The Relationship between Occupational Safety and Health (K3) Knowledge and Machine Work Productivity at UPT Crew Madiun Train

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Abstract: Engineer productivity plays an important role in maintaining safety, punctuality, and quality of railway services. This study aims to analyze the relationship between occupational safety and health (K3) knowledge and engineer productivity at UPT Crew PT Kereta Api Indonesia (Persero) Operational Area 7 Madiun. The study used an observational analytical design with a cross-sectional approach. A total of 42 engineers were selected through simple random sampling from a population of 73 people. Data were collected using a valid and reliable questionnaire, then analyzed univariately and bivariately using the chi-square test at a significance level of 5%. Most respondents had poor K3 knowledge (66.7%) and low work productivity (61.9%). K3 knowledge was significantly related to work productivity, $\chi^2(1) = 6.108$; $p = 0.013$. Machinists with good OHS knowledge were 5.40 times more likely to have high productivity (OR = 5.40; 95% CI [1.35–21.64]). Strengthening OHS training, safety culture, procedural compliance, and fatigue management needs to be prioritized to support productivity and operational safety.

Keywords: Occupational Safety And Health; Machinists; Work Productivity; Railway Transportation

Abstract : *Produktivitas masinis berperan penting dalam menjaga keselamatan, ketepatan waktu, dan mutu layanan perkeretaapian. Penelitian ini bertujuan menganalisis hubungan pengetahuan keselamatan dan kesehatan kerja (K3) dengan produktivitas masinis di UPT Crew PT Kereta Api Indonesia (Persero) Daerah Operasi 7 Madiun. Penelitian menggunakan desain analitik observasional dengan pendekatan potong lintang. Sebanyak 42 masinis dipilih melalui simple random sampling dari populasi 73 orang. Data dikumpulkan menggunakan kuesioner yang telah valid dan reliabel, kemudian dianalisis secara univariat dan bivariat menggunakan uji chi-square pada taraf signifikansi 5%. Sebagian besar responden memiliki pengetahuan K3 kurang baik (66,7%) dan produktivitas kerja rendah (61,9%). Pengetahuan K3 berhubungan signifikan dengan produktivitas kerja, $\chi^2(1) = 6,108$; $p = 0,013$. Masinis dengan pengetahuan K3 baik memiliki peluang 5,40 kali lebih besar untuk memiliki produktivitas tinggi (OR = 5,40; 95% CI [1,35–21,64]). Penguatan pelatihan K3, budaya keselamatan, kepatuhan prosedur, dan pengelolaan kelelahan perlu diprioritaskan untuk mendukung produktivitas serta keselamatan operasi.*

Kata Kunci : *Keselamatan Dan Kesehatan Kerja; Masinis; Produktivitas Kerja; Transportasi Perkeretaapian*

INTRODUCTION

Railway transportation is a high-risk socio-technical system that relies on facilities, infrastructure, operational governance, safety communication, and human competence. In the system, the driver occupies a critical position because his decisions, vigilance, and compliance with procedures are directly related to travel safety, punctuality, efficiency, and service quality. Driver productivity is therefore inappropriate if it is only interpreted as the number of trips or tasks completed. Productivity also includes the ability to achieve consistent, timely, efficient, and meet safety targets. Research on the urban train industry shows that communication, training, support systems, and organizational safety values are important elements in maintaining worker health and operational quality (Derahim et al., 2021). Safety and productivity should be placed as mutually reinforcing goals.

The work of a machinist has distinctive physiological and psychological demands. Engineers have to maintain attention for long periods of time, work on a rotating schedule, face monotonous tasks, respond to precise signals, and bear the heavy consequences of mistakes. Monotony is related to changes in brain activity and cardiovascular responses that may reflect decreased alertness (Lees et al., 2021, 2023). Systematic reviews also place fatigue and distraction as factors that degrade train drivers' ability to detect information, make decisions, and control travel safely (Fan et al., 2022). In Australia and New Zealand, patterns of schedule, sleep duration, well-being, and fatigue were reported to be related to drivers' perceptions of driving performance and safety (Dorrian et al., 2022). The evidence confirms that driver productivity is inseparable from schedule management, sleep, mental load, and alertness.

The Indonesian context shows a similar problem. Studies of freight train drivers found that the duration of blinking and changes in facial expressions can identify increased fatigue during travel, especially in monotonous conditions and certain task times (Auliani, Puspasari, et al., 2024). Qualitative studies show that long working hours, irregular schedules, limited rest facilities, managerial support, and operational communication disorders can exacerbate fatigue and hinder recovery (Auliani, Az-Zahra, et al., 2024). Research on metro train drivers also found that mental fatigue is closely related to mental workload at the end of shifts (Hassanzadeh Rangi et al., 2023). Sleep disorders need attention because untreated severe obstructive sleep apnea is associated with an increase in safety incidents in critically categorized railway workers (Abeyaratne et al., 2023). Exposure to stressful events can also affect cognitive processes and the ability to maintain safe operations (Liddell et al., 2024).

In facing these risks, occupational safety and health (K3) functions as a protection system as well as the foundation of sustainable productivity. K3 includes hazard recognition, risk control, communication, incident reporting, emergency preparedness, surveillance, and organizational learning. A study in Indonesia found that the perception of the safety climate is related to worker safety behavior (Hertanto et al., 2023). Other research shows that the quality of the safety climate is influenced by experience, education, position, job status, and work location, so interventions need to be tailored to the characteristics of the workforce (Kadir et al., 2022). In the work of machinists, the consistent application of K3 has the potential to reduce errors, incidents, operational disruptions, and lost work time.

The foundation of the implementation of K3 is safety knowledge. Knowledge allows workers to recognize hazards, understand the consequences of unsafe actions, follow standard operating procedures, use safety means, and make informed decisions in abnormal conditions. Safety knowledge is positively related to safety compliance and performance (Putra et al., 2022; Sinaga & Sinaga, 2022). However, knowledge does not automatically turn into behavior if it is not supported by leadership, communication, supervision, and the opportunity to implement procedures. Meta-analyses show that safety leadership influences worker participation, either directly or through the safety climate (Zhao et al., 2022). Safety communication also mediates the relationship between safety culture and safety performance, so information about risks, procedures, and feedback must be conveyed clearly and sustainably (Naji et al., 2022).

Safety culture and climate are important because work behavior takes place in an organizational context. Written policies are ineffective when production targets are perceived as more important than safety, reporting errors is punishable, or supervision is only conducted after an incident. Safety leadership and climate have been shown to predict compliance and better safety outcomes (Omidi et al., 2023). A safety climate can also reduce the risk of accidents through reduced work stress (Khoshakhlagh et al., 2023). Therefore, increasing the knowledge of K3 drivers needs to be accompanied by periodic training, emergency simulations, procedure updates, two-way communication, competency evaluation, fearless reporting, and fatigue management. The approach ensures that knowledge is reflected in safe actions during operations.

A preliminary study at the UPT Crew of PT Kereta Api Indonesia (Persero) Operation Area 7 Madiun shows that the productivity of some drivers has not been optimal. Previous research has discussed driver fatigue, safety climate, K3 knowledge, safety behavior, and performance. However, studies that assess the relationship between K3 knowledge and driver productivity in the context of Indonesia's national railway operations are still limited. The characteristics of a machinist's work that are high-risk, strictly procedural, demanding punctuality, and influenced by rotational work provide a different context from general work. Based on these gaps, this study aims to analyze the relationship between K3 knowledge and driver productivity in the UPT Crew of PT Kereta Api Indonesia (Persero) Operating Area 7 Madiun. The research hypothesis states that there is a relationship between K3 knowledge and work productivity.

RESEARCH METHODS

This study uses a quantitative approach with an observational analytical design through a cross-sectional approach. Independent and dependent variables were measured over the same period without intervention, so the results of the study were interpreted as relationships or associations and were not used to infer cause-and-effect relationships. The research was carried out at the UPT Crew of PT Kereta Api Indonesia (Persero) Operation Area 7 Madiun in May-June 2026. The research population consists of all 73 drivers who serve in the unit. The sample size was determined using the Slovin formula with an error rate of 10% and obtained 42 respondents. The sample was selected using a simple random sampling technique so that each member of the population had an equal chance of being selected. The independent variable in this study is knowledge of occupational safety and health (K3), while the dependent variable is work productivity. K3 knowledge is defined as the respondent's level of understanding of the basic principles of K3, operating procedures, the use of personal protective equipment, hazard control, handling emergencies, and preventing work accidents. Work productivity is measured based on indicators of work quality, work quantity, punctuality, and independence. The scores of both variables are then categorized based on the measurement criteria established in the research instrument.

Data were collected using a structured questionnaire that was compiled based on the indicators of each variable. The instrument has gone through a validity test using *Pearson's Product Moment* correlation and a reliability test using *Cronbach's alpha* coefficient. All statements have a validity coefficient value above *the r-value of the table and each scale obtains* Cronbach's alpha value > 0.70, so that the instrument is declared valid and reliable. After obtaining an explanation of the research and providing written consent, the respondents filled out the questionnaire independently. The data collected then goes through the stages of completeness (editing*),* coding*,* scoring*, data entry (*entering), and data cleaning (*cleaning*). Data collection is carried out after obtaining permission from the research site and ethical approval from the relevant institution. Each respondent was informed about the purpose and benefits of the research, the confidentiality of the data, the voluntary nature of participation, and the right to terminate participation without consequence. The identity of the respondents is kept confidential and all data is only used for academic purposes. Univariate analysis is used to present the characteristics of respondents and the distribution of variables in the form of frequency and percentage. Bivariate analysis was performed using *the Pearson chi-square* (χ^2) test with a confidence level of 95% and $\alpha = 0.05$. The relationship is stated to be significant if the *p* value of $p < 0.05$ is obtained. The magnitude of the association

was calculated using *odds ratio* (OR) and a 95% confidence interval based on tables 2 × 2. All statistical results are interpreted according to the characteristics of the cross-cut design.

RESULTS AND DISCUSSION

Characteristics of Respondents

A total of 42 drivers participated in this study and all questionnaires returned met the completeness of the data so that they could be analyzed. The characteristics of the respondents which include gender, age, duration of work per day, working period, and education level are presented in Table 1.

Table 1: *Characteristics of Engineers in UPT Crew PT Kereta Api Indonesia Operating Area 7 Madiun (n = 42)*

Characteristics	n	%
Gender		
Male	42	100,0
Women	0	0,0
Age		
< 24 years old	5	11,9
25–34 years old	25	59,5
35–44 years old	11	26,2
> 45 years old	1	2,4
Working duration per day		
≤ 4 hours	21	50,0
> 4 hours	21	50,0
Working period		
≤ 10 years	23	54,8
> 10 years	19	45,2
Education		
High School	22	52,4
SMK	15	35,7
Bachelor (S1)	5	11,9

Note. Premiere date, 2026. A line without a number indicates a characteristic group.

Table 1 shows that all respondents were male. This condition illustrates the characteristics of machinists at the research site which are still completely dominated by male workers. Such dominance needs to be understood as a specific picture of the research population and cannot be used to conclude that the work of machinists in general can only be done by men. The homogeneous composition of respondents by gender also limits the analysis of possible differences in K3 knowledge or productivity based on gender. Most of the respondents were 25–34 years old, which was 25 people or 59.5%. The age group of 35–44 years amounted to 11 people or 26.2%, while respondents aged less than 24 years were five people or 11.9%. Only one respondent or 2.4% were over 45 years old. The distribution shows that the majority of drivers are in the productive age range. In this age range, workers generally have relatively good physical capacity, adaptability, and competency development opportunities. However, productive age does not automatically guarantee high productivity because the performance of the driver is also affected by mental load, rotational work patterns, sleep quality, rest duration, and fatigue during duty.

Fatigue is one of the important factors in the job of a train driver because his job demands constant vigilance in relatively monotonous situations. Research on train drivers shows that fatigue can be related to work patterns, sleep disturbances, mental load, duration of blinking, changes in facial expressions, as well as decreased ability to maintain attention during travel (Auliani et al., 2023, 2024a, 2024b; Hassanzadeh-Rangi et al., 2023; Iridiastadi, 2021). Therefore, the dominance of respondents at productive age still needs to be accompanied by schedule management and fatigue so that physical and cognitive abilities can be maintained. The duration of work per day was divided

evenly, namely 21 respondents or 50.0% worked for ≤ 4 hours and 21 respondents or 50.0% worked for > 4 hours. This division shows a variation in the duration of operational tasks. However, the duration of the work does not always reflect the actual workload because a shorter trip can still have high demands on concentration, track conditions, departure schedules, and operational pressures. On the other hand, longer trips can increase the risk of monotony and fatigue if they are not accompanied by adequate rest time.

Based on the service period, as many as 23 respondents or 54.8% had a working period ≤ 10 years, while 19 respondents or 45.2% had worked for more than 10 years. The distribution is relatively balanced between drivers with shorter working hours and more experienced drivers. Work experience can improve procedural mastery and the ability to recognize operational situations, but long experience also does not always guarantee compliance when workers begin to normalize risks or execute procedures based on habits. Therefore, refresher training is still required for all working age groups. The majority of respondents had a high school education, namely 22 people or 52.4%, followed by vocational schools as many as 15 people or 35.7% and bachelors as many as five people or 11.9%. Different formal educational backgrounds can influence the way workers receive and understand information. However, the competence of a driver is not only determined by general education, but also by technical education and training, certifications, experience, competency evaluations, and coaching provided by the company. K3 training needs to be designed using language, simulations, and evaluation methods that can be understood by all levels of education.

K3 Knowledge and Work Productivity Distribution

The distribution of occupational safety and health knowledge and machinist work productivity is presented in Table 2.

Table 2 : Distribution of K3 Knowledge and Work Productivity (n = 42)

Variable	Categories	n	%
K3 Knowledge	Less good	28	66,7
	Good	14	33,3
Work productivity	Low	26	61,9
	High	16	38,1

Note. Premiere date, 2026.

Most drivers had K3 knowledge in the poor category, namely 28 respondents or 66.7%, while only 14 respondents or 33.3% had good K3 knowledge. This proportion shows that there is still a gap in understanding the basic principles of K3, hazard control, operating procedures, emergency measures, and accident prevention efforts. This finding is important because machinists work in a system with high safety consequences. A lack of knowledge can affect a worker's ability to recognize hazards and determine appropriate actions when operational irregularities occur. K3 knowledge is one of the foundations for the formation of safe behavior. Workers who understand risks and procedures are expected to be better able to avoid unsafe actions, use safety facilities correctly, and participate in hazard reporting and control. Previous studies have shown that K3 knowledge is related to safety behavior, compliance, safety performance, and the incidence of work accidents (Hedaputri et al., 2021; Putra et al., 2022; Sinaga & Sinaga, 2022). However, knowledge also needs to be strengthened through supervision, communication, worker engagement, and an organizational safety climate so that it can be applied consistently.

Regarding work productivity, 26 respondents or 61.9% were in the low category and 16 respondents or 38.1% were in the high category. The dominance of low productivity indicates that task outcomes have not yet been optimal. In railway operations, productivity should not only be understood as the quantity of completed trips or tasks, but also as work quality, punctuality, independence, procedural compliance, and operational safety. Low productivity may be related to limitations in competence, fatigue management, work schedules, facility conditions, supervisory support, or other operational factors. The subsequent analysis therefore focuses on whether differences in K3 knowledge are associated with differences in machinist work productivity.

The Relationship of K3 Knowledge with Work Productivity

The relationship between K3 knowledge and driver productivity is presented in Table 3.

Table 3: *The Relationship between K3 Knowledge and Machine Work Productivity*

K3 Knowledge	Low productivity, n (%)	High productivity, n (%)	Total, n (%)	*p*	OR [95% CI]
Less good	21 (75,0)	7 (25,0)	28 (100,0)	0,013	1.00 (reference)
Good	5 (35,7)	9 (64,3)	14 (100,0)		5,40 [1,35–21,64]

Note. Pearson chi-square test; $\chi^2(1) = 6.108$. OR indicates the opportunity to be in the high productivity category.

The proportion of high productivity in respondents with good K3 knowledge reached 64.3%, while in respondents with poor K3 knowledge was only 25.0%. On the other hand, as many as 75.0% of respondents with poor K3 knowledge had low productivity. The results of *the Pearson chi-square* test showed the values $\chi^2(1) = 6.108$ and $p = 0.013$. Since *the p-value* is less than 0.05, there is a significant relationship between K3 knowledge and the work productivity of the machinist. An OR value of 5.40 indicates that drivers with good K3 knowledge have a 5.40 times greater chance of being in the high productivity category than drivers with poor K3 knowledge. The 95% confidence interval is in the range of 1.35–21.64 and does not include a value of 1, so the direction of the association is consistent with the results of *the chi-square* test. Nonetheless, the fairly wide range of confidence intervals indicates that large estimates of associations still have uncertainty, likely due to relatively small sample sizes.

Conceptually, K3 knowledge can support productivity because workers who understand safety procedures are better able to recognize unsafe conditions, control potential hazards, follow operating standards, and respond appropriately to emergency situations. These capabilities can prevent errors, reduce operational disruptions, reduce lost work time, and maintain consistency in task execution. Productivity in the context of railways has to do not only with the number of trips completed, but also with punctuality, compliance with procedures, quality of decisions, and travel safety. These findings are in line with the study of Hedaputri et al. (2021), which showed the relationship between the level of K3 knowledge and the incidence of work accidents. Research in various sectors also shows that safety knowledge is related to worker safety behavior and performance (Putra et al., 2022; Sinaga & Sinaga, 2022). Safety knowledge can strengthen the influence of leadership on safety behavior when it is supported by effective supervision and communication. This means that knowledge improvement needs to go hand in hand with leadership support and supervision.

The results of this study are also consistent with the study on the application of the K3 program in the work environment. The implementation of K3, training, supervision, and safety culture is reported to be related to worker productivity and performance (Etruly & Nafi'ah, 2023; Kusumawardani & Budiono, 2024; Setiawan & Astutik, 2022). Other studies show that K3 interventions and the integration of safety practices with organizational commitments can support productivity in a sustainable manner (Lari, 2024; Tan et al., 2023). However, K3 knowledge cannot be seen as the only determinant of productivity. A total of five respondents with good K3 knowledge still have low productivity. This condition shows that knowledge cannot necessarily be applied if there are obstacles such as fatigue, irregular work schedules, limited facilities, less effective communication, target pressure, or a weak safety climate. Knowledge needs to be supported by leadership, safety communication, worker engagement, hazard control, and non-punitive reporting systems (Hertanto et al., 2023; Kadir et al., 2022; Quansah et al., 2023; Yusuf et al., 2025).

Managerial Implications

The findings of the research provide a basis for management to prioritize improving K3 knowledge through continuous learning programs. Training should not only be provided when the driver starts working, but should be carried out periodically in the form of procedure refresh, emergency simulation, case-based learning, competency evaluation, and feedback on compliance. Training materials also need to be tailored to actual risks, technological changes, and inspection findings and operational incidents. Knowledge enhancement programs need to be integrated with the strengthening of the safety climate. Workers' perceptions of organizational commitment can determine whether K3 knowledge is truly applied in their daily work. Empirical evidence shows that the climate of safety, leadership, communication, and worker engagement is related to safety performance in various work sectors (Derahim et al., 2021; Dursun & ŞEngÜL, 2023; Han et al., 2021; He et al., 2023; Rafique et al., 2021). Transparency of safety data and learning from incidents are also necessary to prevent the recurrence of errors and objectively improve systems (Blumenfeld et al., 2023).

Knowledge improvement should be supported by healthy work schedules, fatigue management, adequate rest facilities, proper facility conditions, clear roles, and effective communication with supervisors. These organizational supports help ensure that K3 knowledge is consistently translated into safe and productive work practices rather than remaining only at the level of understanding. The integration of K3 programs with supportive working conditions can strengthen employee performance and sustainable productivity (Pane & Cashmere, 2022; Tan et al., 2023).

Research Limitations

This study has several limitations that need to be considered when interpreting the results. The cross-sectional design cannot ensure the order of time and cannot be used to infer cause-and-effect relationships. The sample came from only one work unit and all respondents were male, so generalization of results to work units, operating areas, or other machinist populations needs to be done carefully. Measurements using self-report questionnaires also have the potential to cause memory bias and the tendency of respondents to give answers that are considered socially appropriate. Categorization of knowledge and productivity scores can reduce the variety of information available. The analysis only used bivariate tests so that confounding factors, such as age, working period, education, work duration, mental load, sleep quality, fatigue, facility conditions, and shift patterns had not been controlled. Further research is suggested involving a larger sample from multiple operating areas, using more objective productivity and fatigue measurements, and applying multivariate analysis. Longitudinal designs or intervention studies are also needed to assess changes in K3 knowledge and productivity over time and to strengthen explanations of the direction of the relationship between the two variables.

CONCLUSIONS AND SUGGESTIONS

This study shows that occupational safety and health (K3) knowledge has a significant relationship with the work productivity of machinists in the UPT Crew of PT Kereta Api Indonesia (Persero) Operation Area 7 Madiun. Drivers with good K3 knowledge have a greater chance of achieving high productivity than drivers with poor K3 knowledge. The findings confirm that understanding operating procedures, hazard identification, risk control, emergency handling, and accident prevention are important parts of supporting the safe, timely, effective, and consistent execution of tasks. Thus, strengthening K3 knowledge is a key strategy for supporting machinist productivity and operational safety.

Based on these results, management is advised to prioritize increasing the productivity of drivers through strengthening knowledge and implementing K3 in a sustainable manner. Efforts that can be made include refresher training, emergency simulations, competency evaluation, supervision of compliance with procedures, open safety communication, learning from operational incidents, fatigue management, adequate scheduling, provision of rest facilities, improvement of facility conditions, and supervisor support. Given that this study uses a cross-sectional design and involves respondents from one work unit, further research is recommended to use a broader

sample, involve multiple operating areas, use objective measurements of productivity and fatigue, and apply multivariate, longitudinal, or interventional analyses so that the relationship between K3 knowledge and productivity can be explained more comprehensively.

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