prior research emphasizing their effectiveness in providing structured and actionable insights (Zhuo, 2019). In terms of operational efficiency, 45.2% report streamlined operations due to Six Sigma, while 39.4% see no improvement and 15.4% are unsure. Improvements are most frequently noted in faster production cycles (39.4%), followed by lower operational costs (22.1%) and better resource utilization (11.5%). These findings align with evidence that Six Sigma facilitates operational streamlining and cost reductions, especially in manufacturing and process-centric industries (Machinini, 2010).

Financial benefits are further reinforced by 22.1% of organizations identifying lower operational costs and 19.2% citing cost reductions. This supports existing research that highlights Six Sigma's capacity to identify and eliminate inefficiencies, translating into measurable cost savings (Snee, 2010). Additionally, 11.5% of organizations report better resource utilization, reflecting Six Sigma's ability to optimize resource allocation and minimize waste. This finding aligns with literature suggesting that Six Sigma fosters a culture of efficiency and accountability (Panat & Ramchandran, 2016). A smaller group (7.7%) report improvements in areas beyond those explicitly identified, indicating that the scope of Six Sigma's impact may vary depending on organizational focus and operational context (Desai et al., 2012).

Regarding future intentions, a majority (57.7%) of organizations do not plan to continue or expand Six Sigma practices, echoing research that highlights challenges in sustaining Six Sigma, including high costs, leadership deficits, and difficulties quantifying benefits (Chakrabarty & Tan, 2007). Conversely, 34.6% intend to continue or expand its use, consistent with studies showing that successful implementations often result in viewing Six Sigma as a strategic tool for ongoing improvement and competitive advantage (Goh, 2010). The remaining 7.7% are uncertain about their future plans, reflecting difficulties some organizations face in aligning Six Sigma with strategic goals or organizational culture (Pepper & Spedding, 2010). Collectively, these findings indicate that while widespread long-term adoption remains limited, a committed segment of organizations recognizes Six Sigma's value and plans to leverage it for sustained operational and strategic gains (Desai & Patel, 2009b).

CONCLUSION

This study provides strong evidence that Six Sigma has the potential to significantly enhance operational efficiency, improve product and service quality, and reduce costs in Afghanistan's food and medicine industries. The research indicates that while awareness and adoption remain limited—with only 42.3% of organizations formally implementing Six Sigma—the methodology delivers tangible benefits for organizations that have embraced it. Improvements were particularly noted in faster production cycles, better resource utilization, and cost reduction, confirming the methodology's effectiveness in addressing process inefficiencies (Albliwi et al., 2014; Antony et al., 2012).

However, the study also reveals several challenges that limit the broader impact of Six Sigma. These include low awareness, underutilization of key Six Sigma tools such as SIPOC and Pareto analysis, insufficient formal training, and inadequate monitoring of defect rates. Such obstacles suggest that the methodology's full potential remains untapped, highlighting the need for stronger leadership support, accessible training programs, and systematic implementation strategies. These findings directly address the study's research questions by demonstrating both the current level of adoption and the socioeconomic and organizational factors that hinder effective implementation (Alsaadi, 2024; Chakravorty, 2010).

Moreover, the study highlights that organizations planning to continue or expand Six Sigma practices—approximately 34.6%—are more likely to achieve sustained operational improvements, whereas the majority (57.7%) who do not plan for expansion may struggle to maintain long-term efficiency gains. This emphasizes the importance of aligning Six Sigma initiatives with organizational strategy and culture, particularly in contexts like Afghanistan where infrastructural and resource constraints are prominent.

In conclusion, to fully realize Six Sigma's potential in Afghanistan, organizations should prioritize:

- **Increasing awareness and knowledge** of Six Sigma principles across all management levels.
- **Providing accessible and structured training programs** (Green Belt, Black Belt, etc.) to strengthen tool utilization and problem-solving skills.
- **Embedding systematic performance tracking** for defects, quality, and efficiency to enable continuous improvement.
- **Fostering leadership commitment and organizational support** to integrate Six Sigma into strategic decision-making.

By addressing these factors, Afghanistan's industries can leverage Six Sigma to overcome inefficiencies, enhance product and service quality, reduce costs, and ultimately compete more effectively in global markets. The findings offer practical guidance for policymakers, industry leaders, and quality management professionals seeking to implement process improvement methodologies in developing economies.

LIMITATION

Limited Geographic Scope: Because data collection was mostly carried out in places with better access to infrastructure and industry expertise, the study may not fully reflect all of Afghanistan, possibly leaving out insights from more rural or underdeveloped areas.

Sample Size and Diversity: Although the study collected 104 responses, the sample size is still relatively small and may restrict the generalizability of the findings across all Afghan industrial sectors. Some industries and demographic groups may be underrepresented, potentially introducing bias into the results. Furthermore, the original draft lacked a clear connection to foundational theories. This revised version links the DMAIC methodology to established quality management principles such as Total Quality Management (TQM) and Continuous Improvement (CI), reinforcing the theoretical grounding of the research. Additionally, a notable limitation is that most respondents are from the manufacturing sector, which may further limit the applicability of the results to other industries such as services, logistics, or construction.

Data from Self-Reports: Because self-administered questionnaires are used, the data is dependent on respondents' opinions and self-reports, which may introduce biases like overestimation or underestimation of the difficulties and success of implementing Six Sigma.

Limited Longitudinal Insight: Without taking into consideration long-term trends or changes that can affect the methodology's efficacy in regional industries, the study just offers a snapshot of Six Sigma implementation and its effects at a particular moment in time.

AUTHORS' CONTRIBUTIONS

- Rahmatullah Seeyall led the study from the initial idea to the final draft. He designed the research framework, developed the questionnaire, and carried out the data collection through both online surveys and hard-copy questionnaires. He also coordinated the overall research process and ensured the study objectives were properly addressed.
- Waheed Ullah Hafiz handled the data analysis. He was responsible for organizing the collected data, conducting statistical analysis using SPSS, and interpreting the results that informed the findings and discussion of the study.
- Barialai Mohammadi focused on the literature review. He reviewed and synthesized previous studies related to Six Sigma and operational efficiency, helping to build the theoretical foundation and align the study with existing research.
- Iftikhar Hussain provided critical academic support by reviewing the manuscript, offering constructive feedback, and helping refine the structure, discussion, and conclusions. He also carried out the final review before submission.
- All authors contributed to the study and approved the final version of the manuscript.

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CONFLICT OF INTEREST STATEMENT

We certify that this study does not involve any conflicts of interest. The study was carried out completely impartially and independently.

DATA AVAILIBILTY STATEMENT

The data supporting the findings of this study were collected through a combination of online surveys and physical (hard copy) questionnaires distributed to professionals in the food, pharmaceutical, and medicine industries across Afghanistan. Due to privacy and confidentiality considerations, the datasets are available from the corresponding author upon reasonable request.

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