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Identifying and Analyzing Factors Influencing Occupational Accidents in the Construction Sector: A Review of 10-year Research

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Abstract

The construction sector is one of the industries that has a high risk of occupational accidents. Therefore, preventing accidents from occurring is crucial, one of which is by identifying the factors caused. The present study aims to review articles published in the last 10 years to identify and analyze factors related to the incidence of occupational accidents in the construction sector. A systematic search method was conducted until December 2023 on the following databases: Scopus, ScienceDirect, and Google Scholar. A total of twenty-three articles were included in this review with all articles being original research and discussing factors that contribute to occupational accidents in the construction sector. Our findings show that there are several factors influencing an increase in occupational accidents, namely individual factors, including male gender, younger age, lack of work experience, not long working period, being married, poor level of work safety knowledge, absence of occupational safety training, low level of education, and job dissatisfaction; unsafe action factors, including not using personal protective equipment (PPE) or using inappropriate PPE, not following work safety regulations, applying inappropriate standard operational procedures (SOPs), and fatigue; unsafe condition factors, including the absence of occupational safety and health (OS&H) supervision and inappropriate installation of safety signs; environmental factors, including thermal stress, interference, smooth surfaces, work platform height, and extreme temperature changes during summer and winter; psychological and occupational stress factors, including high time pressure, high workload, poor work schedule, and violence and bullying perpetrated by co-workers or supervisors; and defective equipment factors. In conclusion, individual, unsafe actions, unsafe conditions, environmental, psychological and occupational stress, and defective equipment factors have a significant influence on occupational accidents at construction sites.

Keywords: accidents, construction, factors, occupational accidents

Introduction

Various development projects such as housing, health services, educational facilities, airports, bridges, highways, excavation, demolition and large-scale painting works are examples of coverage in the construction industry (Abukhashabah et al., 2020). Construction, categorized as a high-risk industry, is an industry that has a high rate of occupational accidents due to the complexity and location of the construction (Antoniou & Merkouri, 2021), where the construction site is a workplace that

has many dangerous activities and the possibility of many occupational accidents (Goh et al., 2016). Several studies describe several types of occupational accidents that often occur at construction sites, such as falls from heights, being hit by falling objects or heavy construction equipment, broken bones, exposure to hazardous materials, moving equipment, vehicle accidents, moving machine components, and electric shocks, as well as death (Abukhashabah et al., 2020; Winge & Albrechtsen, 2018).

As one of the jobs with the highest risk of occupational accidents, construction contributes to many occupational accidents, injuries and deaths globally. Globally, the ratio of fatal occupational accidents is 14:100,000 workers with an estimated total of around 350,000 fatal occupational accidents and non-fatal occupational accidents amounting to around 264 million accidents (Hämäläinen et al., 2006; Takala, 1999). Meanwhile, the incidence of occupational accidents among construction workers, as stated by the Occupational Safety and Health Administration construction worker safety report, affects at least 600,000 fatal accidents or 1:6 of fatal accidents in the workplace are occupational accidents among construction workers (Ashuro et al., 2021). In Indonesia, occupational accidents in the construction sector account for around 30% of all occupational accidents (Machfudiyanto et al., 2023). The high number of occupational accidents in construction means that strategic prevention and risk management efforts continue to be conducted to minimize and reduce the incidence of occupational accidents at construction sites.

One effort to prevent occupational accidents in the construction sector is to identify, analyze and understand in depth the factors that influence the occurrence of occupational accidents. Therefore, the main aim of this review is to identify and analyze the factors that cause occupational accidents in construction workers, and was conducted on original research publications within the last 10 years (2013-2023). By understanding the factors that play an important role in occupational accidents, preventive measures can then be developed in the construction industry which are expected to minimize and prevent occupational accidents.

Methods

The present study used a literature review method. Data were obtained from published articles extracted through systematic searches on the following three major databases: Scopus, ScienceDirect, and Google Scholar. The first step was to conduct a literature search on the aforementioned databases in December 2023 using several combinations of keywords below.

Table 1. Keywords used to identify records in each database.

Database	Keywords
Scopus	TITLE-ABS-KEY ("factors") AND ("accidents" OR "injury" OR "work-related accidents" OR "occupational accidents") AND ("construction" OR "construction industry") AND PUBYEAR > 2012 AND PUBYEAR < 2024 AND (LIMIT-TO (OA, "all")) AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (LANGUAGE, "English"))
ScienceDirect	Title, abstract, keywords: (“factors”) AND (“accidents” OR "injury" OR "work-related accidents" OR "occupational accidents") AND (“construction” OR "construction industry")
Google Scholar	“factors” “accidents” "injury" "work-related accidents" "occupational accidents" “construction” "construction industry"

The results of identifying articles from the database were then grouped and, if any, duplicates were removed using the Mendeley reference manager. Next, we conducted an initial screening by evaluating the title and abstract, and all irrelevant articles to this study were excluded. The remaining records are then filtered using inclusion and exclusion criteria. The inclusion criteria used were original research articles in Indonesian and English, published in the last 10 years (January 2013 – December 2023), open access or full-text articles, and studies discussing factors influencing occupational accidents at construction sites or among construction workers. Meanwhile, the exclusion criteria applied included review articles and studies discussing factors causing occupational accidents in sectors other than construction.

In the end, all articles included based on the inclusion and exclusion criteria were assessed for

article eligibility. At this stage, if there were differences of opinion, a careful discussion was carried out to make the decision to include the article. After all studies were included for review, we carried out a qualitative analysis which we then explained in the discussion in the form of identifying and analyzing the factors influencing occupational accidents in construction workers. The entire selection process for included articles is depicted in Figure 1.

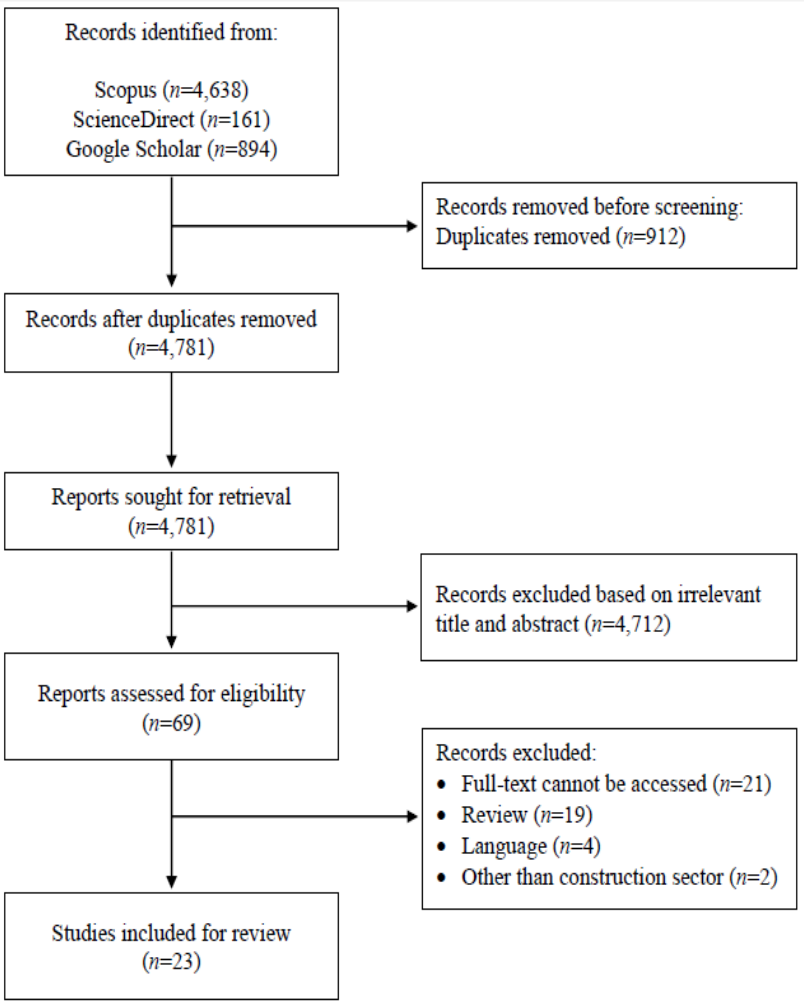

Fig. 1. Study selection process.

Results and Discussion

After identifying articles through a systematic search, 4,781 articles were retrieved for screening, after 912 duplicates were removed. A total of 4,712 studies were excluded based on irrelevant title and abstract, remaining 69 articles. Finally, article eligibility assessment was carried out and 23 articles were included for review.

Tabel 1. Summary of the included articles.

Reference	Results
(Van Der Klauw et al., 2014)	In the construction industry, high time pressure (p<0.05; OR=1.47) and violence and harassment perpetrated by co-workers or supervisors (p<0.05; OR=1.84) have a significant relationship with the incidence of occupational accidents. Thus, it can be concluded that psychosocial factors have an important role in occupational accidents in the construction sector and other sectors.
(Yilmaz, 2014)	Several dangerous behaviors are factors that cause occupational accidents, including the highest being unsafe behavior (67%), followed by not using PPE or appropriate PPE (13%), using dangerous tools (8%), working very fast (5%), carrying dangerous loads (4%), working

Reference	Results
	outside of their own duties (1%), not adhering to work discipline (1%), and being tired and lacking sleep (1%).
(Gonzalez-Delgado et al., 2015)	Factors involved in occupational accidents included male gender (OR=5.86, 95% CI=4.22-8.14), age (OR=1.04, 95% CI=1.03-1.06), working in that position within a period of 1-10 years (OR=1.37, 95% CI=1.15-1.63), working as a facility operator, machine, or assembler (OR=3.28, 95% CI=2.12-5.07), and workers without qualifications (OR=1.96, 95% CI=1.18-3.24).
(Khodabandeh et al., 2016)	Several factors such as male gender (100%), age range 30-39 years (25.6%), secondary education level (38.2%), married (44.4%), causal worker (54.5%), unskilled at work (54.5%), not having insurance coverage (66.1%), and working during the day (40.2%) contribute to occupational accidents and fatal injuries that pose a risk of death in the construction industry.
(Hatami et al., 2017)	A number of factors that have a significant influence on occupational accidents include younger age (p=0.001; OR=0.98, CI=0.97-0.99), being married (p=0.02; OR=1.37, CI=1.04-1.79), place of work accident (p=0.007; OR=1.86, CI=1.18-2.92), lack of information (p=0.007; OR=5.28, CI=1.57-17.75), not complying with work safety regulations (p=0.001; OR=3.11, CI=1.87-5.17), not using PPE (p=0.001; OR=2.98, CI=1.62-5.50), and defective equipment (p=0.01; OR=2.22, CI=1.18-4.20).
(Otiki Makori et al., 2018)	The findings in this research state that technical, skills, work environment, and work practice and safety factors have an influence of up to 23.5% of changes in the occurrence of occupational accidents in construction with an R-square of 0.235. Skills (p=0.042) and work experience (p=0.002) have a negative and significant relationship to the occurrence of occupational accidents in construction.
(Suak et al., 2018)	Based on the test results, not using PPE (p=0.011) is a factor that significantly influences occupational accidents among construction project workers.
(Betsis et al., 2019)	The most construction workers involved in occupational accidents were aged 24-34 years (26%) and 35-44 years (26%), male (98%), skilled workers (46%) followed by unskilled workers (37%), and workers with less than 12 months of experience (68%). Apart from that, environmental factors also contribute to the occurrence of occupational accidents, where cases increase in summer (31%) and winter (26%).
(Farid et al., 2019)	The research results show that there is a significant relationship between stress factors and occupational accidents (p=0.001).
(Panjaitan & Silalahi, 2019)	The study results show that there is a significant relationship between the use of PPE and occupational accidents (p=0.031).
(Abbasi et al., 2020)	There are several factors that support the occurrence of occupational accidents, but some of them that are significantly related are education level (p=0.03), presence of a safety supervisor (p=0.04), safety training (p=0.002), and history of previous occupational accidents (p=0.027).
(Biabani et al., 2020)	The test results concluded that there was a significant relationship between occupational accidents in the construction sector and marital status (p<0.001), age (p<0.001), education level (p<0.001), and work experience (p<0.001).
(Irawati, 2020)	The study findings concluded that there were factors that significantly influenced occupational accidents, namely unsafe conditions (p=0.000) and unsafe actions (p=0.000).
(Vosoughi et al., 2020)	Factors that cause workers on construction projects to fall from heights include individual factors (level of education, training hours, use of PPE, age and experience, psychological or occupational stress), ognaization factors (management commitment, safety culture, mutual understanding, monitoring/organization size/project size), and environmental factors (thermal stress, interference, smooth surfaces, work platform height).
(Tri Handari & Qolbi, 2021)	The bivariate test results show that there is a significant relationship between the use of PPE (p=0.010; PR=3.556, 95% CI=1.436-8.805) the level of knowledge (p=0.003; PR=4.215, 95% CI=1.710-10.389) and the incidence of occupational accidents.
(Huda et al., 2021)	OS&H knowledge (p=0.003), OS&H supervision (p=0.001), unsafe actions (p=0.002), and unsafe conditions (p=0.000) are the main factors that are significantly related to occupational accidents in the construction sector on building construction projects.
(Komarudin et al., 2022)	There are several significant direct influences, including personal factors on unsafe actions (p=0.006), OS&H management on unsafe actions (p=0.000), and personal factors on occupational accidents (p=0.012). Therefore, it can be inferred that personal factors have a significant influence on occupational accidents through unsafe actions.
(Hamudya et al., 2023)	There is a significant relationship between several factors and occupational accidents in construction workers, including age under 36 years (p=0.008; OR=4.246, 95% CI=1.157-11.581), not long working period (p=0.005; OR=6.163, 95% CI=1.803-21.066), and not using PPE (p=0.017; OR=3.692, 95% CI=1.372-9.933).

Reference	Results
(Karel et al., 2023)	There is a significant correlation between low knowledge (p=0.001; OR=0.188, 95% CI=0.065-0.544), inappropriate application of SOPs (p=0.023; OR=0.304, 95% CI=0.107-0.869), and inappropriate installation of safety signs (p=0.020; OR=0.303, 95% CI=0.109-0.844) and occupational accidents.
(Mayandari & Inayah Z, 2023)	Several factors that influence the occurrence of occupational accidents include level of knowledge (p=0.001), unsafe actions (p=0.000), use of PPE (p=0.002), and work environment (p=0.004).
(Rachmat & Ramdhan, 2023)	Several factors related to occupational accidents include the level of work stress (p=0.21; OR=3.448, 95% CI=1.267-9.387), outdoor work climate (p=0.021; OR=3.448, 95% CI=1.267-9.387), high workload (p=0.006; OR=2.166, 95% CI=1.272-3.689), bad work schedule (p=0.002; OR=2.948, 95% CI=1.497-5.803), education level (p=0.0001; OR=4.004, 95% CI=1.942-8.422), and work period of less than 12 months (p=0.039; OR=9.180, 95% CI=1.089-77.400).
(Wulandari et al., 2023)	Unsafe actions (p=0.008) and work fatigue (p=0.014) are factors that significantly influence occupational accidents.
(Yosef et al., 2023)	In this study, male gender (p=0.042; AOR=1.74, 95% CI=1.02-2.97), being married (p=0.001; AOR=2.79, 95% CI=1.50-5.17), not using PPE (p=0.032; AOR=1.67, 95% CI=1.12-2.85), no work safety training (p=0.017; AOR=1.45, 95% CI=1.06-2.98), and job dissatisfaction (p<0.001; AOR=5.97, 95% CI=3.48-10.2) are factors that are significantly related to occupational accidents in the construction sector.

Individual Factors

The occurrence of occupational accidents is influenced by various factors, including individual factors (Vosoughi et al., 2020), which include gender, age, marital status, worker skills, education level, level of knowledge, safety training, length of service and work experience, history of previous occupational accidents, and job dissatisfaction. Furthermore, individual factors are significantly related to occupational accidents as shown by the relationship between personal factors and unsafe acts (p=0.006), occupational safety and health (OS&H) management on unsafe acts (p=0.000), and personal factors and occupational accidents (p=0.012) (Komarudin et al., 2022).

Based on gender, men are one of the factors causing occupational accidents in the construction sector. This is in accordance with several research results conducted by Gonzales-Delgado et al. with the result OR=5.86, 95% CI=4.22-8.14 (Gonzalez-Delgado et al., 2015), Khodabandeh et al. which states that as many as 100% of male workers experience occupational accidents (Khodabandeh et al., 2016), research by Betsis et al. which states that as many as 98% of workers who experience occupational accidents are male workers (Betsis et al., 2019), as well as research by Yosef et al. which concluded that male gender significantly influences occupational accidents (p=0.042; AOR=1.74, 95% CI=1.02-2.97) (Yosef et al., 2023). Male gender is one of the factors causing accidents due to high work demands, this is in accordance with research which states that there is a positive relationship between work demands in the male group and occupational accidents (r=0.24; p<0.001) (Osca & López-Araújo, 2020). In addition, men have high risk-taking behavior and have different tasks at work, especially in the construction sector, compared to female workers (Chou et al., 2022).

The second individual factor is age, where age has a significant correlation with the incidence of occupational accidents in construction, indicated by a p-value of <0.001 (Biabani et al., 2020) and the OR value is 1.04 with 95% CI=1.03-1.06 (Gonzalez-Delgado et al., 2015). There are several studies which state that there is an influence of age, whether younger or older, in relation to the incidence of occupational accidents. Study by Hatami et al. concluded that younger age (p=0.001; OR=0.98, CI=0.97-0.99) is correlated with occupational accidents (Hatami et al., 2017). This is supported by research conducted by Betsis et al. which found that occupational accidents occurred at ages 24-34 years (26%) and 35-44 years (26%) (Betsis et al., 2019). Apart from that, the age range of 30-39 years (25.6%) (Khodabandeh et al., 2016) and age under 36 years (p=0.008; OR=4.246, 95% CI=1.157-11.581) (Hamudya et al., 2023) also have a positive correlation with occupational accidents in the construction industry. This is in accordance with research which states that the average age of workers involved in accidents in

the 1996-2015 period in Spain was 35.31 years (Camino López et al., 2018). The findings in this review are that young people are more likely to experience occupational accidents in construction. This is most likely due to the fact that younger workers are more often given or take lower positions in the workplace, thereby providing a higher burden of risk and draining physical energy (Ajslev et al., 2017). Additionally, carelessness, haste, rushing and not being careful are likely reasons why younger construction workers are more likely to experience occupational accidents (Hamudya et al., 2023).

Increasing age allows for increased work experience, thereby increasing alertness towards occupational accidents at construction sites (Faris & Harianto, 2014). The results of our study found that lack of work experience has a significant relationship to the incidence of occupational accidents in construction, as shown by several studies that workers with less than 12 months of experience (68%) (Betsis et al., 2019) and less work experience with p=0.002 (Otiki Makori et al., 2018) and p<0.001 (Biabani et al., 2020). Apart from that, a short period of work (p=0.005; OR=6.163, 95% CI=1.803-21.066) (Hamudya et al., 2023), a work period of less than 12 months (p=0.039; OR=9.180, 95% CI=1.089-77.400) (Rachmat & Ramdhan, 2023), and working in that position for a period of 1-10 years (OR=1.37, 95% CI=1.15-1.63) (Gonzalez-Delgado et al., 2015) have a significant correlation with occupational accidents due to experience and a short work period. Therefore, we can conclud that the higher the work experience and the longer the work period, the smaller the risk of occupational accidents occurring at construction sites.

Marital status is a factor that also influences the incidence of occupational accidents (p<0.001) (Biabani et al., 2020). This is corroborated by the findings of several studies which found that there was a significant influence between married status and occupational accidents, including research conducted by Khodabandeh et al. (44.4% of workers are married and have had occupational accidents) (Khodabandeh et al., 2016), Hatami et al. (p=0.02; OR=1.37, CI=1.04-1.79) (Hatami et al., 2017), and Yosef et al. (p=0.001; AOR=2.79, 95% CI=1.50-5.17) (Yosef et al., 2023). This possibility is supported by the reason that married workers require more money for their family life, so they have to do more work with insufficient rest. This also has an impact on stress and fatigue in married workers compared to single workers because married workers have higher life responsibilities to meet family needs (Ashuro et al., 2021; Yosef et al., 2023). As of, the marital status of construction workers has a significant effect on the incidence of occupational accidents at construction sites due to excessive stress and fatigue compared to single workers.

Skills are basic things that construction workers must have, because they involve work safety and avoiding occupational accidents. Skills in working in the construction sector greatly influence occupational accidents (p=0.042) (Otiki Makori et al., 2018). Several studies agree with this, shown by research results which say that occupational accidents are significantly related to workers without qualifications (OR=1.96, 95% CI=1.18-3.24) (Gonzalez-Delgado et al., 2015) and unskilled workers (Betsis et al., 2019; Khodabandeh et al., 2016). Several studies believe that lacking skills at work is related to low knowledge of work safety, which is strengthened by the absence of work safety training (Dudarev et al., 2013; Farrow & Reynolds, 2012; Khodabandeh et al., 2016).

Regarding workers' lack of skills due to their level of knowledge and lack of training regarding work safety, these two reasons are also directly related to occupational accidents at construction sites. This is in accordance with several studies which state that the level of knowledge or lack of information related to work safety has a significant effect on occupational accidents, as in the research by Hatami et al. (p=0.007; OR=5.28, CI=1.57-17.75) (Hatami et al., 2017), Handari and Qolbi (p=0.003; PR=4.215, 95% CI=1.710-10.389) (Tri Handari & Qolbi, 2021), Huda et al. (p=0.003) (Huda et al., 2021), Karel et al. (p=0.001; OR=0.188, 95% CI=0.065-0.544) (Karel et al., 2023), as well as Mayandari and Inayah (p=0.001) (Mayandari & Inayah Z, 2023). Considering previous research which states that the level of knowledge and the absence of safety training are correlated with occupational accidents, we again reviewed several studies related to the absence of safety training and

occupational accidents. Our findings state that work safety training significantly influences the incidence of occupational accidents with a value of p=0.002 (Abbasi et al., 2020) and p=0.017; AOR=1.45, 95% CI=1.06-2.98 (Yosef et al., 2023). All the research we reviewed shows a significant relationship between job skills and occupational accidents at construction sites. This is due to the low level of knowledge regarding work safety. This low level of knowledge is believed to be due to minimal or non-existent work safety training.

The level of worker education has a significant influence on awareness of the importance of work safety, ways of thinking when dealing with work, and prevention or avoidance of occupational accidents at construction sites (Faris & Harianto, 2014). The results of our study state that the level of education has a significant effect on occupational accidents among construction workers, as shown by research conducted by Abbasi et al. (p=0.03) (Abbasi et al., 2020), Biabani et al. (p<0.001) (Biabani et al., 2020), and Rachmat and Ramadhan (p=0.0001; OR=4.004, 95% CI=1.942-8.422) (Rachmat & Ramdhan, 2023). In addition, research by Khodabandeh et al. concluded that workers with a secondary education level experienced more occupational accidents at construction sites (Khodabandeh et al., 2016).

Apart from all this, job dissatisfaction or work environment factors have a negative influence on the level of worker productivity in the construction sector (Abrey & Smallwood, 2014). Our review found one study that stated that construction workers' dissatisfaction with their jobs had a significant relationship to occupational accidents at construction sites (p<0.001; AOR=5.97, 95% CI=3.48-10.2) (Yosef et al., 2023). These results are supported by other studies which conclude that the relationship between job satisfaction and unsafe acts produces a significant relationship (p<0.05) (Akbari et al., 2019). Unsafe actions will have an impact on increasing the incidence of occupational accidents when working at construction sites. Thus, it can be concluded that job dissatisfaction contributes to occupational accidents.

Based on the results of the review, we believe that individual factors, including male gender, younger age, lack of work experience, not long work experience, being married, poor level of work safety knowledge, absence of work safety training, low education levels, as well as job dissatisfaction, have a significant influence on the incidence of occupational accidents at construction sites.

Unsafe Action Factors

There are various unsafe actions carried out by construction workers which increase the incidence of occupational accidents at construction sites. The results of our study found that unsafe behavior and actions have a positive influence on the incidence of occupational accidents (Yilmaz, 2014). In addition, several other studies support this statement as evidenced by the results of the p value which shows a significant effect, namely p=0.000 (Irawati, 2020), p=0.002 (Huda et al., 2021), p=0.000 (Mayandari & Inayah Z, 2023), and p=0.008 (Wulandari et al., 2023).

The results of our review state that one of the unsafe acts that is most discussed and has the greatest influence on occupational accidents, and even has a strong influence, is related to the use of PPE. This is reinforced by the results of several studies regarding the relationship between the use of PPE and occupational accidents in the construction sector conducted by Panjaitan and Silalahi (p=0.031) (Panjaitan & Silalahi, 2019), Handani and Qolbi (p=0.010; PR=3.556, 95% CI=1.436-8.805) (Tri Handari & Qolbi, 2021), as well as Mayandari and Inayah (p=0.002) (Mayandari & Inayah Z, 2023). In this case, the increase in occupational accidents was positively influenced by workers not using PPE or using inappropriate PPE (Yilmaz, 2014). This is corroborated by several other research results that we reviewed, that not using PPE has a strong influence on increasing the frequency of occupational accidents at construction sites, such as in studies conducted by Hatami et al. (p=0.001; OR=2.98, CI=1.62-5.50) (Hatami et al., 2017), Suak et al. (p=0.011) (Suak et al., 2018), Hamudya et al. (p=0.017; OR=3.692, 95% CI=1.372-9.933) (Hamudya et al., 2023), and Yosef et al. (p=0.032; AOR=1.67, 95% CI=1.12-2.85) (Yosef et al., 2023).

The use of PPE is very important in all work sectors, especially the construction sector which has a higher frequency of occupational accidents.

Moreover, with the addition of other factors that have a high possibility of occupational accidents occurring, such as workers using dangerous tools, working very quickly or in a hurry, and carrying dangerous loads (Yilmaz, 2014). Because the death rate due to occupational accidents in the construction sector is three times higher than in other sectors (Darda'u Rafindadi et al., 2022), the use of PPE is important for construction workers to protect themselves from the possibility of detrimental and fatal occupational accidents (Colares et al., 2019; Jaafar et al., 2018). More so, workers will become less productive because they feel unsafe at construction site due to not using PPE (Ammad et al., 2021). Finally, we can conclude that the use of PPE has a big influence on increasing the frequency of occupational accidents among workers at construction sites.

Apart from using PPE to minimize the occurrence of occupational accidents, work safety regulations are implemented to eliminate potential dangers and reduce the risk of occupational accidents at construction sites (Othman, 2012). In this study, we found that violating work safety regulations has a significant influence on increasing occupational accidents. This is proven by two studies with results that do not comply with work safety regulations (p=0.001; OR=3.11, CI=1.87-5.17) (Hatami et al., 2017) and implementation of inappropriate SOPs (p=0.023; OR=0.304, 95% CI=0.107-0.869) (Karel et al., 2023) have an impact on increasing occupational accidents in the construction sector. In conclusion, work safety regulations that are violated increase the frequency of occupational accidents.

The construction industry is a dangerous work sector and provides tasks that are physically and mentally demanding for its workers, so they will easily experience fatigue. The frequency of fatigue among construction workers is quite high and is predicted to have a big influence on occupational accidents (Namian et al., 2021). Our review found that work fatigue has a significant effect on increasing the occurrence of occupational accidents at construction sites (p=0.014) (Wulandari et al., 2023). A study tested construction workers using the Fatigue Assessment Scale for Construction Workers (FASCW) by giving experimental tasks, with the research results that the level of worker fatigue increased significantly along with the number of trials carried out and workers tended to make more mistakes when the fatigue condition increased (D. Fang et al., 2015). Strengthening these findings, other research reveals that fatigue increases physical and cognitive function difficulties which may have an impact on work safety (Zhang et al., 2015).

In our review, we found that not using PPE or using inappropriate PPE, not following work safety regulations, applying inappropriate SOPs, and fatigue are unsafe actions that have a significant influence on increasing occupational accidents.

Unsafe Condition Factors

Unsafe actions carried out by construction workers may also be influenced by unsafe conditions at construction sites, which causes an increase in the incidence of occupational accidents (Chi et al., 2013; Nkem et al., 2015; Widjaja & Abdullah, 2021). This is in accordance with our findings in two studies which state that unsafe conditions have a significant influence on occupational accidents among construction workers (p=0.000) (Huda et al., 2021; Irawati, 2020). Thus, unsafe construction workplace conditions contribute greatly to the occurrence of occupational accidents.

One important factor in the unsafe conditions category is the absence of OS&H supervisors. In construction projects, work safety is crucial and needs to be paid attention to in order to create a safe work culture and environment (Pinto, 2014). By supervising work safety, it will increase the productivity of construction project workers, thereby minimizing the incidence of occupational accidents (Djaelani & Retnowati, 2022). This statement is strengthened by our findings in several studies which state that the presence of safety supervisors has a significant effect on the incidence of occupational accidents, in accordance with research conducted by Abbasi et al. (p=0.04) (Abbasi et al., 2020) and Huda et al. (p=0.001) (Huda et al., 2021). These findings conclude that the absence of safety supervisors has an impact on increasing the incidence of accidents at construction sites.

Apart from the role of work safety supervisor, safety signs have an important role in increasing workers' awareness of dangers at the work site.

Installation of safety signs plays an important role in safety management because it can provide understanding regarding dangerous information at construction sites and workers can take action in the form of protection to minimize or avoid accidents (Y. Fang et al., 2022; Laughery & Wogalter, 2014). There is one study that we found which states that inappropriate installation of safety signs has a strong influence on the occurrence of occupational accidents at construction sites (p=0.020; OR=0.303, 95% CI=0.109-0.844) (Karel et al., 2023).

Based on the results of our review, it can be concluded that unsafe condition factors have a significant influence on increasing the incidence of occupational accidents at work sites, such as the absence of OS&H supervision and inappropriate installation of safety signs.

Environmental Factors

A construction site is a complex system that includes various aspects that work together to complete a construction project, therefore, the construction environment has a much higher risk of occupational accidents compared to other work environments (Putri & Lestari, 2023; Sulistyaningtyas, 2021). A study stated that environmental factors and safety performance have a significant correlation (Kasuma et al., 2019). Thus, environmental factors play an important role in occupational accidents. This is in accordance with our findings in several studies which say that environmental factors, such as thermal stress, interference, smooth surfaces, and work platform height, have a significant influence on the frequency of accidents at construction sites (Vosoughi et al., 2020). Along with that, other research also suggests that there is a significant influence of the work environment on occupational accidents (p=0.004) (Mayandari & Inayah Z, 2023), outdoor work climate (p=0.021; OR=3.448, 95% CI=1.267-9.387) (Rachmat & Ramdhan, 2023), and places of occupational accidents (p=0.007; OR=1.86, CI=1.18-2.92) (Hatami et al., 2017). Therefore, creating a safe work environment at construction sites has an important role in preventing and minimizing occupational accidents.

One of the environmental factors that we found in this study was an increase in the incidence of accidents at construction sites which occurred in summer and winter (Betsis et al., 2019). Summer and winter are two seasons that affect the productivity of construction workers due to extreme temperature changes. High temperatures that occur during summer carry the risk of dehydration and excessive fluid loss through sweat, which causes dizziness, headaches, nausea and vomiting. These conditions contribute to the incidence of heat cramps, heat stroke, heat exhaustion, and heat rash (Kang & Ryu, 2019). Furthermore, in research conducted in China, summer heat can exceed 40˚C and is difficult for workers to tolerate, causing workers to quickly feel tired and increasing the incidence of occupational accidents (Shao et al., 2019).

Conversely, during winter with heavy snowfall, freezing, and drought, the frequency of occupational accidents increases due to increased incidence of hypothermia, frostbite, and chilblains (Kang & Ryu, 2019). In addition, exposure to cold air has an impact on reducing the agility, sensitivity, and strength of construction workers, resulting in slow movement of workers, difficulty in moving, and decreased muscle strength, which will increase the risk of accidents (Widiastuti & Dharmosamoedero, 2015). Adding, that in winter, material transportation, exterior wall work, and not paying attention to safety precautions are the causes of accidents (J.-S. Kim & Kim, 2019). From these findings, we can say that extreme increases and decreases in temperature, which occur in summer and winter, have a strong influence on the risk of increasing occupational accidents at construction sites.

Environmental factors have been proven to have a significant effect on increasing the incidence of accidents at construction sites. This is because the work environment is related to work safety and worker productivity. Several causes that are included in environmental factors, according to what we found, include thermal stress, interference, smooth surfaces, work platform height, and extreme temperature changes during summer and winter.

Psychological and Occupational Stress Factors

The fact is that the construction environment is considered a work environment with a high level of stress with high levels of mental health problems, which causes a decrease in

productivity and an increase in errors in carrying out work, where these work errors are associated with accidents at construction sites (Lim et al., 2017; Xiong et al., 2015). According to the statement in the study, we found a significant relationship between stress and occupational accidents, which was shown by research conducted by Farid et al. (p=0.001) (Farid et al., 2019) and Rachmat and Ramdhan (p=0.21; OR=3.448, 95% CI=1.267-9.387) (Rachmat & Ramdhan, 2023).

Furthermore, various stress triggers cause an increase in occupational accidents, including age, safety equipment, safety culture, excessive workload, physical illness, responsibility, participation in decision making, low social support, financial conditions, time pressure, high working hours, poor coping mechanisms, and lack of knowledge (Gómez-Salgado et al., 2023; Sunindijo & Kamardeen, 2017). In accordance with our findings, several studies highlight several factors that cause stress at construction sites, such as high time pressure (p<0.05; OR=1.47) (Van Der Klauw et al., 2014), high workload (p=0.006; OR=2.166, 95% CI=1.272-3.689), and poor work schedules (p=0.002; OR=2.948, 95% CI=1.497-5.803) (Rachmat & Ramdhan, 2023).

Stress in construction project workers can also come from their co-workers or superiors. The presence of bullying in the workplace has an impact on the mental health of project workers, which is then considered a stress trigger and exacerbates other stressors that the worker may experience (Attell et al., 2017; Salin & Notelaers, 2017). Bullying and harassment are two reasons for the increase in mental health problems, according to the results of this study (Rouhanizadeh & Kermanshachi, 2021). Furthermore, Kim and Ahn argued that stress in workers tends to have negative psychological responses, such as anxiety and depression, and physiological responses, such as hypertension, cardiovascular acceleration, headaches, and decreased consciousness, all of which then cause human error and increase work accident (W.-I. Kim & Ahn, 2013). This is in accordance with our findings that violence and bullying perpetrated by co-workers or supervisors significantly influence occupational accidents among construction project workers (p<0.05; OR=1.84) (Van Der Klauw et al., 2014).

Consequently, psychological and occupational stress greatly influences the increase in accidents at work sites. This is because stress triggers psychological and physiological responses in individuals which can increase human error, which in turn has an impact on injuries and accidents at work. Some stress triggers that we found were high time pressure, high workload, poor work schedule, and violence and bullying perpetrated by co-workers or supervisors.

Defective Equipment Factors

In improving the safety of construction workers, attention must be paid to work equipment. There is one study which states that defective equipment significantly influences accidents at construction sites (p=0.01; OR=2.22, CI=1.18-4.20) (Hatami et al., 2017). Equipment that is worn or damaged, if it cannot be repaired, must be replaced with a new one periodically (Yuliandi & Ahman, 2019). This is because it will endanger project workers and will increase the risk of accidents during work. So, apart from factors originating from individuals and the environment, factors from defective equipment will also increase accidents at construction sites.

Conclusion

We conclude several factors influencing an increase in occupational accidents, namely individual factors, including male gender, younger age, lack of work experience, not long working period, being married, poor level of work safety knowledge, absence of occupational safety training, low level of education, and job dissatisfaction; unsafe action factors, including not using PPE or using inappropriate PPE, not following work safety regulations, applying inappropriate SOPs, and fatigue; unsafe condition factors, including the absence of OS&H supervision and inappropriate installation of safety signs; environmental factors, including thermal stress, interference, smooth surfaces, work platform height, and extreme temperature changes during summer and winter; psychological and occupational stress factors, including high time pressure, high workload, poor work schedule, and violence and bullying perpetrated by co-workers or supervisors; and defective equipment factors.

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