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Effectiveness of the Safety Friendly Program in reducing accident frequency rate

Naim Fathoni*, Doni Hikmat Ramdhan

Program Studi Magister Keselamatan dan Kesehatan Kerja, Fakultas Kesehatan Masyarakat, Universitas Indonesia
Corresponding author: *E-mail: naimfathony@gmail.com

Abstract

Background: Occupational accidents remain a major challenge in the mining industry because mining operations involve complex activities and high-risk working conditions. To prevent accidents and improve safety performance, PT X implemented the Safety Friendly Program, which includes safety observations, safety inspections, and management engagement activities. An evaluation of the program is needed to determine whether its implementation is accompanied by an improvement in occupational safety performance.
Purpose: To analyze the effectiveness of the Safety Friendly Program in reducing the Accident Frequency Rate (AFR) at PT X.
Method: A quantitative approach with a time-series comparative design. Secondary data were obtained from the Health, Safety, and Environment Department of PT X from July 2025 to March 2026. The data included safety observations, safety inspections, management engagement activities, and AFR. Data were analyzed descriptively using IBM SPSS Statistics version 25 and presented in tables and trend analyses to compare changes across the study periods.
Results: The Safety Friendly Program was implemented consistently throughout the study period. Safety observations reached 513 activities in the third quarter of 2025, 512 activities in the fourth quarter of 2025, and 494 activities in the first quarter of 2026. Safety inspection findings increased from 279 in the fourth quarter of 2025 to 290 in the first quarter of 2026. The number of workers involved in management engagement activities also increased from 293 in the third quarter of 2025 to 309 in the first quarter of 2026. During the same period, AFR decreased from 10.57 in the third quarter of 2025 to 8.02 in the fourth quarter of 2025 and further declined to 3.07 in the first quarter of 2026. Overall, AFR decreased by 70.96%.
Conclusion: The consistent implementation of the Safety Friendly Program was accompanied by a substantial decline in AFR during the study period. Safety observations, safety inspections, and management engagement activities may support accident prevention and strengthen safety practices in mining operations. However, this descriptive trend should not be interpreted as evidence of a causal relationship. Continued implementation and periodic evaluation are recommended to improve occupational safety performance.

Keywords: Accident Frequency Rate; Management Engagement; Mining Industry; Occupational Safety; Safety Friendly Program.

INTRODUCTION

The mining industry is a strategic sector that plays an important role in supporting national economic growth through its contributions to state revenue, employment, and regional development. However, mining is also recognized as a high-risk industry because its operations involve heavy equipment, hazardous activities, dynamic working conditions, and exposure to various physical, chemical, and mechanical hazards (Tarwaka, 2014; Tian, Wang, & Gao, 2022).

The International Labour Organization (ILO) reported that occupational accidents and work-related diseases cause more than 2.78 million deaths worldwide each year, while approximately 374 million workers experience non-fatal occupational accidents

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(International Labour Organization, 2019). In Indonesia, data from BPJS Employment showed that the number of occupational accident cases increased from 114.000 in 2019 to more than 177.000 in 2020 (Ministry of Manpower of the Republic of Indonesia, 2022). In the mining sector, occupational accidents are generally caused by a combination of human factors, unsafe conditions, unsafe acts, and inadequate operational supervision in the workplace (Hannani, Bascompta, Sabzevar, Dehghani, & Khajevandi, 2023; Pranitasari & Alfarius, 2023; Pratiwi, Thamrin, Wahyu, Naiem, Razak, Syam, & Mallongi, 2024).

Theoretically, Heinrich et al. (1980) explained that occupational accidents result from a sequence of interrelated factors, beginning with weaknesses in management control and leading to unsafe actions or conditions (Heinrich, Petersen, & Roos, 1980). Through the Swiss Cheese Model, Reason emphasized that accidents are not solely caused by individual errors but also by weaknesses across multiple layers of an organization's control system (Reason, 2016). Although these two classical frameworks remain relevant, they should be complemented by contemporary safety perspectives that emphasize safety climate, safety leadership, and proactive safety indicators as important drivers of safety performance (Cooper, 2000; Haas & Yorio, 2021; Zhang, Hua, Huang, & Shi, 2022).

To control occupational risks, mining companies are required to implement the Mining Safety Management System (SMKP), as stipulated in the Decree of the Minister of Energy and Mineral Resources Number 1827 K/30/MEM/2018 (Ministry of Energy and Mineral Resources of the Republic of Indonesia, 2018; Wardani, Nursanto, & Amri, 2022). One indicator commonly used to evaluate safety performance is the Accident Frequency Rate (AFR), which measures the number of occupational accidents per one million working hours, with a lower value indicating better company safety performance (Bird, Germain, & Clark, 1990). AFR was selected as the outcome measure because it is a standardized and routinely documented lagging indicator that can be used to compare safety performance across different periods.

PT X, a coal mining contractor operating in East Kalimantan, implements a Safety Friendly Program comprising safety observations, safety inspections, and management engagement activities that are conducted regularly with the direct involvement of company leaders. The program is designed to improve safety communication, strengthen field supervision, identify potential hazards at an early stage, and encourage active worker participation.

Previous studies have shown that behavior-based safety programs and management involvement are associated with reductions in occupational accident rates. Ayuni et al. (2022) reported that the implementation of Behaviour Based Safety (BBS) was associated with a decrease in occupational accidents, while Amirudin et al. (2025) identified a similar pattern in the implementation of the SMART Safety Program in reducing AFR. However, these studies still have several limitations that provide a research gap for the present study (Ayuni, Yusuf, & Dwiyanti, 2022; Amirudin, Triraharjo, Zulkarnaen, Ramli, & Fikriansyah, 2025). First, previous studies have generally focused on individual or single safety interventions, such as behavioral observations within BBS, and therefore have not fully described the contribution of an integrated safety program. Second, most studies have not explicitly linked program components with standardized outcome indicators such as AFR. Third, research conducted specifically in the context of coal mining contractors in Indonesia remains limited.

The novelty of this study lies in evaluating the Safety Friendly Program as an integrated safety intervention that combines safety observations, safety inspections, and direct management involvement within a single program model and relates its implementation to AFR trends in the context of a coal mining contractor.

RESEARCH METHOD

A quantitative approach with a retrospective observational evaluation design and descriptive time-series analysis. A quantitative approach was selected because the study analyzed numerical data on program implementation and occupational safety performance (Creswell & Creswell, 2009). The observation period covered only three quarters, from the third quarter of 2025 to the first quarter of 2026. This period was insufficient for conducting an interrupted time-series analysis or establishing a causal relationship between the program and changes in safety performance. Therefore, the study was not classified as an interrupted time-series study and did not claim to establish the causal effectiveness

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Program Studi Magister Keselamatan dan Kesehatan Kerja, Fakultas Kesehatan Masyarakat, Universitas Indonesia
Corresponding author: *E-mail: naimfathony@gmail.com

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of the program. Instead, it evaluated changes in program implementation and AFR trends during the study period.

The study used secondary data obtained from the Safety, Health, and Environment (SHE) Department of PT X, a coal mining contractor operating in East Kalimantan. The data covered the period from July 2025 to March 2026. Consequently, the total sample size for the monthly observations consisted of nine months (n = 9 months). Data on program implementation, including safety observations, safety inspections, and management engagement activities, were recorded monthly within this nine-month period. Meanwhile, AFR data were documented quarterly, resulting in only three observation points (n = 3 quarters): the third quarter of 2025, the fourth quarter of 2025, and the first quarter of 2026.

The study population consisted of all documented Safety Friendly Program implementation data and occupational accident statistics during the study period. A total sampling technique was applied, meaning that all available data meeting the study criteria were included in the analysis. The program components evaluated were safety observations, safety inspections, and management engagement activities, while AFR was used as the occupational safety performance indicator. AFR was calculated by dividing the number of occupational accidents by the total number of working hours and multiplying the result by 1.000.000, in accordance with the company's safety performance measurement standards.

Data were analyzed using IBM SPSS Statistics version 25. The analysis was limited to descriptive statistics, including the mean, standard deviation, minimum, and maximum values, as well as trend analysis (Ghozali, 2021). Inferential analyses, such as correlation and regression tests, were not performed because AFR was available for only three quarterly observation points. This number was insufficient to generate valid and stable statistical estimates. Therefore, the pattern between Safety Friendly Program implementation and AFR was described by comparing trends across the observation periods rather than testing a statistical relationship.

This study acknowledged several potential confounding factors that could affect AFR independently of the Safety Friendly Program. These factors included total working hours, production targets and operational intensity, the number and characteristics of workers, changes in contractors or subcontractors, variations in operational conditions, other safety initiatives implemented simultaneously, and incident-reporting practices. These factors were not controlled within the research design and were therefore explicitly considered limitations of the study.

The study used secondary data with formal permission from PT X. All information concerning the company's identity and operational data was kept confidential and used solely for research purposes.

RESEARCH RESULTS

Safety Friendly Program Implementation

Table 1. Quarterly Distribution and Monthly Descriptive Statistics of Safety Friendly Program Implementation

Variable	Q3 2025	Q4 2025	Q1 2026	Mean/SD
Program Component (n/%)				
Safety Observations	513/33.77	512/33.71	494/32.52	168.78/13.25
Safety Inspections	284/33.29	279/32.71	290/34.00	94.78/3.87
Management Engagement	293/32.41	302/33.41	309/34.18	100.44/5.15

Note: Descriptive statistics were calculated from monthly data covering nine months. Percentages represent the distribution of each program component across the three observation periods.
Source: Secondary data from PT X, 2026.

Table 1 shows that the Safety Friendly Program was implemented continuously throughout the study period. Safety observations remained relatively stable, safety inspection findings decreased slightly in Q4 2025 before reaching their highest level in Q1 2026, and management engagement increased consistently across the three quarters. The monthly descriptive statistics also indicate relatively consistent implementation, as reflected by the limited variation in each program component.

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Program Studi Magister Keselamatan dan Kesehatan Kerja, Fakultas Kesehatan Masyarakat, Universitas Indonesia
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Trend in Accident Frequency Rate

Table 2. Workforce, Working Hours, Occupational Accidents, and Accident Frequency Rate by Quarter

Period	Workforce, n	Working Hours	Occupational Accidents, n	AFR
Q3 2025	1.899	532.669.50	15	10.57
Q4 2025	2.053	595.062.05	4	8.02
Q1 2026	2.313	724.735.05	6	3.07

Source: Secondary data from PT X, 2026.

As presented in Table 2, AFR decreased from 10.57 in Q3 2025 to 8.02 in Q4 2025 and 3.07 in Q1 2026, representing an overall reduction of 70.96%, despite increases in the workforce and total working hours. This pattern describes a temporal trend during program implementation and should not be interpreted as evidence of a causal relationship.

DISCUSSION

The findings showed that the Safety Friendly Program at PT X was implemented relatively consistently throughout the observation period through three main components: safety observations, safety inspections, and management engagement activities. Within the safety performance measurement framework, these components can be classified as leading indicators because they represent preventive activities undertaken before an incident occurs, whereas AFR is a lagging indicator that records events that have already occurred (Bird et al., 1990). This distinction explains why stronger proactive activities are theoretically expected to precede and accompany improvements in outcome indicators and provides the conceptual basis for interpreting the trends between program implementation and AFR.

The observed patterns can be interpreted through several complementary theoretical frameworks. Bird et al.'s (1990) loss causation theory views an accident as the end of a sequence involving lack of control, basic causes, immediate causes, incidents, and losses; therefore, effective prevention should begin upstream through stronger supervision and management commitment (Bird et al., 1990). Reason's organizational accident model explains accidents as the result of latent weaknesses aligning across several layers of defense; within this framework, observations, inspections, and management engagement serve as layered defenses that help close potential gaps (Reason, 2016). Cooper's reciprocal model of safety culture further proposes that safety results from interactions among personal, behavioral, and environmental or system factors, meaning that a program combining behavioral observation, condition improvement, and management commitment addresses all three dimensions (Cooper, 2000; Suwarto, Karim, & Sejati, 2021).

Descriptively, the volume of safety observations remained relatively stable across the three periods, at 513, 512, and 494 activities, while AFR decreased. Therefore, the decline in AFR was not accompanied by a clear increase in the number of observations, making the trend-level relationship between the two variables less apparent. From a theoretical perspective, safety observation is rooted in Heinrich's domino theory, which proposes that many accidents begin with unsafe acts and that interrupting the sequence at the behavioral stage can prevent injury. This idea is reinforced by the accident pyramid or triangle principle, which considers serious incidents to be the peak of a much larger number of risky behaviors and unsafe conditions at the base, allowing observations to identify these precursors before they escalate. Within the Behaviour Based Safety framework, observation functions as a feedback mechanism in the antecedent-behaviour-consequence sequence to encourage safer behavior (Ayuni et al., 2022; Li, Wu, Luo, Gao, & Yin, 2019; Yang, Kim, & Rodgers, 2024). However, these theories emphasize the quality of observations and the follow-up actions taken, rather than the number of observations alone, which may explain why a stable observation volume was not clearly reflected in the AFR trend. Given the limited data, the specific

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Program Studi Magister Keselamatan dan Kesehatan Kerja, Fakultas Kesehatan Masyarakat, Universitas Indonesia
Corresponding author: *E-mail: naimfathony@gmail.com

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contribution of safety observations could not be determined conclusively.

Safety inspections recorded the highest number of findings in Q1 2026, with 290 findings, at the same time that AFR reached its lowest value of 3.07. This temporal pattern is consistent with the theoretical role of inspections as a mechanism for controlling unsafe conditions. In the Swiss Cheese Model, systematic inspections function as an active barrier by identifying and addressing unsafe conditions before weaknesses in different defense layers align and lead to an incident (Reason, 2016). From the perspective of Bird et al.'s (1990) loss causation theory, inspections address immediate causes in the form of substandard conditions, so a higher number of findings may reflect stronger detection capability rather than a simple increase in hazards (Bird et al., 1990). This interpretation is consistent with Amirudin et al. (2025) and with the shift toward proactive safety indicators, which views the ability to identify and correct hazards as a sign of a more mature safety system (Amirudin et al., 2025). Nevertheless, the observed pattern is descriptive and cannot be interpreted as evidence that inspections caused the decline in AFR.

Management engagement showed the trend most closely aligned with the decline in AFR, increasing successively from 293 to 302 and then 309 activities while AFR decreased across the same periods. This pattern can theoretically be explained through safety climate and safety leadership theories. Management commitment is widely regarded as a key determinant of safety climate because workers' perceptions of leadership commitment shape the priority given to safety and, in turn, influence safe behavior in the workplace. The direct presence of leaders in management engagement activities represents visible felt leadership and leader–member exchange, which can reinforce safety norms, promote two-way communication, and improve compliance with safe work procedures (Aifah, Luthi, & Saputra, 2025) . Within Cooper's (2000) safety culture framework, management involvement influences both personal and situational dimensions, supporting its role as an upstream driver in the chain of safety control. Although this component showed the clearest alignment with the AFR trend and was consistent with theoretical expectations, it still did not establish a causal relationship because of the study design and the limited number of observation points.

Overall, the three program components represent different intervention points in the accident causation chain: observations address behavior or unsafe acts, inspections address unsafe conditions, and management engagement addresses organizational commitment and safety climate. Together, these components form a layered defense system that is theoretically more robust than a single intervention, providing the conceptual basis for the integrated approach that represents the novelty of this study. The decline in AFR as an outcome indicator, alongside the continued implementation of proactive activities, is consistent with the leading and lagging indicator framework (Bird et al., 1990). However, because AFR can also be affected by factors outside the program, as discussed below, this relationship should be interpreted as a conceptually plausible pattern rather than empirical confirmation of causality.

The reduction in AFR during the observation period cannot be fully attributed to the Safety Friendly Program because several potential confounding factors may also have affected it, including total working hours, production targets and intensity, workforce size and characteristics, contractor or subcontractor turnover, operational changes, other concurrent safety initiatives, and incident-reporting practices. Company data showed that the workforce increased from 1,899 employees in Q3 2025 to 2,053 in Q4 2025 and 2,313 in Q1 2026, while total working hours rose from 532,669.50 to 595,062.05 and 724,735.05, representing an increase of approximately 36% over the study period. Because AFR is calculated as the number of accidents per one million working hours, an increase in the number of working hours can mathematically reduce the AFR when the number of accidents remains unchanged or does not increase proportionally. Therefore, part of the observed reduction in AFR may reflect the larger working-hour denominator rather than solely a decrease in the level of occupational hazard. These considerations emphasize the need for caution when interpreting the findings.

This study has several limitations, including the small number of AFR observation points, the use of data from only one company, the absence of a control group, the inability to control potential confounding factors, and reliance on secondary data whose quality depends on the company’s recording system. These limitations restricted the analysis to descriptive trends

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and limited the generalizability of the findings. Future studies should use longer observation periods with monthly AFR data, include multiple companies or study sites, apply comparative designs, and control relevant confounding factors to provide a more robust evaluation of the relationship between safety programs and AFR.

CONCLUSION

The Safety Friendly Program at PT X was implemented consistently from Q3 2025 to Q1 2026 through safety observations, safety inspections, and management engagement activities. During the same period, AFR decreased from 10.57 to 3.07, with management engagement and safety inspections showing the closest descriptive alignment with this trend. However, the findings cannot establish a causal relationship because the study used a descriptive observational design, had only three AFR observation points, lacked a control group, and did not control for increases in workforce and working hours. Therefore, PT X should maintain these proactive safety activities while improving monthly AFR recording and related operational data to support more robust future evaluations.

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