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Minimization of Sewing Defects for Quality Improvement in Basic Jacket Manufacturing Using the PDCA Cycle

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Research Article

Keywords: PDCA Cycle, Sewing Defects, Outerwear Quality, Garment Manufacturing, Pareto Analysis, Fishbone Diagram, RMG Industry

Posted Date: September 22nd, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11078577/v1

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Additional Declarations: The authors declare no competing interests.

Abstract

Quality control and productivity optimization are paramount in the Ready-Made Garments (RMG) industry to maintain global competitiveness and meet strict buyer specifications. This empirical research investigates the structured application of Deming's Plan-Do-Check-Act (PDCA) quality management framework to minimize sewing defects during basic jacket assembly. Conducted as a plant-level case study at Patriot Eco Apparel Ltd. in Gazipur, Bangladesh, primary quality audit data was collected across two consecutive 16-day production cycles (pre- and post-intervention) with sample sizes of $N_1 = 3,200$ units and $N_2 = 3,200$ units. Using statistical quality control tools—including Pareto analysis, cause-and-effect (fishbone) diagrams, and the 5WH framework—the study identified six major defect categories (broken stitch, skip stitch, open seam, pleat, puckering, and down stitch) accounting for 95% of total non-conformances. Root-cause analysis pinpointed needle friction, tension imbalances, feeder misalignment, and operator handling errors as key drivers. Targeted shop-floor interventions during the "Do" phase—such as needle re-selection, thread tension standardization, feeder alignment, and operator skill refreshers—resulted in a reduction of total defect counts from 720 to 208 pieces. The average sewing defect rate dropped from 22.50% to 6.50%, yielding a 16.00% net quality improvement. This paper details specific defect mechanisms, root-cause remedies, and financial/operational implications, providing a comprehensive blueprint for garment manufacturing plants.

1. Introduction

The Ready-Made Garments (RMG) sector serves as the economic backbone of Bangladesh, contributing over 80% of total foreign exchange earnings and providing employment to more than four million workers, the majority of whom are women. Over the past four decades, Bangladesh has established itself as a premier global manufacturing hub for apparel, trailing only China in total export volume. However, as international fashion markets evolve toward fast fashion cycles, reduced lead times, strict environmental compliance, and stringent quality benchmarks, domestic apparel manufacturers face severe operational challenges. To maintain global market share and sustain profitability under rising raw material and labor costs, garment factories must transition from traditional, end-of-line reactive inspection models toward proactive, continuous quality management methodologies.

Among various garment classifications, outerwear manufacturing—specifically basic jacket assembly—presents some of the most intricate production challenges on the factory floor. Unlike simple t-shirts or standard trousers, a basic jacket is a multi-component garment incorporating a heavy woven shell fabric (such as denim or heavy twill), lightweight woven or knitted lining materials, fusible non-woven interlinings, functional trims (zippers, press buttons, adjusters), and structural padding. Joining these diverse fabric layers with varying elasticities, thicknesses, and surface frictions requires complex, multi-stage sewing sequences using specialized industrial sewing machines.

High sewing defect rates in jacket assembly lines lead to severe operational inefficiencies. Defective garments require laborious unpicking and re-stitching, which degrades fabric strength, increases

material scrap, consumes extra sewing thread, creates production bottlenecks, and inflates direct labor costs. Furthermore, high defect rates decrease the First Time Through (FTT) yield, forcing management to allocate excessive resources to end-line inspection and off-line rework stations rather than core production activities.

Deming's Plan-Do-Check-Act (PDCA) framework offers a structured, scientific approach to continuous quality control and process optimization. By systematically identifying root causes of defects, implementing targeted process adjustments, evaluating post-intervention results, and standardizing effective routines, the PDCA cycle establishes a culture of continuous improvement. While PDCA has been widely studied in general automotive, electronics, and heavy manufacturing industries, empirical studies detailing its step-by-step implementation and quantitative impact on complex outerwear sewing lines in Bangladesh remain limited.

This research addresses this operational gap by presenting an in-depth, plant-level empirical case study conducted at Patriot Eco Apparel Ltd., a leading garment manufacturing facility located in Gazipur, Bangladesh. The primary objective of this study is to diagnose the root causes of sewing defects in basic jacket manufacturing, execute low-cost shop-floor interventions using the PDCA cycle, quantify the resulting defect reduction, and establish standard operating procedures (SOPs) to prevent defect recurrence.

2. Literature Review

Quality management literature extensively documents the transition from traditional final product inspection to Total Quality Management (TQM) and statistical process control. Modern manufacturing philosophy emphasizes that quality cannot be inspected into a product; rather, it must be built into the production process itself. High defect rates directly contribute to the Cost of Poor Quality (COPQ), which includes both internal failure costs (scrap, rework, re-inspection) and external failure costs (buyer rejections, financial penalties, brand damage).

The Plan-Do-Check-Act (PDCA) cycle, originally introduced by Walter Shewhart and popularized by W. Edwards Deming, is recognized worldwide as a fundamental framework for continuous quality improvement. In apparel manufacturing contexts, Islam and Islam (2017) demonstrated that integrating statistical quality control charts within the PDCA framework reduced process variability and isolated machine-induced sewing errors in woven shirt production. Similarly, Muzahidul Islam et al. (2013) applied Pareto analysis and cause-and-effect diagrams within a PDCA cycle to enhance First Time Through (FTT) rates in knitwear manufacturing, achieving a 52.62% reduction in bottom hem stitching defects.

The 80/20 Pareto principle plays a pivotal role in quality diagnosis by demonstrating that a small number of defect types (the 'vital few') account for the vast majority of non-conformances. Tahiduzzaman et al. (2018) highlighted that deploying Pareto charts allows factory quality teams to prioritize intervention efforts on high-frequency defects, yielding maximum quality improvement with minimal resource

allocation. Complementing Pareto analysis, Ishikawa's Cause-and-Effect (Fishbone) diagram provides a structured method to categorize potential root causes across four major operational vectors: Man (operator skill, fatigue, handling), Machine (calibration, needle selection, maintenance), Material (fabric properties, thread strength), and Method (line balancing, operation sequence, standard settings).

Specific to sewing mechanics, Doulah et al. (2012) observed that sewing defect occurrences—such as skip stitches, thread breakage, and seam puckering—are predominantly driven by improper needle-thread interactions, incorrect machine timing, and uncalibrated thread tensions. Research across adjacent light manufacturing domains, including packaging (Nguyen et al., 2020), footwear assembly (Zadry & Darwin, 2020), and electronic component production (Realyvásquez-Vargas et al., 2018), consistently confirms that low-cost, method-oriented adjustments within the PDCA cycle yield substantial defect reductions without requiring capital-intensive automation overhauls.

Despite extensive general literature on garment quality, detailed empirical studies focusing specifically on multi-layer outerwear and jacket assembly lines are sparse. Outerwear garments present unique sewing dynamics due to heavy fabric GSM, structural interlinings, and complex seams (such as shoulder joins, sleeve attachments, and zipper plackets). This study bridges this gap by providing empirical data and practical root-cause solutions tailored to basic jacket sewing operations in Bangladesh.

3. Materials and Methodology

This study was conducted on an active jacket assembly line at Patriot Eco Apparel Ltd., located in Gazipur, Bangladesh. The empirical investigation spanned a total production period of 32 working days, divided into two distinct 16-day monitoring phases: Phase 1 (Baseline / Pre-PDCA Implementation in August 2020) and Phase 2 (Evaluation / Post-PDCA Implementation in September 2020).

3.1 Product Specifications and Bill of Materials

The target garment for this case study was a standard men's basic denim/twill outerwear jacket. The complete Bill of Materials (BOM) utilized during assembly on the sewing line is detailed below:

• **Shell Fabric:** 100% Cotton woven denim / heavy twill (320-350 GSM) providing structural shape and weather resistance.

• **Lining Fabric:** 100% Polyester taffeta lining (70-80 GSM) used for inner body and sleeve lining.

• **Interlining:** Non-woven fusible interlining (40 GSM) applied to the collar, front plackets, and pocket flaps for stiffness.

• **Sewing Thread:** Core-spun 100% polyester sewing thread (Ticket 40 for heavy stress seams, Ticket 80 for internal assembly).

• **Trims & Accessories:** Heavy-duty brass front zipper, metal press snap buttons, brand/care woven labels, and synthetic shoulder padding.

3.2 PDCA Research Framework

The methodology followed a rigorous four-stage PDCA implementation structure:

• **1. Plan Stage:** Audited end-line daily inspection reports over 16 days (N1 = 3,200 jackets). Categorized defect frequencies using Pareto analysis to isolate the 'vital few' defect types. Formulated fishbone diagrams and 5WH questions to determine underlying root causes.

• **2. Do Stage:** Executed targeted shop-floor corrective actions on the active sewing line. Interventions included machine maintenance, needle size/type adjustments, thread tension standardization, operator double-handling training, and seam guide installation.

• **3. Check Stage:** Conducted a secondary 16-day quality audit post-intervention across an identical sample size (N2 = 3,200 jackets). Monitored daily defect rates, First Time Through (FTT) yield, and defect category shifts.

• **4. Act Stage:** Standardized effective corrective actions into permanent factory standard operating procedures (SOPs), machine setup checklists, and daily pre-production line balancing protocols.

4. Results and Discussion

4.1 Pre-Implementation Defect Diagnosis (Baseline Phase)

During the 16-day baseline observation period (August 2020), end-line quality controllers audited 3,200 basic jackets. A total of 720 sewing defects were detected, establishing an average baseline defect rate of 22.50%. Pareto analysis was conducted to rank and classify these non-conformances based on frequency and cumulative percentage impact.

Table 1
Baseline Sewing Defect Frequency and Pareto Classification (Pre-PDCA Phase, N = 3,200)

Defect Category	Defect Count (pcs)	Defect Percentage (%)	Cumulative Percentage (%)	Pareto Status
Broken Stitch	216	30.00%	30.00%	Vital Few
Skip Stitch	180	25.00%	55.00%	Vital Few
Open Seam	126	17.50%	72.50%	Vital Few
Pleat	72	10.00%	82.50%	Vital Few
Puckering	54	7.50%	90.00%	Vital Few
Down Stitch	36	5.00%	95.00%	Vital Few
Others (Oil Stain, Label Missing, etc.)	36	5.00%	100.00%	Useful Many

As demonstrated in Table 1, six major sewing defect categories—Broken Stitch, Skip Stitch, Open Seam, Pleat, Puckering, and Down Stitch—accounted for 95.00% of total quality failures. Addressing these six core defect types was established as the primary focus during the subsequent 'Do' phase.

4.2 Cause-and-Effect Analysis and Corrective Actions (Do Phase)

Fishbone (Ishikawa) diagrams were constructed for each major defect type, categorizing root causes across Man, Machine, Material, and Method. The 5WH framework (Who, What, Where, When, Why, How) was then applied to formulate specific, targeted remedies.

Table 2
Comprehensive Root Cause Analysis and Implemented Corrective Actions

Defect Category	Identified Root Causes (Fishbone Analysis)	Executed Shop-Floor Interventions
Broken Stitch	• Excessive needle thread tension • Blunt or burred needle points • Excessive needle friction at high speeds • Incorrect thread path threading	• Standardized tension settings using digital tension meters • Replaced worn needles with ball-point needles (Nm 90/14) • Applied silicone needle coolant oil • Re-threaded machine guides per SOP
Skip Stitch	• Incorrect hook/looper timing • Bent needle curvature • Insufficient presser foot pressure • Excessive machine vibration	• Re-timed hook clearance gap to 0.05–0.10 mm • Implemented daily needle straightness checks • Adjusted presser foot spring tension • Serviced and balanced sewing head mounts
Open Seam	• Operator margin misalignment • Uneven fabric feeding on heavy joins • Low seam allowance • Rushing at seam ends	• Installed magnetic edge seam guides on throat plates • Conducted operator retraining on double-layer handling • Enforced mandatory 1/2 inch seam allowance • Re-balanced sewing line workstation cycle times
Pleat	• Differential feeding mismatch • Excessive presser foot pressure • Uneven manual fabric pulling	• Re-aligned upper and lower feed dogs • Reduced presser foot pressure for lining joins • Trained operators on relaxed fabric feeding technique
Puckering	• Thread tension too high for lining • Structural jamming from thick thread • Worn feed dog teeth	• Reduced bobbin and needle thread tension • Switched to finer Ticket 80 thread for linings • Replaced worn feed dogs and throat plate inserts
Down Stitch	• Lack of seam tracking guidelines • Poor operator focus/fatigue • Unstable fabric positioning	• Marked stitch line templates on complex curves • Introduced ergonomic seating and lighting

Defect Category	Identified Root Causes (Fishbone Analysis)	Executed Shop-Floor Interventions
		• Added fabric holding clamps on assembly tables

4.3 Post-Implementation Results and Comparison (Check Phase)

In the 16-day post-implementation evaluation phase (September 2020), an identical sample size of N2 = 3,200 basic jackets was inspected. Total defect occurrences plummeted from 720 pieces to 208 pieces, representing an overall 71.11% reduction in total defect counts. The average sewing defect rate dropped from 22.50% to 6.50%, achieving a net quality improvement of 16.00%.

Table 3
Comparative Analysis of Sewing Quality Before and After PDCA Implementation

Defect Category	Pre-PDCA Count (N = 3200)	Post-PDCA Count (N = 3200)	Count Reduction (pcs)	Improvement (%)
Broken Stitch	216 pcs (6.75%)	58 pcs (1.81%)	-158 pcs	73.15% Reduction
Skip Stitch	180 pcs (5.63%)	46 pcs (1.44%)	-134 pcs	74.44% Reduction
Open Seam	126 pcs (3.94%)	38 pcs (1.19%)	-88 pcs	69.84% Reduction
Pleat	72 pcs (2.25%)	22 pcs (0.69%)	-50 pcs	69.44% Reduction
Puckering	54 pcs (1.69%)	18 pcs (0.56%)	-36 pcs	66.67% Reduction
Down Stitch	36 pcs (1.13%)	12 pcs (0.38%)	-24 pcs	66.67% Reduction
Others	36 pcs (1.13%)	14 pcs (0.44%)	-22 pcs	61.11% Reduction
Total Defects / Average Defect Rate	**720 pcs (22.50%)**	**208 pcs (6.50%)**	**-512 pcs (-16.00%)**	**71.11% Overall Reduction**

4.4 Financial and Operational Impact Analysis

Beyond percentage defect reductions, minimizing sewing defects generates immediate financial and operational benefits on the factory floor:

- • **Direct Labor Cost Savings**: By eliminating 512 defect occurrences per 3,200 jackets, the factory saved approximately 85.3 hours of off-line unpicking and re-stitching labor per month, allowing operators to focus entirely on direct production.
- • **Material Savings**: Reduced unpicking preserved fabric strength around needle holes, eliminating garment rejections and saving high-value denim and lining yardage.

- • **First Time Through (FTT) Yield**: FTT yield increased from 77.50% to 93.50%, drastically reducing end-line inspection bottlenecking and ensuring on-time shipment schedules.

5. Conclusion

This empirical study conclusively validates the application of Deming's Plan-Do-Check-Act (PDCA) quality management framework for minimizing sewing defects in basic jacket manufacturing. By systematically integrating Pareto analysis, cause-and-effect (fishbone) diagrams, and targeted shop-floor interventions at Patriot Eco Apparel Ltd. in Gazipur, Bangladesh, total sewing defect occurrences were reduced from 720 to 208 pieces across identical production sample sizes of 3,200 jackets. The average defect rate decreased from 22.50% to 6.50%, achieving a 16.00% net quality improvement and a 71.11% overall reduction in non-conformances.

The findings demonstrate that achieving dramatic quality gains in outerwear assembly does not require expensive capital investments in automated sewing heads. Instead, low-cost, systematic process controls—such as standardizing thread tension, replacing blunt needles, adjusting feed dog heights, installing magnetic seam guides, and conducting refresher training for sewing operators—deliver rapid and sustainable results. Standardizing these practices into permanent factory SOPs provides garment manufacturers with a practical, scalable blueprint to lower production costs, increase throughput yield, and satisfy stringent international quality standards.

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Figures

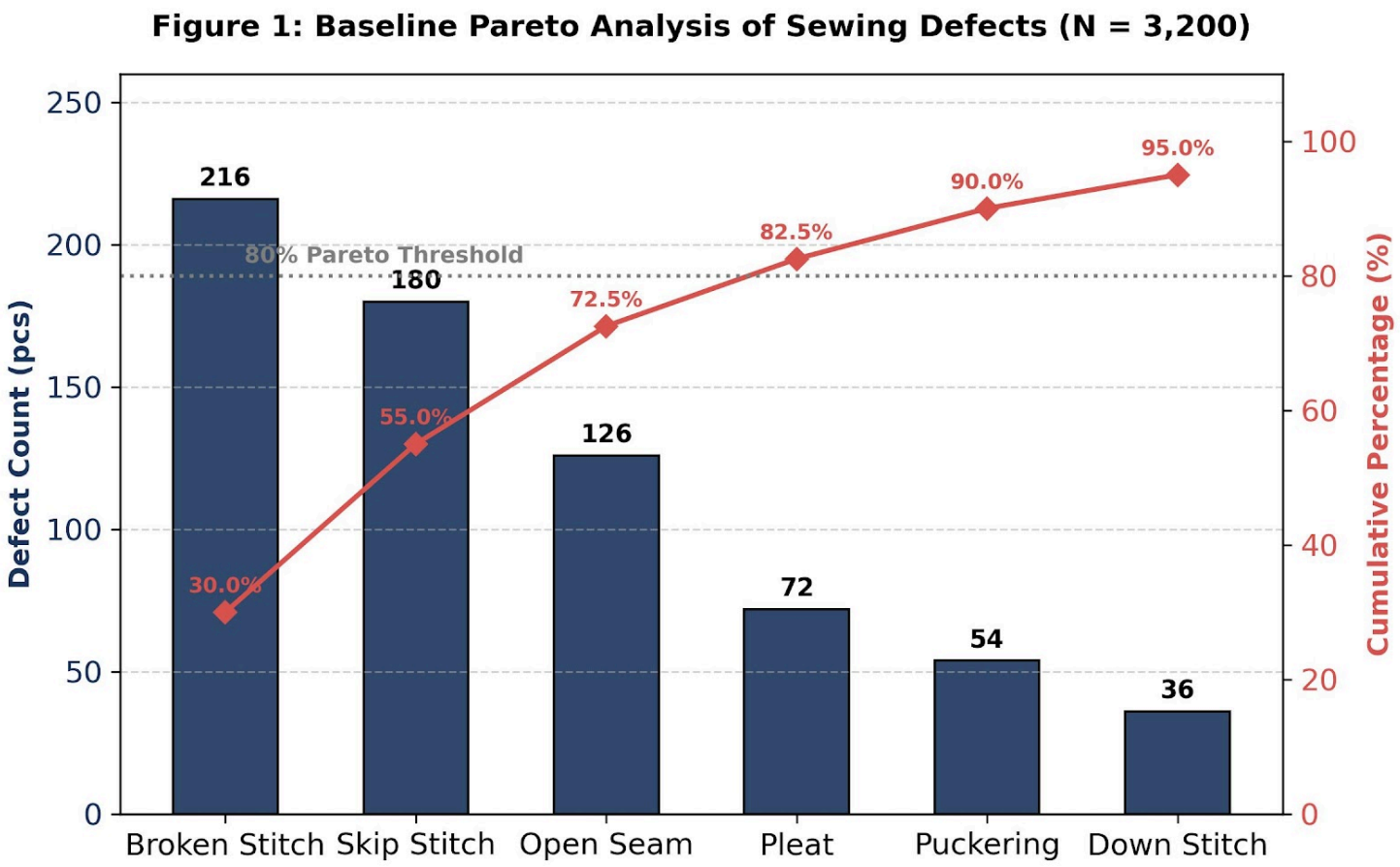


Figure 1

Pareto chart illustrating the relative frequencies and cumulative percentage distribution of sewing defects audited during the 16-day baseline observation period prior to PDCA implementation. The primary y-axis displays defect quantities (pieces), while the secondary y-axis shows the cumulative percentage. The six dominant defect types—broken stitch (30.0%), skip stitch (25.0%), open seam (17.5%), pleat (10.0%), puckering (7.5%), and down stitch (5.0%)—collectively account for 95.0% of total non-conformances, crossing the critical 80% Pareto threshold.

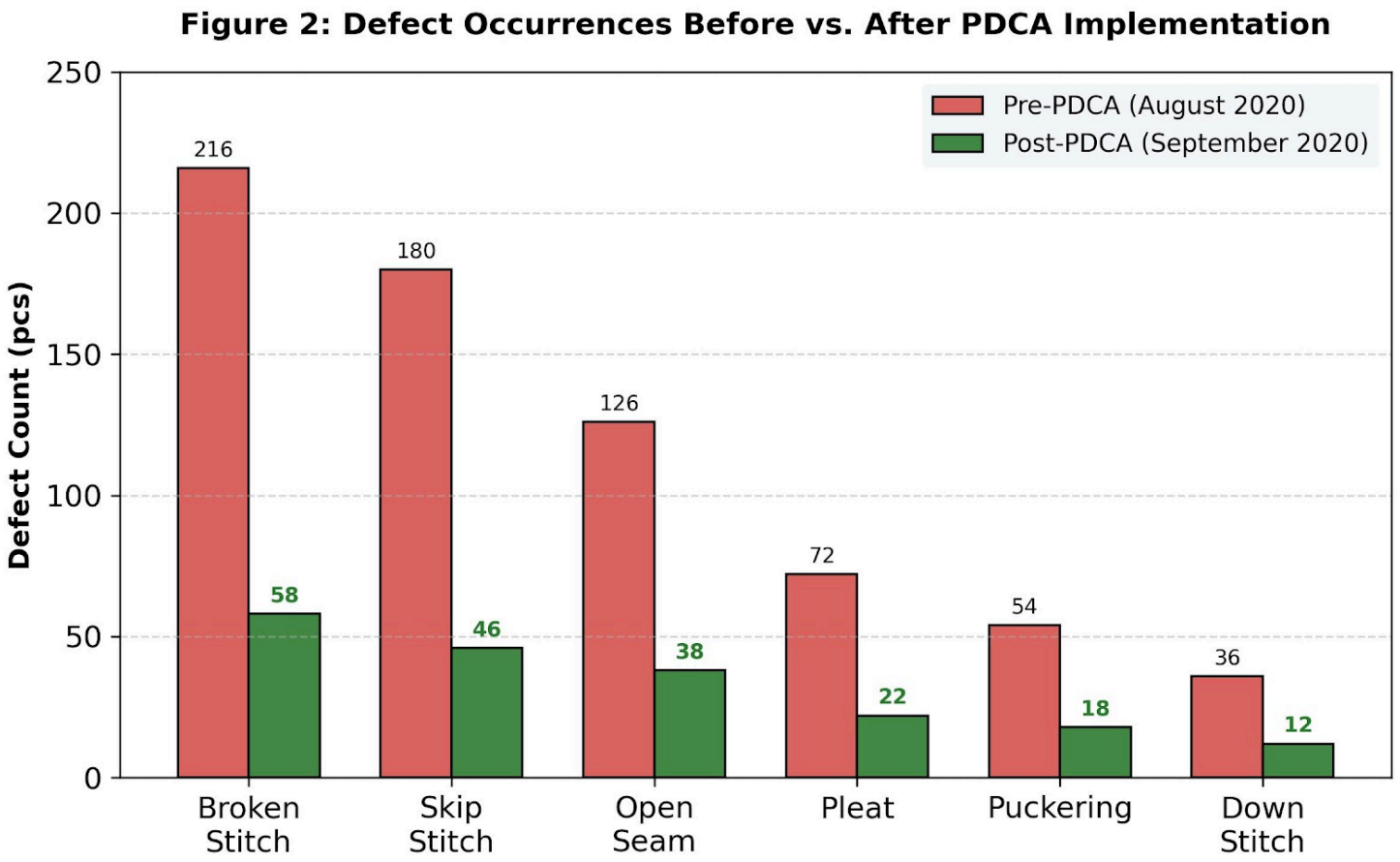


Figure 2

Comparative bar chart displaying absolute defect counts across major sewing defect categories before (August 2020) and after (September 2020) PDCA cycle execution. Red bars represent baseline defect frequencies ($N_1 = 3,200$), and green bars represent post-intervention defect frequencies ($N_2 = 3,200$). Substantial reductions were observed across all non-conformance types, led by skip stitch (-74.4%) and broken stitch (-73.1%).

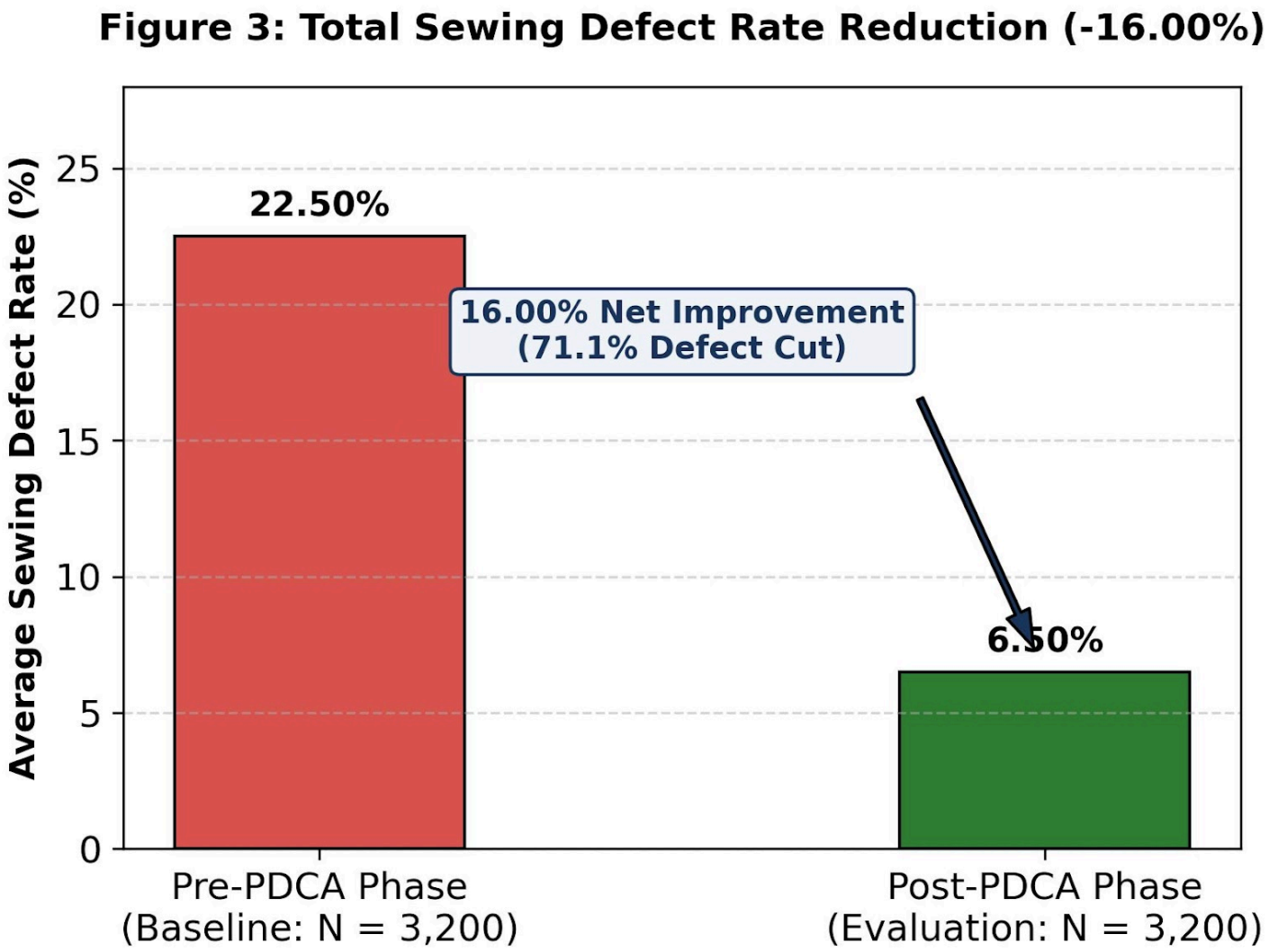


Figure 3

Overall quality performance trend highlighting the reduction in average sewing defect rate from 22.50% ($N_1 = 3,200$) to 6.50% ($N_2 = 3,200$) following shop-floor PDCA interventions. The implementation achieved a 16.00% net absolute quality improvement, corresponding to a 71.1% overall reduction in total defective garments.