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An Overview of The Relationships Between Accidents and Near Miss **Events**

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An Overview of The Relationships Between Accidents and Near Miss Events

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Abstract

There are various approaches to prevent occupational accidents. Investigating performing root-cause analysis to the causes of occupational accidents is a widely used method. However, the root-cause analysis approach is a precaution taken after the event because of a work accident. Another indicator that shows the potential for occupational accidents to occur is near-miss events. The best way to prevent occupational accidents is to be informed about the near-miss events that started the accident. It provides us with opportunities to identify a near-miss event and learn the precautions that must be taken to prevent the accident from causing dire consequences and eliminate its causes. In this study, various studies revealing the relationship between accidents and near-miss events in different sectors were examined and concrete suggestions were put forward to ensure that both employees and employers adopt this approach based on reducing accidents.

Keywords: Near-misses; accidents; accident precursor; safety management; industrial sectors

1. INTRODUCTION

It's easy to make excuses for an accident. A mistake is often denied by saying, "It could have been worse". We call this self-justification. However, the definition and classification of a near miss requires much more insight. It involves the recognition of dangerous situations and actions before an actual event occurs. It requires good observation, judgment, and critical thinking.

Herbert W. Heinrich (1931) stated that a fatal or major accident could occur due to thirty minor injury accidents and approximately 300 near-miss events. The accident pyramid, introduced to the occupational safety literature as the Heinrich Pyramid Theory, is shown in Figure 1[a]. Figure 1[a] shows that for every accident, there may be more near-miss events that may be precursors to some accidents and less significant consequences (Wright and Van der Schaaf, 2004; Pariyani, 2011).

In 1969, Frank Bird Jr. examined a group of 641 occupational accidents in a workplace; death or loss of limb, etc. He claimed that the basis of the accidents was 10 minor injury accidents, 30 accidents caused by machinery and equipment, and 600 near-miss events (Figure [b]).



Figure 1 Heinrich [a], Bird [b] and ConocoPhilips [c] Accident Pyramids

More recently, ConocoPhillips Marine (2003) also demonstrated the huge difference between serious accidents and near-miss events. ConocoPhillips' study found that for every major injury or serious event, there are an estimated

3000 near misses. The increase in the number of near-miss events demonstrated significant improvements in safety culture and accident prevention in the workplace. It also found that over 300,000 risky behaviors for every major injury (Figure 1 [c]).

The natural conclusion that the presented security pyramids teach us is that obvious that proactive safety management and event management, not properly analyzing accidents and real events, and not creating visibility into what is happening under the iceberg will lead to painful consequences.

In various definitions of near-miss events, they are accepted as antecedents of accidents and explained that they are events that can be repeated and observed in more environments than accidents (Jones et al., 1999; David et al., 2006; Saleh et al. 2013; Papillion, 2014; Gnoni and Saleh, 2017; Yıldırım, 2021; Duan and Zhou, 2023).

WHO (2005) defines a near-miss event as an important problem that can potentially cause harm but is not accidental. Additionally, in 2015, OSHA defined it as a situation that could have caused serious accidents but did not occur events.

In the Occupational Health and Safety (OH&S) regulation published by the Ministry of Labor and Social Security in 2012, a near-miss event is defined as "an event that occurs in the workplace, which has the potential to cause damage to the employee, workplace or work equipment, but does not cause damage" (Official Gazette No.28512, 2012).

The unifying point of all the definitions is that a near-miss event, which does not result in negative consequences, has a positive outcome.

Some statistics have shown that near-miss events account for 75% of the total accident number. Many studies have confirmed that near-miss events constitute a source of information, thanks to a correct understanding of security measures. Also, learning from near-miss events is cheaper than learning from accidents (Guo et al., 2016; Zhou et al., 2017).

Most near-miss studies have focused on gaining a qualitative insight into how the events leading to the accident unfolded.

There are generally two ways to go about this. The first of these is a retrospective analysis, which focuses on determining the causal basis and production stage of the near-miss events. The second is a forward-looking analysis of hypothetical futures that highlight potential occupational accidents (Saleh et al., 2013; Zhou et al., 2017).

According to the research conducted by Thoroman et al. (2018), near-miss events are seen as an important tool to improve safety for three reasons. First, they provide a lower inference regarding safety prevention because more-near miss events occur than accidents. Second, since there is a consistent relationship between accidents and near-miss events, near-miss events provide information about the potential accident situation. Thirdly, it provides information about how competent the system is here by determining error compensation factors thanks to the measures taken against recorded near-miss events.

Hollnagel (2004) stated that the reason why accidents occur is that the truth behind them is not fully defined. He stated that finding the cause or explanation of accidents would provide positive developments to prevent accidents in the future. He explained that near-miss events should be recorded and that it would be correct to interpret them according to the recorded near-miss events.

Storgard et al. (2012) stated that major accidents could be prevented by applying the results obtained from the analysis of near-miss events and accidents. They suggested that a functional reporting system requires establishing a culture of no blame, management's will to improve security, good communication, feedback, training, and an easy-to-use system.

Work accidents and occupational diseases occurring in various business lines in Turkey cause many employees to be injured, disabled and lose their lives.

OHS Law No. 6331 (2012) mentions reporting near-miss events that occur in the workplace among the duties of the employer (OHS Law No. 6331, article 14, 2012). In addition, the legal obligation to collect near-miss event records at the stage of identifying hazards in risk assessment studies is mentioned (Official Gazette No.28512, 2012). However, this information is based mainly on accidents and does not take into account near-miss events that can cause accidents or dangerous events.

Although it is a legal obligation in Turkey, near-miss records are not kept in many sectors and the understanding of nearmiss events has rarely been established. Additionally, there are a limited number of scientific publications on near-miss events.

2. REPORTING OF NEAR-MISS EVENTS

Because near-miss events are precursors to accidents, analyzing near-miss events is a proactive approach to reducing accidents and can be considered a leading indicator of safety performance. In recent years, some researchers have noted that in addition to identifying near-miss events, it is important to report nearmiss events and analyze reports to predict the probability of accidents.

To learn from near-miss events, various organizations have begun to develop reporting systems since the 1950s. This safety management system and near-miss event reports were determined to be vital for safety (Taylor, 1977; Thomas, 2012; Thoroman et al., 2018).

Reporting near-miss events encourages a proactive approach to accident prevention and contributes to increased overall safety. If adequate corrective-preventive actions are implemented based on the analysis results of near-miss events, accidents caused by the same root cause can be prevented from occurring. In other words, near-miss events increase the chance of gathering preliminary information about possible accidents (Erdoğan, 2011; Hasanspahi**ć** et al., 2020).

A prerequisite for successful near-miss reporting; depends on both creating a fair culture approach and knowing the duties and responsibilities.

Fair culture approach; To get the maximum benefit from a near miss report, every employee needs to understand what a near-miss event is and the system in place to catch a near-miss event. It should also clearly state how people who experience a near-miss event will be treated and the person who reports the near-miss event. It should be made clear that the company encourages near-miss reporting and that it will not result in punitive measures. Fair culture approach; It has a positive impact on the work environment as it encourages employees to report errors and thus helps the company learn from mistakes. This approach is in direct contrast to the Blame Culture. For the success of Fair Culture, employees must provide ongoing training and information regarding near-miss reporting and investigation procedures.

Knowing the duties and responsibilities: A prerequisite for a successful near-miss event is that everyone throughout the company has a positive safety culture. An appropriate OSH requirement is to enable each personnel to fulfill their responsibilities.

Hasanspahić et al. (2020) examined the results of a survey administered to sailors of various experiences, ages, ranks, and nationalities to examine near-miss management systems in maritime. The results showed that near-miss reporting limits appropriate reporting owing to various obstacles. They argued that most shipping companies have the understanding that the more reports there are, the better the quality of the near-miss reporting system, whereas the focus should be on how to improve methods of evaluating near-miss results. They stated that they think that with the continuous training of the crew for the near-miss reporting system, the reporting culture will be improved and therefore safety will increase.

Like accidents, near-miss events vary in severity and probability, but tracking near-miss events should be seen as

an opportunity to improve safety performance.

In recent years, many researchers have focused on near-miss incidents in high-risk sectors such as maritime, civil aviation, iron and steel, petrochemical, and power plants. Additionally, many of these researchers argued that serious accidents could be prevented by applying corrective-preventive actions to data obtained from the analysis of near- miss events and accidents.

The prerequisite for a results-oriented reporting system is the company management's determination to increase safety and the effort to develop a culture of not blaming, good communication and feedback with employees, continuous training, and the creation of an easy-to-use system.

On the other hand, it has been observed that although most companies have written procedures specifying their near-miss reporting obligations, they do not improve their reporting procedures.

The factors that prevent employees from reporting are insufficient knowledge in identifying near-miss events, cultural differences between employees, a culture of blame and fear of punishment, leadership style, and incompetence of managers. To report a near miss, employees must have sufficient knowledge to understand the consequences of potential near-miss events. Insufficient information creates an obstacle to reporting near-miss events (Hasanspahić et al., 2020).

Subject matter experts have stated that it is easier to report near-miss incidents electronically rather than recording them in writing. They also expressed that it was easier to control the feedback regarding the report through the electronic form. However, some older employees may have problems using electronic media (computer or mobile phone), making it necessary to prepare paper-based reports. In addition, the report content should include all descriptive information regarding near-miss events because these are important for possible subsequent analysis (Hasanspahi**ć** et al., 2020).





Hollnagel (2004) stated that the reason why accidents

occur is that the truth behind the accidents cannot be fully defined. He also expressed that all near-miss events should be recorded and that it would be more correct to interpret the recorded near-miss events according to the events and situations.

Jones et al. (1999) showed that when employees were motivated to address near-miss events and increased nearmiss reporting from 0 to 0.5/person*year in activity over 13 years, lost time due to injuries was reduced by approximately 75%.

Uth and Wiese (2004) investigated the relationship between accidents and near-miss events using data from an organization called ZEMA Accident Center (Zentrale Meldeund Auswertestelle) in Germany. As seen in Figure 2, it has been determined that the number of accidents decreases as near-miss event records increase.

3. NEAR-MISS APPLICATIONS IN SOME SECTORS 3.1. Chemical Sector

The chemical sector is one of the most dangerous sectors compared to almost all other sectors in terms of physical, chemical, and biological hazards. The chemical sector is a very high-risk sector where most accidents result in death, serious injury, or occupational diseases. Therefore, near-miss events in the chemical sector must be carefully monitored and their consequences examined in detail.

Van der Schaaf (1995) stated that in a 3-year study period for the design and implementation of the "Near Miss Event Management System" in a chemical plant in Rotterdam, in the southwest of the Netherlands, 90% of the accidents were; It was determined that technical failure occurred in 30%, organizational failure in 10%, operator failure in 50%, and other reasons in 10%. It has been stated that to prevent accidents, it is necessary to focus on near-miss events, which are the precursors of the accident. The importance of training, safety rules, persuasive efforts, and volunteering in reporting near-miss events was stated.

Jones et al. (1999) conducted a study to determine the relationship between accidents and near-miss events in a chemical plant with 3,500 employees in Norway. Figure 3[a] shows that there was a decrease in the number of accidents, with 1,800 near-miss events being reported from 1985 to 1997. In their study conducted in a chemical plant by Dee et al. (2013), they explained the importance of creating a driving force for appropriate hazard identification and corrective actions for the near-miss event management system to be effective. They stated that classifying near-miss events and providing feedback has a positive contribution to risk management.

In recent years, such studies in the chemical sector have degraded to a level where near-miss reporting is no longer sufficient about the number of serious injuries or damage to provide informative feedback. That is, very few accidents occur in the chemical sector, which can be used as a useful database in terms of the relationship between near-miss events and accidents to improve safety.

3.2. Maritime Sector

After the iceberg accident of the famous Titanic ship, which was said to be "God can't sink it" in 1919, many researchers concentrated their studies on maritime accidents.

In the study conducted by Jones et al. (1999) on Norway's maritime sector, it was found that there was an inverse relationship between near misses and accidents. That is, as near-miss event records increase, the number of accidents decreases. Figure 3[b] shows that while near-miss events in the Norwegian shipping sector increased between 1990 and 1997, the accident numbers that occurred decreased significantly. They stated that accidents would decrease if more focus was placed on the importance of near-miss events.



Figure 3 Relationships between accidents and near-miss events that occurred at a chemical sector [a] and maritime sector [b] in Norway (Jones et al., 1999).

Yoo (2018) used route data of commercial and large fishing vessels to determine the areas of near-miss events along the sea coast of South Korea and calculated the ships' distance and time to near-miss events locations from 57824 near-miss events that occurred throughout 2014. As shown in Figure 4[a], shows that the relative frequency of near-miss events increases as the colors turn red, and relatively dangerous locations occur more frequently in areas approaching Busan Port. According to the distribution of 412 collision accident locations between 1997 and 2016 in Figure 4 [b], the accidents mostly occurred in places close to Busan Port, where the density of near misses is high.



Figure 4 Frequency of collision accidents of ships (1997–2016) [a] and near-miss event density on the sea coast of South Korea (2014) (Yoo, 2018)

3.3. Providing Vehicle Maintenance Service Sectors

Winkler et al. (2019) examined a company with 11,000 employees providing maintenance services in Israel between 2000 and 2005 in terms of the number of accidents and near-miss events. In Figure 5[a], they found that the annual number of near misses and accidents has decreased over the years. On the other hand, despite the decrease in the accident frequency over the years, periodic fluctuations are observed in both accidents and near-miss numbers between 2000 and 2004 in Figure 5[b]. It has been determined that the fluctuations in the number of near-miss reports are also reflected in accidents. They put forward this situation with the view that accidents decreased with the development of the company's near-miss culture.



Figure 5 Annual [a] and moth [b] numbers of accidents and near misses (Winkler et al., 2019)

3.4. White Goods Sector

Today, although the white goods industry has switched to robotic technology in its manufacturing, the number of accidents can be significant since the human factor cannot be completely excluded.

Andriulo and Gnoni (2014) investigated the relationship between near misses and accident causes for each department in the Bosch Bari plant. In their study, they implemented two indices defined as the "Near Miss Index" and "Accident Index" to verify the distribution of both accidents and near miss events in each department. As seen in Figure 6, they found that accidents were almost non-existent in sections with many near-miss events.



Figure 6 Distribution of near-miss and accident events changes for different departments of the Bosch factory (Andriulo and Gnoni, 2014)

3.5. Construction Sector

The construction industry ranks first in terms of fatal work accidents compared to all other sectors. Construction industry; It covers a wide range of sub-sectors such as construction, road, bridge, tunnel and metro construction. In such a wide range and very risky sector, it is almost inevitable that there will be a lot of work accidents. On the other hand, many subject experts have stated that accidents will drop to acceptable risk levels after near-miss events in the construction sector are reported and examined.

Wu et al. (2010) conducted a study to close the information gap required for data analysis on this subject by monitoring near-miss events in construction sites in real-time. For this purpose, they used a sensor network that works with a system called Zigbee RFID (a system in which radio frequencies are used to collect information from the transceiver) and stores and transfers security information about equipment and materials. As a result of the research, it was determined that 49% of the 4,640 near-miss events occurred as falls, 15% as crashes, 12% as electric shocks, and 8% as tripping.

Yang et al. (2016) developed wearable inertial measurement units (WIMUs) for employees to collect near-miss data in the construction industry. It is designed as a system that can automatically detect and document near-miss falls based on kinetic data with WIMU. According to the values obtained from the WIMU worn by workers on their bodies, it was stated that it showed 87.5% accuracy performance in near-miss falls and could be used to detect near-miss events and predict future falling accidents (Figure 7). Additionally, it has been stated that the proposed WIMU-based approach will provide financial benefits to businesses due to its small ergonomics and low cost.



Figure 7 Concept of near-miss fall detection using WIMU (Yang et al., 2016)

Raviv and Shapira (2018) analysed 212 tower crane safety violations in the construction industry, as shown in Figure 8; examined the proportional relationships of different causal factors for the severity levels of three events: "near-miss", "damage" and "injury-fatality". By focusing on the connection of near-miss events with the tower crane and the analysis of the causal factors that prevent the events from turning into accidents, it has been understood that there is a relationship between injury/fatality and near-miss events. They stated that the negatives can be prevented by taking precautions in near-miss events.



Figure 8 Causal factor ratio for severity levels (Raviv and Shapira, 2018)

Zhou et al. (2017) analyzed the near-miss management system (WNMS) data of the subway construction of Wuhan, China's largest city. More than 1,100 near-miss events have

been reported in the database. Between 2011 and 2015, it was determined that near-miss events varied over time. It has been observed that near-miss events in the five years was lower in spring and winter and higher in summer and autumn. In addition, it was found that the most common time period for near-miss events during the day was between 8 am and 12 am (Figure 9).



Figure 9 Variation of near-miss events frequency to month [a] and time of occurrence of near-miss events [b] in metro projects in Wuhan (Zhou et al., 2017)

Zhang et al. (2016) collected records of accidents and nearmiss events in the metro operating in Shanghai, China, and collected a total of 249 events that occurred in seven years (2005-2013). Figure 10 [a] summarizes these and shows that the number of near-miss events is 166, while the number of non-serious accidents is 57 and the number of serious accidents is 26. Figure 10 [b] shows the frequency of occurrence of events at daily time intervals over the period. It has been determined that most of the accidents and nearmiss events occurred in the morning when business was busy.



Figure 10 Frequency of events by type [a] and frequency of events during the day [b] (Zhang et al., 2016).

3.6. Cement Sector

The fact that the cement sector is structurally at the top of the heavy and dangerous work category and the low rate of educated and trained workforce in Turkey are the biggest negatives for a safe working environment.

Cement production, it goes through various production stages, starting from open pit mining until it reaches the packaging unit.

The risk factors that threaten OH&S in the main working areas of cement factories can be classified into four groups: risks that may lead to accidents, risks arising from the working environment, chemical and physical risks, and ergonomic risks arising from the work performed.

Unfortunately, no work has been done on the near-miss issue in the cement industry, which carries such a dangerous risk, until 2021.

Yıldırım (2021) conducted a near-miss and OHS perception determination survey on employees of two cement factories

in Turkey, which have two different OHS cultures. As a result of survey studies; While near-miss events are regularly recorded among cement factory employees with high OHS perception, there have been no accidents in the factory for the last 10 years. On the other hand, it has been determined that cement factory employees with moderate OHS perception are reluctant to record near-miss events and there have been some accidents in the factory.

4. CONCLUSIONS

While developments in technology and industry make human life easier, unsafe conditions in working life cause negative consequences. Today, work accidents and occupational diseases threaten the lives of many employees and can cause financial losses.

Since near-miss events occur more frequently than accidents, they allow us to take precautions with proactive approaches. Reporting and investigating near-miss events prevents occupational accidents and is a low-cost and effective element. As explained in this study, examining near-miss events in many sectors and discussing their causes directly contributes to reducing workplace accidents. Additionally, research on near-miss events from a worker psychology perspective needs to be further investigated.

There is not enough research on near-miss events both in the world and in Turkey. However, we can prevent accidents if near-miss events are thoroughly investigated in every business. Therefore, it should not be forgotten that poverty will be prevented by preventing the waste of approximately 4-5% of both the World's and Turkey's Gross National Product (GNP).

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