

## Analyzing The Role Of The PDCA Method In Supporting Continuous Improvement: A Case Study Of A Coal Mining Contractor In South Kalimantan

<sup>1\*</sup>Regiano Al-Alif, <sup>2</sup>Anjar Priyono

<sup>1,2</sup> Management, Faculty of Business and Economics, Universitas Islam Indonesia, Yogyakarta 55584, Indonesia

Email: <sup>1\*</sup>[21311486@students.uui.ac.id](mailto:21311486@students.uui.ac.id), <sup>2</sup>[073110101@uui.ac.id](mailto:073110101@uui.ac.id)

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### ABSTRACT

The mining industry operates in a high-risk environment in which transportation activities contribute significantly to occupational accidents and operational losses. In Indonesia, transportation-related incidents in mining operations remain a critical safety issue, highlighting the need for systematic and sustainable improvement approaches. This study aims to analyze the implementation of the Plan-Do-Check-Act (PDCA) method as a continuous improvement framework in reducing transportation-related incidents within a coal mining contractor operating in South Kalimantan.

This study employs a qualitative case study approach. Data were collected through direct field observations conducted during an industrial internship, semi-structured interviews with key personnel involved in the improvement program, and analysis of internal company documents related to safety performance and continuous improvement initiatives. The PDCA framework was used as the primary analytical lens to examine improvement activities across the planning, implementation, evaluation, and standardization stages.

The findings indicate that the PDCA method was effectively implemented to identify dominant transportation safety risk factors, particularly unsafe driving behavior and limitations in manual monitoring systems. Improvement actions implemented during the Do stage included the adoption of digital fit-for-duty systems, enhanced transportation monitoring technologies, and strengthened supervisory coaching. The Check stage demonstrated measurable improvements in safety compliance and reductions in unsafe driving behavior, while the Act stage focused on standardizing successful practices to support sustainability.

This study concludes that the PDCA method functions as an effective continuous improvement tool for strengthening transportation safety management in high-risk mining operations. The findings provide practical insights for mining contractors seeking to enhance safety performance through structured, data-driven, and sustainable improvement cycles.

**Keywords:** PDCA, Continuous Improvement, Mining Transportation, Safety Management, Case Study

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## **Introduction**

The mining industry in the current era of industrial globalization faces increasingly complex demands related to operational efficiency, occupational safety, and sustainability [1], [2]. Mining companies across various countries are under constant pressure to reduce workplace accidents, control operational costs, and improve the quality of human resources through the implementation of adaptive and sustainable management systems [3]. According to the International Labour Organization (ILO, 2023), the mining sector remains one of the industries with the highest occupational accident rates globally, with more than 250,000 work-related incidents recorded annually [4]. This condition highlights that safety management is not merely a technical issue but a strategic managerial concern that requires structured and continuous improvement-based approaches [5], [6].

In Indonesia, the coal mining industry plays a crucial role as one of the pillars of national economic development [7]. Despite its significant contribution to state revenue and employment, this sector continues to face serious challenges related to occupational safety and operational effectiveness [8]. Data from the Ministry of Energy and Mineral Resources (2023) indicate that, over the last five years, an average of approximately 120 workplace accidents have occurred annually in coal mining areas, with the majority attributed to human error and weak field supervision [9]. This situation emphasizes the need for management approaches that not only reduce operational risks but also foster disciplined and safety-oriented work cultures in high-risk environments such as mining operations [10], [11].

One management approach that is widely adopted to address such challenges is the Plan-Do-Check-Act (PDCA) method [12]. PDCA is designed as a systematic and result-oriented improvement cycle that enables organizations to identify problems, implement corrective actions, evaluate outcomes, and standardize successful practices [13]. In the context of mining operations, PDCA is particularly relevant because it does not function solely as a quality control tool, but also as a strategic framework for developing a culture of continuous improvement within high-risk working environments [14], [15].

This context is reflected in the operational environment of a coal mining contractor company operating in South Kalimantan, which serves as the focus of this study. This research is grounded in the author's direct experience during an industrial internship, where the author was assigned to a unit responsible for managing continuous improvement initiatives and operational performance evaluation. Through this involvement, the author gained direct exposure to the processes, challenges, and decision-making mechanisms related to safety improvement programs in mining transportation activities.

Based on the author's field observations and analysis of internal continuous improvement documentation, it was identified that during the period from January to July 2023, seven incidents involving mining transportation facilities occurred, resulting in significant material losses. Preliminary analysis indicated that the primary contributing factors to these incidents were operator behavior, limited effectiveness of manual supervision systems, and reporting mechanisms that were not yet real-time [16], [17]. Importantly, these incidents were predominantly human-related, indicating that they could be addressed through structured managerial and behavioral interventions [18].

In response to these conditions, the company initiated an Integrated Transport Management improvement program that was integrated with the PDCA method. The program aimed to reduce transportation-related incidents while simultaneously strengthening operational supervision systems. The implementation of this initiative produced positive outcomes, including the achievement of zero transportation accidents during the implementation period and a significant improvement in driver

fitness validation compliance, which increased from 31% to 100%. Due to the author's direct involvement in the implementation and monitoring of this program, the discussion of PDCA in this study is not limited to theoretical perspectives but is deeply informed by practical field experience.

Beyond technical outcomes, this improvement initiative also illustrates a broader transformation in work culture toward a management system based on learning and continuous improvement [19], [20]. The application of PDCA in this program involved social and psychological aspects of the workforce, such as increased safety awareness, changes in driver behavior, and improved work morale resulting from a safer and more controlled working environment [21]. However, from an academic perspective, there remains a need for deeper qualitative understanding of how PDCA influences continuous improvement dynamics, particularly in relation to interactions between individuals, leadership, and organizational culture in field operations [22].

Prior to this study, evaluations of safety improvement programs within the company were largely focused on quantitative indicators and numerical performance outcomes [23]. In contrast, this research offers a distinct contribution by combining internal company data with field-based findings obtained through interviews and direct observation [24]. Through this qualitative approach, the study seeks to explore the meaning behind observed changes, rather than assessing success solely based on numerical outcomes.

Based on the above considerations, this study is conducted to comprehensively understand how the implementation of the PDCA method contributes to building and strengthening a culture of continuous improvement within mining operations, particularly in the context of transportation safety [25], [26]. The study focuses on the application of PDCA within an Integrated Transport Management initiative and analyzes social, organizational, and operational factors influencing its effectiveness. The data used in this research are derived from interviews, field observations, and internal documentation, while the analysis and interpretation reflect the author's own analytical reasoning based on empirical findings. Consequently, this study is expected to contribute both theoretically to the development of operational management and occupational safety literature, and practically to mining companies seeking to design human-centered and system-based continuous improvement strategies [27].

## **Methods**

This study employed a qualitative research approach using a case study design. A qualitative case study is particularly appropriate for examining contemporary phenomena in real-life contexts, especially when the boundaries between the phenomenon and its context are not clearly evident [16]. According to Robert K. Yin (2018), case study research is well suited for addressing "how" and "why" research questions and for exploring processes, mechanisms, and contextual conditions in depth [16], [17]. In line with this perspective, the present study sought to understand how the Plan-Do-Check-Act (PDCA) method was implemented to support continuous improvement within a mining transportation safety initiative.

The phenomenon under investigation was the application of the PDCA method as part of a continuous improvement program aimed at reducing transportation-related incidents in a large coal mining contractor in Indonesia. The research adopted a naturalistic and interpretative stance, as it focused on understanding how PDCA was implemented and experienced in practice without manipulating research variables or experimental conditions [18]. This approach allowed the researcher to capture the meanings, interactions, and operational dynamics associated with PDCA implementation as they occurred in the field [19].

## **1. Unit of Analysis**

The unit of analysis in this study consisted of the project leader and team members directly involved in the transportation incident reduction initiative during the September 2023–April 2024 period. These individuals were selected because of their direct participation in planning, implementing, monitoring, and evaluating PDCA-based continuous improvement activities [20]. By including both managerial and operational actors, the study was able to capture perspectives from multiple organizational levels, thereby providing a more comprehensive understanding of how PDCA was applied, interpreted, and evaluated in practice [21].

## **2. Data Sources and Data Collection**

This study utilized both primary and secondary data sources to ensure a comprehensive understanding of the research phenomenon [22].

Primary data were collected through in-depth interviews and direct field observations. Semi-structured interviews were conducted with the project leader and team members involved in the improvement initiative. An interview guide was prepared in advance to ensure consistency while allowing flexibility for probing questions [23]. Prior to each interview, participants were informed about the research objectives, ethical considerations, and confidentiality of responses to encourage open and honest communication. During the interviews, the researcher actively listened, recorded key points, and allowed participants to elaborate on experiences and perceptions that were relevant to PDCA implementation.

In addition to interviews, direct observation was conducted during the researcher's internship period. Observations focused on daily operational activities related to transportation safety, PDCA implementation practices, interactions between supervisors and operators, and the use of monitoring and reporting systems [24]. Field notes were recorded systematically in the form of observation logs to document activities, behaviors, and contextual conditions relevant to the research objectives.

Secondary data were obtained from two main sources. First, a literature review was conducted to examine academic studies related to PDCA, continuous improvement, and safety management in mining and other high-risk industries [25]. This review provided a theoretical foundation and supported the interpretation of empirical findings. Second, internal company documents were analyzed, including continuous improvement reports, safety records, standard operating procedures, and documentation related to the transportation safety initiative. These documents were used to contextualize field data and to examine how PDCA principles were formally embedded in organizational practices [26].

## **3. Research Instruments**

The primary research instruments used in this study included audio recording devices for interviews, a camera for visual documentation, notebooks for field notes, and a laptop for data organization and analysis. An interview guide was also developed to structure the interview process while allowing flexibility to explore emerging themes [27].

## **4. Data Triangulation**

To enhance the credibility and trustworthiness of the findings, data triangulation was applied. Triangulation is a technique used to validate data by comparing information obtained from different sources and methods [28]. Source triangulation was conducted by comparing interview data across different informants to identify consistency and variation in perspectives. Technique triangulation was achieved by cross-checking findings derived from interviews, observations, and document analysis [29]. This approach enabled the researcher to develop a more robust and comprehensive understanding of PDCA implementation.

## **5. Data Analysis**

Data analysis followed an interactive and iterative qualitative analysis process as proposed by Miles, Huberman, and Saldaña [30]. The analysis involved three main stages: data reduction, data display, and conclusion drawing.

Data reduction involved selecting, simplifying, and organizing raw data obtained from interviews, observations, and documents to focus on information directly related to PDCA implementation and continuous improvement [30]. Relevant excerpts were coded and grouped into thematic categories. Data display was conducted by organizing coded data into thematic matrices and narrative descriptions to facilitate pattern recognition and comparison across data sources. Finally, conclusions were drawn through an iterative process of interpretation and verification, ensuring that emerging findings were consistently supported by empirical evidence from multiple data sources [31].

## **Results and Discussion**

This study presents the results of a qualitative analysis of a continuous improvement initiative implemented through the Plan-Do-Check-Act (PDCA) method in a mining transportation safety context [12], [13]. The findings describe how PDCA was applied by the project team to identify operational problems, design and implement corrective actions, monitor performance outcomes, and standardize new work procedures. Data were derived from field observations, in-depth interviews, and internal continuous improvement documentation, allowing for a comprehensive understanding of the effectiveness of PDCA implementation in supporting safety-oriented and efficiency-driven operational practices [5], [6].

The improvement initiative focused on reducing transportation-related incidents and strengthening operational control through systematic monitoring, behavioral interventions, and procedural standardization. The findings demonstrate that PDCA was not implemented as a purely technical tool but functioned as an integrated management approach involving cross-functional collaboration, digital monitoring systems, and continuous evaluation mechanisms [14], [15].

### **A. Continuous Improvement Process Based on the PDCA Cycle**

#### **1. Plan: Problem Identification and Improvement Design**

The Plan phase began with a structured identification of transportation-related incidents based on incident trend data recorded between January and July 2023. During this period, seven transportation incidents were documented, prompting a comprehensive root cause analysis. Interviews with the project leader and supporting documentation indicated that the analysis process employed fishbone diagrams, Pareto analysis, and why analysis to ensure that contributing factors were systematically identified [1], [12].

The results revealed that human error constituted the dominant contributing factor, followed by weaknesses in manual monitoring systems and delayed feedback mechanisms. These findings align with the principles of PDCA planning as emphasized by W. Edwards Deming, who argued that effective planning must be grounded in empirical data rather than assumptions [23]. In this case, planning activities extended beyond numerical incident data to include field conditions, behavioral compliance issues, and limitations of existing reporting systems [5].

Based on this analysis, the project team established a clear and measurable improvement objective: reducing transportation-related incidents from seven to zero during the implementation period. To achieve this target, a strategic improvement program referred to as Integrated Transport Management was designed for implementation between September 2023 and April 2024. The planning process was conducted collaboratively, involving safety, production, maintenance, and business excellence functions. This cross-functional approach ensured that improvement actions addressed operational, behavioral, and systemic dimensions simultaneously, reflecting the core principles of continuous improvement [6], [11].

## **2. Do: Implementation of Improvement Actions**

The Do phase translated the improvement plan into concrete operational actions. Implementation involved multiple coordinated interventions aimed at addressing the identified root causes. One of the primary actions was the digitalization of operator readiness validation through an online “fit-for-duty” system. Prior to implementation, validation rates were low, indicating limited effectiveness of manual processes. Following digitalization, validation compliance increased substantially, enabling supervisors to monitor operator readiness in real time [15], [24].

In addition, a real-time telematics and dispatch system was deployed across transportation units. This system enabled continuous monitoring of vehicle speed, operating hours, idling behavior, and unsafe driving patterns. The transition from reactive supervision to proactive monitoring allowed immediate detection of deviations from standard operating procedures. When violations were identified, designated personnel intervened directly through on-site coaching to prevent recurrence [16].

These implementation practices reflect the concept of process discipline and visual control discussed by Jeffrey K. Liker, where transparency and real-time feedback support consistent operational behavior [24]. Furthermore, the use of digital systems to prevent data manipulation aligns with the principle of error-proofing (poka-yoke) introduced by Shigeo Shingo, which emphasizes designing systems that minimize the likelihood of human error [25].

Another key intervention involved increasing the frequency of Drug, Alcohol, and Fatigue Testing (DDT). Previously conducted on an annual basis, DDT was rescheduled to occur more regularly during the implementation period. Internal documentation indicated a strong association between increased testing frequency and a reduction in safety-related reports, suggesting that enhanced monitoring contributed to improved behavioral compliance [18].

Importantly, implementation efforts were not limited to technical controls. Coaching by supervisors and designated personnel played a central role in shaping operator behavior. This approach reflects the respect for people principle within continuous improvement philosophy, emphasizing behavioral change through guidance and engagement rather than punitive measures alone [7], [8].

## **3. Check: Performance Evaluation and Monitoring**

The Check phase focused on evaluating the effectiveness of implemented actions using multiple performance perspectives. Evaluation activities were conducted through regular weekly and monthly reviews, supported by data from telematics systems, readiness validation records, and safety reports compiled during the September 2023–April 2024 period [22].

Performance evaluation was conducted across five dimensions: productivity, safety, quality, cost, and morale. From a productivity perspective, the elimination of transportation incidents resulted in the removal of production losses previously associated with operational disruptions. Enhanced monitoring also reduced idle time and inefficiencies, contributing to more effective use of transportation units [14].

Safety performance exhibited the most pronounced improvement. Transportation-related incidents were reduced from seven cases to zero, while operator readiness validation increased from 31% to full compliance. Safety hotline reports related to unsafe behavior declined in parallel with increased monitoring and testing activities. These findings demonstrate that PDCA-based evaluation mechanisms provided timely feedback that supported corrective action and learning [12], [15].

Quality improvements were reflected in faster decision-making and more consistent supervision enabled by real-time monitoring systems. From a cost perspective, property damage losses associated with transportation incidents were eliminated, resulting in measurable financial benefits. Additionally, the use of internal trainers for operator development reduced training-related costs without compromising effectiveness [6].

The inclusion of multiple evaluation dimensions aligns with the holistic performance assessment approach proposed by John S. Oakland, which emphasizes that continuous improvement outcomes should be assessed beyond single performance indicators [26].

#### **4. Act: Standardization and Institutionalization**

The Act phase focused on standardizing successful improvement practices to ensure sustainability. Following positive evaluation results, new procedures were formally documented and integrated into the organization's safety management system. These procedures included mandatory use of digital readiness validation, telematics-based monitoring, structured coaching mechanisms, and regular internal audits [23].

Standardization activities reflect Deming's principle that improvement must be institutionalized through formal procedures to prevent regression [23]. Regular review meetings and continuous improvement forums were established to reinforce learning and adaptation. Interview findings indicated that operators demonstrated increased safety awareness, while supervisors applied monitoring and coaching practices more consistently [19].

Importantly, standardization extended beyond procedural documentation to influence organizational culture. The sustained application of PDCA fostered a shared responsibility for safety and continuous improvement, reinforcing behavioral norms aligned with disciplined and data-driven decision-making [20], [24].

#### **B. Qualitative Analysis of Observations and Interviews**

Qualitative analysis of observational and interview data provided deeper insight into the mechanisms through which PDCA supported continuous improvement. Field observations revealed that prior to digital system implementation, manual reporting processes were often treated as formalities and did not accurately reflect actual operator conditions [21]. Following digitalization, initial resistance and technical challenges emerged, requiring adaptation by both operators and supervisors [18].

Interviews highlighted that behavioral resistance gradually declined as operators recognized the consistency and transparency of monitoring systems. Coaching interactions played a critical role in this transition, enabling behavioral change through dialogue and feedback [7]. Discrepancies between manual records and digital data prior to PDCA implementation further underscored the importance of disciplined planning and evaluation phases [12].

Overall, qualitative findings confirm that PDCA functioned as an integrated improvement mechanism that combined technical controls, behavioral interventions, and cultural reinforcement. These findings support Masaaki Imai's assertion that continuous improvement emerges through sustained, incremental change rather than isolated interventions [27].

### **C. Discussion**

The results demonstrate that PDCA effectively supported continuous improvement in mining transportation safety by enabling systematic problem identification, structured implementation, comprehensive evaluation, and sustainable standardization [5], [12]. Rather than producing short-term performance gains, PDCA facilitated organizational learning and behavioral alignment across operational levels [14].

By integrating digital monitoring systems with human-centered interventions, the initiative addressed both technical and social dimensions of safety management. This finding reinforces the relevance of PDCA as a practical framework for continuous improvement in high-risk industrial settings, particularly when supported by leadership commitment, cross-functional collaboration, and disciplined evaluation processes [6], [15].

### **Conclusion**

This study examined the implementation of the Plan–Do–Check–Act (PDCA) method in supporting continuous improvement, particularly in reducing transportation-related incidents within a mining operational context [12], [13]. Using a qualitative case study approach based on in-depth interviews, field observations during an internship period, and analysis of internal continuous improvement documentation, the study provides a comprehensive understanding of how PDCA was applied in practice and how it contributed to safety improvement outcomes [16], [17].

The findings demonstrate that the PDCA method was effectively implemented across all stages. In the Plan phase, systematic problem identification was achieved through incident trend analysis, Pareto analysis, and fishbone diagrams. The results indicated that human error, limited supervision, and manual monitoring systems were the dominant root causes of transportation incidents. The establishment of a clear and measurable improvement target—reducing incidents from seven to zero—along with the design of an Integrated Transport Management initiative, reflects alignment with PDCA principles and continuous improvement theory [5], [12].

The Do phase resulted in tangible operational and behavioral changes through the implementation of digital readiness validation, telematics-based monitoring, structured coaching, routine inspections, and cross-functional collaboration. These interventions strengthened operator supervision, improved compliance with standard operating procedures, and reduced the likelihood of human error. Field evidence indicated increased operator discipline, enhanced transparency of monitoring systems, and more consistent enforcement of safety standards, consistent with human-centered continuous improvement principles [7], [24].

During the Check phase, continuous evaluation was conducted through weekly and monthly reviews using data-driven indicators related to safety, productivity, quality, cost, and morale. The evaluation results showed significant performance improvements, including full compliance in readiness validation, reductions in unsafe driving behavior, stable unit readiness, and the elimination of transportation-related losses. These findings confirm that PDCA functioned as an active and measurable monitoring cycle rather than an administrative formality [14], [26].

Finally, the Act phase focused on standardizing successful improvements through updated procedures, revised standard operating procedures, continuous coaching mechanisms, and strengthened digital system integration. This stage supported the institutionalization of improvements and contributed to a shift toward a proactive and learning-oriented safety culture [23], [27].

Overall, this study concludes that PDCA is an effective and relevant approach for driving continuous improvement in mining transportation safety. Beyond quantitative outcomes, PDCA facilitated behavioral change, improved supervisory quality, enhanced data accuracy, and supported the development of a structured and sustainable safety management culture [2], [6].

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