Jurnal Kesehatan dan Keselamatan Kerja
Vol 1, No 1, 2026, 47-60 https://doi.org/10.35912/kesmaker.v1i1.6783

Worker Characteristics and Workplace Accident Association Among Welding and Assembly Workers in a Manufacturing Company

Juhanda Juhanda[1*], Diina Maulina[2], Leni Utami[3]
Universitas Ibnu Sina, Batam, Indonesia[1,2,3]
juhanda@gmail.com[1*], dr.diina@uis.ac.id[2],

Article History
Received on 2 Maret 2026
1st Revision on 16 Maret 2026
2nd Revision on 3 April 2026
3rd Revision on 17 April 2026
Accepted on 4 Mei 2026

Abstract

Purpose: Workplace accidents in welding and assembly manufacturing in Indonesia remain a key safety issue. This study examines the relationship between knowledge, age, education, and work tenure and accident occurrence among workers at PT. X, Batam.

Methodology: A quantitative cross-sectional study was conducted on 30 welding and assembly workers using total sampling. Data were collected through structured questionnaires. Occupational Safety and Health (OHS) knowledge was measured using a validated instrument, while demographic data were self-reported. Accident experience was classified as ever or never. Chi-square test ($\alpha = 0.05$) was applied.

Results: Univariate analysis showed 56.7% had experienced accidents; 40% had low OHS knowledge, 63.3% were under 35 years, 73.3% had low education, and 53.3% had short tenure. Chi-square tests indicated significant associations between accidents and knowledge ($p = 0.000$), age ($p = 0.013$), education ($p = 0.014$), and tenure ($p = 0.000$).

Conclusions: All four factors are significantly associated with workplace accidents, with knowledge and tenure showing the strongest relationships and priority for intervention. These findings highlight the importance of strengthening occupational safety culture in manufacturing workplaces.

Limitations: Small sample size and single-company scope limit generalizability and causal inference. Future studies should include larger samples and multiple sites to improve external validity.

Contributions: Findings support targeted OHS training and structured onboarding to reduce accidents in welding and assembly work. The study also provides empirical evidence for policy development in similar manufacturing settings.

Keywords: *Occupational Health and Safety, Work Tenure, Worker Characteristics, Workplace Accidents, Welding*

How to Cite: Juhanda, J., Maulina, D., & Utami, L.. (2026). Worker Characteristics and Workplace Accident Association Among Welding and Assembly Workers in a Manufacturing Company. *Jurnal Kesehatan dan Keselamatan Kerja*, 1(1), 47-60.

1. Introduction

Workplace accidents remain a critical public health and economic challenge in Indonesia's manufacturing sector. The International Labour Organization (ILO) estimates that more than 2.78

million workers die annually from occupational accidents and diseases globally, with approximately 374 million non-fatal occupational injuries occurring each year (Michiko, 2018). In the Asia-Pacific region alone, more than 1.8 million work-related deaths are recorded annually, reflecting the disproportionate burden of occupational risk in developing and industrialising economies. Within Indonesia, the Ministry of Manpower (Kemnaker) documented 157,313 workplace accident cases in 2018 and 130,923 cases from January through September 2019 alone figures that, while showing a decline, represent a sustained public health burden requiring systematic preventive intervention (Biro, 2020).

Occupational accidents are recognized to arise from two primary categories of contributing factors: unsafe actions and unsafe conditions. DuPont's landmark research attributed 76% of workplace accidents to unsafe actions, 4% to unsafe conditions, and 22% to their combination (Yudhawan & Dwiyanti, 2017). The dominant role of unsafe actions in accident causation directs preventive attention toward the human factors that predispose workers to unsafe behavior particularly individual worker characteristics that shape their capacity to recognize hazards, follow safety procedures, and exercise appropriate caution in high-risk tasks.

The ILO (1998) identified worker characteristics specifically age, education level, and work experience as primary human factors in occupational accident causation, a theoretical proposition supported by extensive empirical literature in Indonesian industrial settings (Pratama, 2015; Hernawati, 2008; Ayu & Rhomadhoni, 2019). Knowledge of Occupational Safety And Health (OHS) has been additionally identified as a critical modifiable characteristic: workers with higher OHS knowledge demonstrate safer behaviors, better hazard recognition, and lower accident rates across multiple industrial contexts (Syaputra, 2017; Pratama, 2015).

PT. X is a manufacturing company specializing in pressure vessel and gas heat exchanger production, located in Sekupang, Batam City, Kepulauan Riau Province. The company's core production processes involve welding and assembly operations activities characterized by high-energy hazard exposure including UV radiation from welding arcs, burn risk from molten metal, respiratory hazards from welding fumes, entrapment and crush hazards from assembly equipment, and ergonomic hazards from sustained awkward postures. Field observations and interviews with PT. X's safety personnel confirmed that workplace accidents occur regularly among welding and assembly workers, with documented incidents including thermal burns, respiratory complaints, entrapment injuries, and UV-induced eye damage (Rizka & Mindayani, 2018). Preliminary assessment identified that a significant proportion of workers lacked adequate OHS knowledge, with observable non-compliance with Personal Protective Equipment (PPE) requirements, rushed working behavior, and task-role mismatches among contributing factors.

Despite the recognized importance of worker characteristics as accident risk factors, no published study has examined this relationship specifically among welding and assembly workers in Batam's manufacturing sector a gap with direct implications for OHS program design in this industrially significant location. This study addresses this gap by systematically examining the association between four worker characteristics OHS knowledge, age, education level, and work tenure and workplace accident occurrence among welding and assembly workers at PT. X. Four research hypotheses guide the study: (H1) OHS knowledge is significantly associated with workplace accident occurrence; (H2) age is significantly associated with workplace accident occurrence; (H3) education level is significantly associated with workplace accident occurrence; and (H4) work tenure is significantly associated with workplace accident occurrence. The findings provide both confirmatory evidence for the worker characteristics accident relationship in a previously unstudied context and directly actionable guidance for PT. X's OHS management system regarding which worker characteristic dimensions should be prioritized in accident prevention programs.

2. Literature Review and Hypotheses Development

2.1 Occupational Accidents: Definition and Human Factor Framework

An occupational accident is defined as an unplanned, undesired event occurring in the course of or in connection with work that results in physical injury, health impairment, property damage, or process disruption (Undang-Undang, 1970). The human factor framework for occupational accident causation, as articulated by the International (1998) and elaborated by Triwibowo and Puspihandani (2013), identifies individual worker characteristics as fundamental determinants of accident susceptibility: they shape the worker's capacity to perceive hazards, adhere to safety procedures, and maintain safe behavior under operational pressure. These characteristics are not merely demographic attributes but functional predictors of behavioral safety performance that can be modified through organizational intervention.

The dominant role of unsafe actions in accident causation (DuPont: 76%) positions worker characteristics as primary risk factors because they directly predict unsafe action propensity. Puspandhani (2020) categorized the human factors underlying unsafe actions into dispositional factors (permanent characteristics such as experience, education, and cognitive capacity) and situational factors (transient states such as fatigue, stress, and time pressure). The four characteristics examined in the present study knowledge, age, education, and tenure span both dispositional and developmental categories, providing a comprehensive characterization of the worker-level accident risk profile.

2.2 OHS Knowledge and Workplace Accidents

OHS knowledge refers to the worker's understanding of workplace hazard types, appropriate safety procedures, PPE requirements, and emergency response protocols relevant to their specific work tasks (Pratama, 2015; Nurjanah, 2014). The knowledge safety behavior relationship is mediated through multiple pathways: knowledge enables hazard recognition (identifying that a risk exists), competency development (knowing how to perform tasks safely), and compliance motivation (understanding the consequences of non-compliance). Workers with poor OHS knowledge are empirically more likely to engage in unsafe actions because they cannot recognize the hazardous nature of their behaviors or the severity of potential consequences (Syaputra, 2017).

In the welding context specifically, knowledge is particularly critical because welding hazards UV radiation, fume toxicity, fire and explosion risk, electrical hazard are not immediately visible or intuitively obvious to workers without specific OHS education. Yudhawan and Dwiyanti (2017) demonstrated that knowledge was the strongest predictor of unsafe actions among welding workers at PT Dok Dan Perkapalan Surabaya. Organizational OHS knowledge development mechanisms including safety talks (toolbox meetings), SOP training, and formal OHS certification are therefore directly targeted at the knowledge dimension of accident risk.

2.3 Age and Workplace Accidents

Age functions as a proxy for two opposing accident risk dimensions: physical capacity and experience. Younger workers (< 35 years) have greater physical capacity but typically lower task-specific experience, reduced risk perception from limited hazard exposure history, and psychosocial characteristics including impulsivity, risk tolerance, and competitive behavior that elevate unsafe action propensity (Triwibowo & Puspihandani, 2013). American occupational epidemiological research consistently documents higher accident rates among workers under 35 compared to their more experienced counterparts (Hernawati, 2008). Older workers benefit from accumulated experience, established safety habits, and heightened consequences-awareness, though they may face compensating limitations in physical agility and response speed at advanced ages.

In the Batam manufacturing context, where the workforce skews young due to the city's industrial immigration pattern, the age–accident relationship has direct organizational relevance. The preponderance of younger workers in the PT. X welding and assembly workforce (63.3% aged < 35 years) suggests that age-stratified OHS training and supervisory support programs would address the demographic structure of accident risk.

2.4 Education Level and Workplace Accidents

Education level shapes accident risk through multiple mechanisms: formal education develops the cognitive capacity for hazard recognition and procedural understanding; higher education correlates with greater information-processing competency; and educational experience builds the habit of systematic rule-following that supports OHS compliance (Eka, & Wahyuningsih, 2022; Saragih, Lubis, & Tarigan, 2014). The relationship between education and accident occurrence is not linear very high education does not necessarily translate to safer behavior in manual industrial settings but the distinction between workers with lower (≤ senior high school) and higher education levels consistently predicts accident rate differences in Indonesian manufacturing research (Hernawati, 2008; Ayu, & Rhomadhoni, 2019).

The high proportion of lower-educated workers in the PT. X sample (73.3% with ≤ SMA) reflects the typical educational profile of Batam's manufacturing labor force, drawn from regions with limited tertiary education access. This profile places particular weight on non-formal OHS education including company-administered training, practical certification, and visual safety communication as compensatory mechanisms for formal educational limitations.

2.5 Work Tenure and Workplace Accidents

Work tenure determines accident risk through the accumulation of task-specific knowledge, habituation to workplace hazards, and development of automatic safe behavior patterns over time. The tenure–accident relationship follows a U-shaped curve in many industrial settings: new workers (< 3 years) face high accident risk due to limited task competency and unfamiliarity with site-specific hazards; experienced workers reduce risk through competency accumulation; but very long-tenured workers may develop complacency that re-elevates risk through habituation to hazards they no longer consciously perceive (Sulhinayatillah, 2017; Triwibowo & Puspihandani, 2013). In the PT. X context, where 53.3% of workers have tenure of fewer than three years, the new worker vulnerability is the dominant concern.

2.6 Worker Characteristics and Accidents in Welding and Assembly: Prior Studies

Table 1 summarizes prior empirical studies examining the relationship between worker characteristics and workplace accident occurrence across Indonesian manufacturing and industrial settings.

Table 1. Summary of Prior Studies on Worker Characteristics and Workplace Accident Association

Author(s) & Year	Setting / Population	Method	Key Finding on Worker Characteristics–Accident Relationship
Pratama (2015)	Stevedoring workers, PT Terminal Petikemas Surabaya	Cross-sectional, chi-square	Worker characteristics (age, tenure, education) significantly associated with unsafe actions; knowledge has the strongest relationship with unsafe behaviour ($p < 0.05$)
Handayani (2010)	Rustic Division workers, PT Borneo Melintang Buana Eksport, Yogyakarta	Cross-sectional, chi-square	Age significantly associated with work accidents ($p = 0.018$); younger workers showed higher accident rates due to inexperience and impulsive behaviour
Syaputra (2017)	Production workers, PT Borneo Melintang Buana Eksport	Cross-sectional, chi-square	Knowledge and K3 motivation both significantly associated with work accidents ($p = 0.000$); knowledge is the primary modifiable risk factor
Sulhinayatillah (2017)	Plantation rubber factory workers, PT PP London Sumatera	Cross-sectional, chi-square	Work tenure significantly associated with accident occurrence ($p = 0.007$); shorter tenure increases accident risk due to limited task-specific competency

Author(s) & Year	Setting / Population	Method	Key Finding on Worker Characteristics–Accident Relationship
Yudhawan & Dwiyanti (2017)	Welding workers, PT Dok Dan Perkapalan Surabaya	Cross-sectional, chi-square	Personal factors including knowledge and age significantly associated with unsafe actions among welding workers; findings directly comparable to the present study context
Ayu & Rhomadhoni (2019)	Ship division workers, PT PAL Indonesia	Cross-sectional, chi-square	Individual and job characteristics significantly predict unsafe action; education and tenure are independent significant predictors
Rizka et al. (2018)	Welding workers, CV Cahaya Tiga Putri	Descriptive analytical	Burn injuries, eye damage from UV radiation, and respiratory disorders most prevalent among welders; PPE non-compliance is the primary proximate accident cause
Saragih et al. (2014)	Field workers, PT Telkom, Dairi	Cross-sectional, chi-square	Education level significantly associated with unsafe action; formal and non-formal education both contribute to safer workplace behaviour
Hernawati (2008)	Mining workers, PT Antam Tbk, Pongkor, Bogor	Cross-sectional	All four worker characteristics (knowledge, age, education, tenure) significantly associated with accident occurrence in high-risk mining operations
Present Study (2020)	Welding and assembly workers, PT. X, Batam (n = 30)	Cross-sectional, total sampling, chi-square	All four characteristics (knowledge: p = .000; age: p = .013; education: p = .014; tenure: p = .000) significantly associated with work accidents in welding/assembly context at Batam manufacturing company

As Table 1 demonstrates, prior research consistently documents significant associations between all four worker characteristics and accident occurrence across diverse Indonesian industrial settings. The present study extends this evidence base to the welding and assembly manufacturing context in Batam a setting with distinctive workforce demographic characteristics (young, lower-educated, recent arrivals to the industrial workforce) that may amplify the magnitude of these associations relative to other settings.

2.7 Theoretical Framework

The theoretical framework of this study integrates the human factor model with not health behavior theory (International, 1998; Notoatmodjo, 2012), which posits that health-related behavior including workplace safety behavior is determined by predisposing factors (knowledge, attitudes, beliefs, and personal characteristics), enabling factors (organizational resources and environmental conditions), and reinforcing factors (supervision, peer behavior, and management commitment). This study focuses on four predisposing factors (knowledge, age, education, tenure) as determinants of accident-related unsafe behavior. The framework predicts that workers with poor OHS knowledge, younger age, lower education, and shorter tenure are more likely to engage in unsafe actions that precipitate accidents.

3. Research Methodology

3.1 Research Design

This study employs a quantitative cross-sectional analytical design, examining the association between worker characteristic variables and workplace accident occurrence at a single point in time (Hansen, Schlünssen, Fonager, Bønløkke, Hansen, & Bøggild, 2022; Wiratna, 2014). The cross-sectional design is appropriate for the study's objectives of establishing the prevalence and co-occurrence patterns of worker characteristics and accidents, while acknowledging that it does not support causal inference about the direction or temporal precedence of these associations (Ferreira,

Correa, Lacerda, Hajat, & Araújo, 2020). The analytical (rather than purely descriptive) orientation reflects the use of bivariate chi-square testing to establish the statistical significance of the associations.

3.2 Research Setting, Population, and Sample

The study was conducted at PT. X, a manufacturing company specializing in pressure vessel and gas heat exchanger production, located in Sekupang, Batam City, Kepulauan Riau Province, Indonesia. Data were collected from 20 March to 13 August 2020. The study population comprised all 30 permanent welding and assembly workers employed at PT. X at the time of data collection. A total sampling technique was applied enrolling all 30 workers as study participants ensuring that results characterize the complete accessible population without sampling error (Wiratna, 2014). The decision to use total sampling was made because the population size was sufficiently small to permit census-type data collection within the available research period.

3.3 Variables and Measurement

The dependent variable was workplace accident occurrence, measured as a binary categorical variable: "ever experienced a workplace accident" vs. "never experienced a workplace accident" during employment at PT. X, assessed through direct interview. Four independent variables were assessed. OHS knowledge was measured using a validated structured knowledge questionnaire assessing workers' understanding of welding hazards, PPE requirements, emergency procedures, and OHS regulations; responses were scored and classified as Good (≥ 60% correct) or Poor (< 60% correct). Age was assessed through self-report and classified as Young (< 35 years) or Mature (≥ 35 years), consistent with the classification used by Hernawati (2008) and Handayani (2010). Education level was classified as Low (senior high school or below, ≤ SMA/STM) or High (diploma or university qualification). Work tenure was classified as New (< 3 years) or Experienced (≥ 3 years), consistent with Sulhinayatillah (2017).

3.4 Data Collection

Primary data were collected through structured questionnaire-based interviews conducted individually with each of the 30 participating workers. The interview setting ensured privacy to minimize social desirability bias in responses about accident experience and OHS knowledge. Prior to data collection, the questionnaire instruments were subjected to validity testing (Pearson correlation) and reliability testing (Cronbach's Alpha) to confirm measurement quality. All participants provided informed verbal consent prior to interview commencement.

3.5 Data Analysis

Data were analyzed at two levels. Univariate analysis generated frequency distributions and percentages for all study variables, characterizing the demographic and OHS knowledge profile of the respondent population. Bivariate analysis examined the association between each worker characteristic and workplace accident occurrence using the chi-square (χ^2) test at significance level $\alpha = 0.05$. The null hypothesis for each test was that there is no association between the worker characteristic and accident occurrence; the null hypothesis was rejected when $p < 0.05$, indicating a statistically significant association Wiratna, 2014. Data were processed and analyzed using SPSS version 22.

4. Results and Discussions

4.1 Univariate Analysis: Worker Characteristics and Accident Prevalence

4.1.1 OHS Knowledge

Table 2. Distribution of OHS Knowledge Among Welding and Assembly Workers (n = 30)

Knowledge Level	n	Percentage (%)
Good (Baik)	18	60.0
Poor (Kurang Baik)	12	40.0
Total	30	100.0

Table 2 shows that most respondents had good OHS knowledge, accounting for 18 workers (60.0%), while 12 workers (40.0%) were categorized as having poor OHS knowledge (Nurjanah, 2014). These findings indicate that although the majority of welding and assembly workers possess adequate knowledge of occupational health and safety principles, a substantial proportion still lack sufficient understanding of workplace hazards and safe work practices. This condition may increase the likelihood of unsafe behavior and occupational accidents, particularly in high-risk activities such as welding and assembly operations. Previous studies have shown that inadequate OHS knowledge is associated with lower safety compliance and a higher risk of workplace accidents among industrial worker.

4.1.2 Age

Table 3. Age Distribution of Welding and Assembly Workers (n = 30)

Age Category	n	Percentage (%)
Young (< 35 years)	19	63.3
Mature (≥ 35 years)	11	36.7
Total	30	100.0

Table 3 shows that the majority of respondents were classified as young workers (< 35 years), comprising 19 individuals (63.3%), while 11 respondents (36.7%) were categorized as mature workers (≥ 35 years). This distribution indicates that the welding and assembly workforce at PT. X is predominantly composed of younger employees. In occupational safety research, younger workers are often considered more vulnerable to workplace accidents due to limited work experience, lower hazard recognition capability, and a greater tendency to engage in risk-taking behaviors compared with older workers. The predominance of younger workers in this study therefore highlights the importance of targeted supervision, safety training, and mentoring programs to reduce accident risks in high-hazard manufacturing environments.

4.1.3 Education Level

Table 4. Education Level Distribution (n = 30)

Education Level	n	Percentage (%)
Low (≤ Senior High School / SMA)	22	73.3
High (Diploma / University)	8	26.7
Total	30	100.0

Table 4 shows that most respondents had a low education level (≤ senior high school), accounting for 22 workers (73.3%), while only 8 workers (26.7%) had a higher education level (diploma or university). This finding indicates that the welding and assembly workforce at PT. X is predominantly composed of workers with relatively limited formal educational attainment. Previous studies have reported that education level influences workers' ability to understand safety procedures, recognize workplace hazards, and comply with occupational safety regulations. Consequently, workers with lower educational backgrounds may require more intensive safety communication and practical training to ensure adequate understanding of OHS requirements. These findings highlight the importance of non-formal OHS education, including structured safety training, visual safety communication, and competency-based certification programs, to strengthen hazard awareness and safe work practices among industrial workers.

4.1.4 Work Tenure

Table 5. Work Tenure Distribution (n = 30)

Work Tenure Category	n	Percentage (%)
New (< 3 years)	16	53.3
Experienced (≥ 3 years)	14	46.7

Work Tenure Category	n	Percentage (%)
Total	30	100.0

Table 5 shows that 16 respondents (53.3%) had a work tenure of less than 3 years, while 14 respondents (46.7%) had worked for 3 years or more. These findings indicate that slightly more than half of the welding and assembly workers at PT. X were relatively new employees. Work tenure is an important factor in occupational safety because it reflects the extent of workers' experience, familiarity with workplace hazards, and adaptation to safety procedures. Employees with shorter work tenure generally have less practical experience in identifying and responding to workplace risks, making them more vulnerable to occupational accidents. Therefore, the predominance of workers with shorter tenure in this study highlights the need for comprehensive orientation programs, continuous supervision, and mentoring by experienced workers to strengthen safety competency and reduce accident risk.

4.1.5 Workplace Accident Prevalence

Table 6. Workplace Accident Experience (n = 30)

Accident Experience	n	Percentage (%)
Ever Experienced Accident	17	56.7
Never Experienced Accident	13	43.3
Total	30	100.0

Table 6 shows that 17 respondents (56.7%) reported having experienced at least one workplace accident during their employment at PT. X, while 13 respondents (43.3%) reported never experiencing a workplace accident. This finding indicates that workplace accidents remain a common occurrence among welding and assembly workers. The relatively high accident prevalence may be attributed to the hazardous nature of welding and assembly activities, which expose workers to multiple occupational risks, including thermal hazards, mechanical injuries, hazardous fumes, ultraviolet radiation, and ergonomic strain. Previous studies have reported that welding workers are particularly vulnerable to burns, eye injuries, respiratory disorders, and other work-related injuries due to frequent exposure to high temperatures, welding fumes, and potentially dangerous equipment. These findings emphasize the importance of strengthening hazard control measures, ensuring proper use of Personal Protective Equipment (PPE), and continuously improving occupational safety programs to minimize accident occurrence in manufacturing environments (Rizka & Mindayani, 2018).

4.2 Bivariate Analysis: Chi-Square Tests

Table 7. Chi-Square Test Results: Association Between Worker Characteristics and Workplace Accidents

Variable	p-value	α	χ^2	df	Conclusion
Knowledge (X1) – Work Accidents (Y)	0.000	0.05	—	1	Significant (H1 Supported)
Age (X2) – Work Accidents (Y)	0.013	0.05	—	1	Significant (H2 Supported)
Education (X3) – Work Accidents (Y)	0.014	0.05	—	1	Significant (H3 Supported)
Work Tenure (X4) – Work Accidents (Y)	0.000	0.05	—	1	Significant (H4 Supported)

Table 7 shows that all examined worker characteristics were significantly associated with workplace accident occurrence. OHS knowledge (p = 0.000), age (p = 0.013), education level (p = 0.014), and work tenure (p = 0.000) all had p-values below the significance level of 0.05. Therefore, hypotheses H1, H2, H3, and H4 were supported. These findings indicate that workplace accidents among welding and assembly workers are significantly related to workers' knowledge, demographic characteristics, and employment experience.

4.2.1 Knowledge and Workplace Accidents (H1)
H1 is supported: chi-square analysis reveals a highly significant association between OHS knowledge and workplace accident occurrence ($p = 0.000 < \alpha = 0.05$). This finding confirms that workers with poor OHS knowledge are significantly more likely to have experienced workplace accidents. The highly significant p-value (0.000) indicates the strongest statistical evidence among all four tested relationships. This result is consistent with Pratama (2015), who found a significant knowledge unsafe action association among stevedoring workers ($p < 0.05$), and with Syaputra (2017), who found identical significance ($p = 0.000$) in a production worker sample. The practical implication for PT. X is clear: OHS knowledge improvement through structured safety training, certification programs, and daily safety talks (which the company already partially implements) is the highest-priority, most evidence-supported accident prevention intervention available.

4.2.2 Age and Workplace Accidents (H2)
H2 is supported: chi-square analysis demonstrates a significant association between age and workplace accident occurrence ($p = 0.013 < \alpha = 0.05$). Younger workers (< 35 years) showed significantly higher accident rates than their more mature counterparts. This finding is consistent with Handayani (2010), who found a significant age accident association ($p = 0.018$) in a comparable Indonesian manufacturing setting. The mechanisms linking youth to elevated accident risk include lower accumulated task experience, greater impulsivity, reduced consequence-awareness, and the tendency toward rushed working and hazard indifference documented in qualitative field observations at PT. X. For PT. X, this finding supports age-stratified supervisory intensity: younger workers should receive more frequent supervision, more structured orientation programs, and more intensive mentorship pairing with experienced workers (Badri, Nadeau, & Gbodossou, 2021).

4.2.3 Education Level and Workplace Accidents (H3)
H3 is supported: chi-square analysis demonstrates a significant association between education level and workplace accident occurrence ($p = 0.014 < \alpha = 0.05$). Workers with lower education levels (≤ SMA) showed significantly higher accident rates than those with higher education. This finding aligns with Saragih, Lubis, and Tarigan (2014), who found education significantly associated with unsafe action ($p < 0.05$), and with Sukamto's study at PT. Elnusa Geosains ($p = 0.012$). Eka and Wahyuningsih (2022) provides the theoretical mechanism: formal education develops the cognitive and behavioral foundations for procedural compliance and hazard recognition that directly protect against accident occurrence. The contribution of non-formal education to this relationship is particularly relevant for PT. X's workforce: structured OHS training programs, visual safety procedures, and practical certification can partially compensate for lower formal educational attainment and reduce the education linked accident risk differential.

4.2.4 Work Tenure and Workplace Accidents (H4)
H4 is supported: chi-square analysis reveals a highly significant association between work tenure and workplace accident occurrence ($p = 0.000 < \alpha = 0.05$), matching the significance level of the knowledge variable. Workers with shorter tenure (< 3 years) showed significantly higher accident rates than experienced workers. This finding is consistent with Sulhinayatillah (2017), who found a significant tenure–accident association ($p = 0.007$), and confirms the new worker vulnerability documented across Indonesian manufacturing literature (Hernawati, 2008; Pratama, 2015). The practical implication is that PT. X should implement a structured new worker orientation and onboarding program for all employees in the first three years of employment, incorporating progressive exposure to higher-risk tasks only after demonstrated competency at lower-risk levels, regular supervisor check-ins, and buddy-system pairing with experienced workers.

4.3 Integrated Discussion and Practical Implications
The finding that all four worker characteristics are independently and significantly associated with workplace accident occurrence confirms the multidimensional nature of accident risk in welding and assembly manufacturing. No single characteristic fully explains accident occurrence; rather, accident vulnerability is a compound profile in which low knowledge, young age, low education, and short tenure act as co-occurring and mutually reinforcing risk factors (Guo, Yiu, & González, 2022; Yang,

Li, Cao, & Luo, 2023). Workers presenting multiple risk characteristics simultaneously young, newly employed, lower-educated, with poor OHS knowledge represent the highest-risk subgroup requiring the most intensive preventive attention.

The similar p-values and statistical patterns between knowledge (p = 0.000) and tenure (p = 0.000) are theoretically coherent: both are modifiable through organizational intervention and both reflect the same underlying mechanism of inadequate task-specific safety competency. Knowledge can be directly improved through training; tenure-related competency gaps can be addressed through structured onboarding, mentorship, and task progression protocols. Education while not directly modifiable for current employees is addressed through non-formal training that can compensate for formal educational limitations (Kim, Rahim, & Lee, 2021). Age the least directly modifiable characteristic is addressed through supervision calibration and work design that accounts for the behavioral characteristics of younger workers.

The company's existing safety measures daily safety talks before shifts, SOP instruction, pre-work prayer, and periodic certification programs provide an organizational foundation for OHS knowledge development. However, the 40% poor knowledge prevalence and 56.7% accident prevalence suggest that these measures are not yet achieving sufficient impact, particularly for new workers and those with lower baseline education. Intensifying these programs increasing frequency, improving content specificity to welding and assembly hazards, and implementing competency-based assessment is the most direct evidence-based intervention for accident reduction at PT. X.

4.4 Discussions

The results of this study demonstrate that workplace accidents among welding and assembly workers at PT. X are significantly associated with four worker characteristics: OHS knowledge, age, education level, and work tenure. These findings confirm that occupational accident risk in manufacturing environments is multifactorial and influenced by both individual and experiential factors (Mulyani, Lamag, & Pamungkas, 2026; Habil, Jumadi, Pratiwi, & Vonny, 2025).

The most dominant finding is the strong association between OHS knowledge and workplace accidents (p = 0.000). Workers with poor OHS knowledge were more likely to experience accidents, indicating that knowledge is a critical determinant of safe work behavior. This is consistent with previous studies showing that inadequate safety knowledge significantly increases workplace accident risk among welding workers . Although PT. X has implemented safety talks and training programs, the relatively high proportion of workers with low knowledge suggests that current interventions are not yet fully effective or consistently absorbed by workers, particularly those with limited educational backgrounds.

Age was also significantly associated with workplace accidents (p = 0.013), with younger workers showing higher accident prevalence. Similar findings have been reported in recent studies indicating that younger workers tend to have higher risk-taking behavior and lower safety awareness in industrial settings (Islam, Hossain, Khan, & Islam, 2025). These behavioral tendencies highlight the need for stricter supervision and structured mentoring systems for new and younger workers in high-risk operations such as welding and assembly.

Education level showed a significant relationship with accident occurrence (p = 0.014). Workers with lower formal education were more frequently involved in accidents, likely due to limitations in hazard comprehension and procedural adherence. This is supported by evidence that education significantly influences safety behavior, risk perception, and compliance with occupational safety procedures (Zeng, 2023). However, this limitation can be mitigated through effective non-formal education such as practical training and competency-based safety certification.

Work tenure demonstrated a highly significant relationship with workplace accidents (p = 0.000), indicating that less experienced workers are more vulnerable to occupational hazards. Similar findings have been reported in welding-related studies where new workers consistently show higher accident

rates due to limited field adaptation ((Mulyani et al., 2026); (Novianus, 2025)). This emphasizes the importance of structured onboarding programs, gradual task assignment, and mentorship systems.

Overall, the findings confirm that workplace accidents at PT. X are not caused by a single factor but rather by a combination of individual characteristics that interact to shape risk levels. Workers with multiple risk factors such as low knowledge, young age, low education, and short tenure represent the most vulnerable group requiring targeted intervention.

From a practical perspective, PT. X should prioritize strengthening OHS training programs, improving competency-based evaluation systems, and enhancing supervision for new and younger workers. Existing safety measures should be optimized by tailoring training content to welding and assembly hazards and ensuring consistent implementation across all shifts. These improvements are essential to reduce accident prevalence and improve occupational safety performance in the company.

5. Conclusions

5.1 Conclusion

This study examined the association between four worker characteristics and workplace accident occurrence among 30 welding and assembly workers at PT. X, Batam, using a cross-sectional quantitative design and chi-square bivariate analysis. All four hypotheses were supported by statistically significant findings. OHS knowledge is significantly associated with workplace accident occurrence ($p = 0.000$); age is significantly associated with workplace accident occurrence ($p = 0.013$); education level is significantly associated with workplace accident occurrence ($p = 0.014$); and work tenure is significantly associated with workplace accident occurrence ($p = 0.000$). Accident prevalence in this sample is high (56.7%), reflecting the compound hazard profile of welding and assembly operations and the risk-amplifying demographic characteristics of the workforce (63.3% young workers; 73.3% lower-educated; 53.3% short-tenured; 40.0% with poor OHS knowledge).

The findings collectively indicate that PT. X's highest-priority accident prevention investments should target knowledge improvement (through structured, certified OHS training specific to welding and assembly hazards), new worker orientation (structured 3-year onboarding programs with progressive task exposure and mentorship), and intensified supervision for younger workers during peak unsafe behavior risk periods. These interventions address the two most statistically significant risk factors (knowledge and tenure) and are modifiable through organizational action, making them the most cost-effective evidence-based prevention strategies available.

5.2 Research Limitations

Four limitations qualify this study's findings. First, the small sample size ($n = 30$) substantially limits statistical power; the chi-square test may be underpowered for detecting moderate-strength associations, and the binary variable classification may obscure gradient relationships within characteristic categories. Larger-sample replications are needed to confirm the magnitude and consistency of these associations. Second, the cross-sectional design prevents causal inference: the observation that poor OHS knowledge is associated with higher accident rates does not establish whether low knowledge causes accidents, or whether workers who have experienced accidents develop more cautious (but still ultimately insufficient) safety attitudes. Longitudinal designs would enable examination of temporal precedence. Third, workplace accident data were collected retrospectively through self-report, introducing the potential for recall bias and under-reporting of minor incidents . Fourth, potential confounding variables including shift work, task assignment, PPE availability, and supervisor quality were not measured and may partially account for observed associations.

5.3 Suggestions and Directions for Future Research

For PT. X management, four recommendations follow directly from the study findings. First, mandatory structured OHS certification and training programs should be implemented for all new workers prior to independent task assignment in welding and assembly areas, with knowledge assessment confirming minimum competency standards before exposure to high-risk tasks. Second, a

structured three-year new worker orientation program incorporating progressive task exposure, buddy-system pairing with experienced workers, and regular supervisor competency check-ins should address the tenure-related accident vulnerability documented here. Third, age-stratified supervision protocols should increase supervisory contact frequency and safety coaching intensity for workers under 35 years during the first two years of employment. Fourth, non-formal OHS education programs including visual safety communication in the form of hazard pictograms, point-of-work safety reminders, and practical scenario-based training should compensate for the formal educational limitations of the workforce majority.

Future research should address the limitations identified above through several avenues. Multi-site studies enrolling larger samples of welding and assembly workers across Batam's manufacturing sector would enable sufficient statistical power for multivariate logistic regression, enabling simultaneous control of confounding factors and estimation of independent adjusted odds ratios for each worker characteristic. Longitudinal cohort studies tracking new workers over their first three years of employment would enable examination of how knowledge, tenure, and accident risk evolve together over time, providing causal evidence for the onboarding intervention recommendations made here. Research incorporating objective accident recording (rather than self-report) and validated OHS knowledge instruments would address measurement reliability concerns. Finally, intervention studies evaluating the effectiveness of structured OHS training programs on knowledge improvement and subsequent accident rate reduction would provide the causal evidence base needed to justify the training investments recommended in this study.

Acknowledgement
The authors express sincere gratitude to the management and all participating workers of PT. X, Batam, for granting research access and contributing their time and candid responses throughout the data collection process. The authors also thank the Faculty of Health Sciences at Universitas Ibnu Sina Batam for institutional support, and acknowledge the guidance of the supervising faculty throughout the research process.

Author Contributions
JJ conceptualized the study, designed the research methodology, collected and analyzed the data, and prepared the original manuscript draft. DM contributed to the study design, data interpretation, and critical revision of the manuscript for important intellectual content. LU supervised the research process, validated the findings, and reviewed and edited the final manuscript. All authors discussed the results, contributed to the final version of the manuscript, and approved the submitted version.

References
Ayu, F., & Rhomadhoni, M. N. (2019). Pengaruh karakteristik individu dan karakteristik pekerjaan terhadap perilaku tidak aman (unsafe action) pada pekerja divisi kapal niaga PT PAL Indonesia tahun 2018 [Effect of individual and job characteristics on unsafe actions among ship division workers at PT PAL Indonesia in 2018]. *Medical Technology and Public Health Journal*, *3*(1), 44-53. https://doi.org/10.33086/mtphj.v3i1.948

Badri, A., Nadeau, S., & Gbodossou, A. (2021). A systematic review of occupational health and safety risk assessment methods. *Journal of Loss Prevention in the Process Industries, 71, 104419*. https://doi.org/10.1016/j.jlp.2021.104419

Biro Humas Kemnaker. (2020). *Menaker Ida canangkan bulan K3 nasional tahun 2020 [Minister Ida launches K3 National Month 2020]*.

Eka Putri & Wahyuningsih. (2022). Faktor-faktor yang berhubungan dengan kecelakaan kerja di PT. *X. Jurnal Kesehatan Masyarakat*, *10*(6), 643-655. https://doi.org/10.14710/jkm.v10i6.36483

Ferreira, M. J. M., Correa, F. G. S., Lacerda, E. M., Hajat, S., & Araújo, L. F. (2020). Analysis of risk factors in occupational accidents in Brazil: A population-based study. *Journal of Occupational and Environmental Medicine*, *62*(2). https://doi.org/10.1097/JOM.0000000000001793

Guo, B. H. W., Yiu, T. W., & González, V. A. (2022). Predicting safety behavior in the construction industry: Development and test of an integrative model. *Safety Science, 145, 105490*. https://doi.org/10.1016/j.ssci.2021.105490

Habil, H., Jumadi, H., Pratiwi, S. W., & Vonny, P. (2025). Factors related to work accidents in welding workshops in Paleteang District. *Journal of Midwifery and Nursing*, *7*(3), 500-508. https://doi.org/10.35335/jmn.v7i3.6718

Handayani, E. (2010). *Hubungan antara penggunaan alat pelindung diri, umur dan masa kerja dengan kecelakaan kerja pada pekerja bagian rustic di PT Borneo Melintang Buana Eksport Yogyakarta [Relationship between PPE use, age, and tenure with work accidents in rustic workers at PT Borneo Melintang Buana Eksport Yogyakarta] [Skripsi, Universitas Ahmad Dahlan]* (Doctoral dissertation).

Hansen, P. W., Schlünssen, V., Fonager, K., Bønløkke, J. H., Hansen, C. D., & Bøggild, H. (2022). Association of perceived work pace and physical work demands with occupational accidents: A cross-sectional study of ageing male construction workers in Denmark. *BMC Public Health*, *22*(1), 18. https://doi.org/10.1186/s12889-021-12461-6

Hernawati. (2008). *Faktor-faktor yang berhubungan dengan kejadian kecelakaan kerja berdasarkan karakteristik pekerja dan unit kerja di area pertambangan PT Antam Tbk UBPE Pongkor Bogor Jawa Barat tahun 2006–2007 [Factors associated with occupational accident occurrence based on worker and work unit characteristics at PT Antam Tbk mining area] [Skripsi, Universitas Indonesia]* (Doctoral dissertation).

International Labour Organization (ILO). (1998). *Encyclopaedia of occupational health and safety (4th ed.)*.

Islam, K. S., Hossain, A., Khan, M. R., & Islam, M. T. (2025). The role of age in shaping risk-taking behaviors and safety awareness in the manufacturing sector. *American Journal of Advanced Technology and Engineering Solutions*, *1*(1), 98-121. https://doi.org/10.63125/sq8jta62

Kim, N. K., Rahim, N. F. A., & Lee, S. H. (2021). The effects of onboarding and safety orientation programs on occupational safety outcomes among industrial workers. *International Journal of Occupational Safety and Ergonomics*, *27*(4), 1127-1138. https://doi.org/10.1080/10803548.2020.1843354

Michiko Miyamoto. (2018). Bulan K3 nasional: Menuju budaya pencegahan keselamatan dan kesehatan kerja yang lebih kuat di Indonesia [K3 National Month: Towards a stronger occupational safety and health prevention culture in Indonesia]. *International Labour Organization*.

Mulyani, W., Lamag, P. W. A., & Pamungkas, A. I. (2026). Factors associated with work-related accidents among welding shop workers. *MEDICA International Medical Scientific Journal*, *8*(4), 232-241. https://doi.org/10.53770/medica.v8i4.979

Notoatmodjo, S. (2012). Promosi kesehatan dan perilaku kesehatan [Health promotion and health behavior]. *Rineka Cipta*.

Novianus, C. (2025). Analysis of unsafe action among welding workshop workers in Bogor City. *Jurnal Fisioterapi dan Kesehatan Indonesia*, *5*(2), 239-251. https://doi.org/10.59946/jfki.2025.463

Nurjanah, B. S. (2014). Perilaku tidak aman (unsafe behaviour) pada pekerja di Unit Material PT Sango Ceramics Indonesia Semarang [Unsafe behaviour among workers in the Material Unit at PT Sango Ceramics Indonesia Semarang]. *Jurnal Kesehatan*, *7*(2), 353-360.

Pratama, A. K. (2015). Hubungan karakteristik pekerja dengan unsafe action pada tenaga kerja bongkar muat di PT Terminal Petikemas Surabaya [Relationship between worker characteristics and unsafe actions among stevedoring workers at PT Terminal Petikemas Surabaya]. *The Indonesian Journal of Occupational Safety and Health*, *4*(1), 64-74. https://doi.org/10.20473/ijosh.v4i1.2015.64-73

Puspandhani, M. E. (2020). Analisis faktor penyebab terjadinya kecelakaan kerja pada pekerja di unit spinning perusahaan manufaktur Kota Cirebon. *Jurnal Cahaya Mandalika*, *1*(1), 42-54. https://doi.org/10.36312/jcm.v1i1.41

Rizka Pisceliya, D. M., & Mindayani, S. (2018). Analisis kecelakaan kerja pada pekerja pengelasan di CV Cahaya Tiga Putri [Analysis of workplace accidents among welding workers at CV Cahaya Tiga Putri]. *Jurnal Riset Hesti Medan Akper Kesdam I/BB Medan*, *3*(1), 66-75. https://doi.org/10.34008/jurhesti.v3i1.28

Saragih, F. R. P., Lubis, H. S., & Tarigan, L. (2014). Faktor-faktor yang berhubungan dengan tindakan tidak aman pada pekerja lapangan PT Telkom Cabang Dikilang Kabupaten Dairi tahun 2014 [Factors associated with unsafe actions among field workers at PT Telkom Dairi Branch 2014]. *Fakultas Kesehatan Masyarakat, Universitas Sumatera Utara*.

Sulhinayatillah. (2017). *Faktor-faktor yang berhubungan dengan kejadian kecelakaan kerja pada karyawan bagian produksi di PT PP London Sumatera Indonesia Tbk Palangisang Crumb Rubber Factory Bulukumba tahun 2017 [Factors associated with workplace accident occurrence among production employees at PT PP London Sumatera Indonesia Tbk] [Skripsi, Universitas Hasanuddin]* (Doctoral dissertation).

Syaputra, E. (2017). *Hubungan pengetahuan dan motivasi K3 dengan kecelakaan kerja karyawan produksi PT Borneo Melintang Buana Eksport [Relationship between OHS knowledge and motivation and workplace accidents among production employees at PT Borneo Melintang Buana Eksport] [Skripsi, Universitas Muhammadiyah Pontianak]* (Doctoral dissertation).

Triwibowo, C., & Puspihandani, M. E. (2013). Pengantar dasar ilmu kesehatan masyarakat [Introduction to the basics of public health science]. *Nuha Medika*.

Undang-Undang Republik Indonesia Nomor 1 Tahun 1970 Tentang Keselamatan Kerja [Law of the Republic of Indonesia Number 1 of 1970 on Work Safety]. (1970).

Wiratna, V. (2014). Metodologi penelitian [Research methodology]. *Pustakabarupress*.

Yang, X., Li, H., Cao, D., & Luo, X. (2023). Factors influencing workplace accident risks: A systematic review and meta-analysis. *Safety Science, 163, 106120*. https://doi.org/10.1016/j.ssci.2023.106120

Yudhawan, Y. V., & Dwiyanti, E. (2017). Hubungan personal factors dengan unsafe actions pada pekerja pengelasan di PT Dok Dan Perkapalan Surabaya [Relationship between personal factors and unsafe actions among welding workers at PT Dok Dan Perkapalan Surabaya]. *Jurnal Ilmiah Kesehatan Media Husada*, *6*(1), 141-150. https://doi.org/10.33475/jikmh.v6i1.154

Zeng, et al. (2023). Safety behavior and education influence in occupational safety compliance. *Sustainability*, *15*(19), 14641. https://doi.org/10.3390/su151914641