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A Study of the Unsafe Actions of Staff in the Maintenance and Overhaul Unit at a Petrochemical Complex and the Presentation of Control Strategies

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Abstract

Background: Today, oil, gas, and petrochemical industries are of strategic significance in the macro-development of oil-rich countries. These industries, given the nature of the work and the technical complexity of the various processes, are hazardous and susceptible to occupational accidents. More than 90% of the accidents are related to the faults and unsafe actions of personnel, either directly or indirectly.
Objectives: The aim of this study is to investigate the unsafe actions of staff working in the maintenance unit of a petrochemical complex.
Materials and Methods: This is a descriptive and analytical study conducted on 167 morning-shift workers at the Mahshahr petrochemical complex. The data were collected based on a checklist of unsafe actions prepared through a direct observation of their activities and an analysis of work instructions, documents, and incident reports. SPSS statistical software was also used for data analysis and relevant testing.
Results: According to the results of this study, the mean number of unsafe actions performed by the employees was 42%. The highest number of unsafe actions achieved in the maintenance mechanical unit was 52.8%, 47.1% in repair services, and 43.8% in machinery. The highest frequency of unsafe actions were caused by indiscretion and negligence, a failure to use a face shield and goggles, and non-compliance with safety principles.
Conclusions: According to the findings, there has been a rise in the number of unsafe actions in machinery and maintenance service units compared to other maintenance units. As such, training courses based on the behavior-based safety principles at the beginning of employment, close monitoring of health safety environment (HSE) officials on the implementation of regulations, and provision of appropriate scheduling based on weather conditions and the nature of maintenance services are recommended. In addition, a refrainment from hastiness in performing duties, enhanced participation from the employees to improve occupational safety, and the production and distribution of high-quality personal protective equipment (PPE) is also recommended to mitigate unsafe actions.

Keywords: Unsafe, Occupational, Incidents, Industry

1. Background

Today, oil, gas, and petrochemical industries are of strategic significance in the macro-development of the country. Iran is an oil-rich country, with the bulk of its earning coming from the national wealth of oil (1). Development and the advancement of technology as provided by these industries, given the nature of work, technical complexity, and various processes involved, is replete with potential work-related hazards and accidents, which may be followed by consequences such as injuries, human casualties, environmental pollution, and the ultimate shutdown of a business (2). According to the information released by the international labor organization in 2009, approximately 52% of workers worldwide are vulnerable to occupational hazards, which shows a 2.4% increase from 2007 (3). Further, occupational accidents are regarded as the third main cause of mortality in the world, the second cause of mortality in Iran, and one of the most important safety, health, and socioeconomic risk factors in industrial and developing societies (4).

Given the dire consequences of occupational accidents in these industries, research has been undertaken to explore the reasons for these accidents. Unsafe actions and conditions have been identified as the underlying cause of these accidents (5). In this regard, some experts believe that the majority of the events are rooted in the unsafe actions of the staff, defined as behavior committed without considering the safety rules, regulations, standards, and specified criteria in system, which can affect system safety level (6). Accordingly, incident statistics demonstrate that more than 90% of industrial accidents are directly or indirectly related to the unsafe actions of staff members (7). The findings of another study suggest that 88% of occupational accidents in Britain are caused by unsafe ac-

tions (8). In the past few decades, adverse and catastrophic accidents such as Felix Euro in the United Kingdom, Bhopal in India, Chernobyl in Russia, etc. further support this claim (9). Still, there is a paucity of research on the causes of unsafe actions and work-related accidents in petrochemical industries. As such, there is room for further research in this field.

2. Objectives

Research can help identify the causes of unsafe actions, contributing to their prevention and mitigation, consequently, the prevention of occupational accidents. Therefore, this study aims to identify and evaluate occupational unsafe actions and their relationship with the demographic features of employees such as age, work experience, marital status, level of education, and responsibility in the maintenance and overhaul unit at a petrochemical complex.

3. Materials and Methods

In this cross-sectional descriptive and analytical study, the unsafe actions of 167 morning-shift workers in the maintenance and overhaul unit at a petrochemical complex were investigated randomly through the observation and sampling of safe actions in 2014. This study was conducted over 80 days.

In this regard, a preliminary evaluation was undertaken to first become introduced to the staff and the work processes in the petrochemical complex. After defining unsafe actions, a list of potential unsafe actions in the maintenance and overhaul unit at a petrochemical complex was prepared. The list was based on the American national standards institute (ANSI) standards (version Z 16.2), the type and nature of the work, accident reports, existing cultural conditions, interviews with officials and employees, health service executive regulations and guidelines, and a safety and occupational assessment.

Given the ratio of unsafe actions to the total actions sampled in the pilot study on seven occupational groups, and considering a sampling error of 5% and K = 2 based on the standard normal table, a total of 2029 observations were estimated to achieve a confidence level of 95% using the following equation.

$$N = \left(\frac{K}{S}\right)^2 P(1-q) \quad (1)$$

The safe act observations were distributed among the occupational groups of the maintenance and overhaul unit based on the cluster division. In addition, as indicated in the literature, an average observation time of 3 seconds was determined for each employee's performance (10). The demographic information of staff including age, experience, education, marital status, etc. were gathered by a questionnaire to determine their correlation to the unsafe actions of the employee. Further, SPSS statistical software was used to perform a descriptive statistics analysis, the Kolmogorov-Smirnov test, an analysis of variance (ANOVA), the Pearson correlation, a t test, and a chi square analysis.

4. Results

According to the results of questionnaires, the demographic and occupational characteristics of the subjects are given in Table 1.

The subjects had a mean age of 35.32 ± 8.25 years and an average work experience of 10.07 ± 7.09 years. In terms of population distribution and education levels, 21.6% of subjects had a high school diploma or less and 37.1% had a bachelor degree or higher. In addition, 80.2% of subjects in the study were married. Finally, 91% had attended health and safety training courses.

In this study, a total of 2,029 observations were made. The highest and lowest number of observations belonged to the maintenance services and condition monitoring units with 477 and 155 observations respectively. According to the findings, 960 observations fell into the category of unsafe actions and the rest were considered safe actions. The results of the chi square test regarding the unsafe actions and job categories were significant ($P \leq 0.001$).

Therefore, given that 42% of unsafe actions were performed by employees of the petrochemical complex in the maintenance unit, and 52.8% in the mechanical unit, it can be concluded that the rate of unsafe actions in mechanical unit was higher than the rest of the occupational groups. Table 2 reveals the extent of unsafe actions according to the type of jobs.

Table 1. Demographic Features of the Study Subjects

Variables	Values
Age [a]	35.32 ± 8.25
Work experience [a]	7.09 ± 10.07
Married [b]	80.2
Single [b]	19.8
Middle school education [b]	6.6
High school education [b]	15
Diploma [b]	31.1
Associate degree [b]	10.2
Bachelor degree and higher [b]	1.37
Health and safety training [b]	91
Lack of health and safety training [b]	9

[a] Values are presented as mean ± SD.
[b] Values' unit is %.

According to the results regarding the relative frequency of unsafe actions performed by the employees in the maintenance unit, the highest number of unsafe actions included indiscretion and negligence (17.2%). A failure to use a face shield or goggles (12.1 %) was also detected, along with noncompliance with work safety principles (9.6%) (Figure 1).

The statistical findings also reveal a significant inverse relationship between unsafe actions and variables of age, work experience, and education. In addition, a significant relationship was found between unsafe actions and marital status, type of job, and health and safety education (Table 3).

Table 2. Relationship Between Unsafe Actions and Job Category[a]

Job Category	No. of Subjects	No. of Observations	No. of Unsafe Actions	Unsafe Actions, %
Maintenance services	36	477	225	47.1
Mechanics	27	358	189	52.8
Precision instruments	27	357	142	39.7
Electricity	29	384	161	41.9
Maintenance planning	24	250	89	35.6
Condition monitoring	9	155	54	34.8
Sensitive machinery	15	228	100	43.8
Total	167	2,209	960	42

[a]P value = 0.001.

Table 3. Relationship Between Variables and Unsafe Actions of Staff in the Maintenance unit at the Petrochemical Complex

Variable	No. of Staff	Mean ± SD [a]	P Value
Training			.001
Yes	152	19.59 ± 10.23	
No	15	28.13 ± 6.72	
Marital status			.013
Single	33	24.30 ± 8.88	
Married	134	19.38 ± 10.35	
Education level			.001
Middle school education	11	32.82 ± 3.92	
High school education	25	28.88 ± 6.15	
Diploma	52	21.98 ± 9.29	
Associate degree	17	17.59 ± 7.97	
Bachelor degree and higher	62	14.10 ± 8.79	
Age, y			.001
≤ 30	55	23.16 ± 9.99	
31 - 35	51	23.45 ± 10.32	
36 - 40	27	18.07 ± 8.46	
> 41	34	12.97 ± 7.64	
Work experience, y			.001
≤ 5	49	25.51 ± 9.75	
6 - 10	55	22.11 ± 10.38	
11 - 15	33	17.15 ± 7.81	
16 - 20	13	12.62 ± 6.95	
> 21	17	11.94 ± 6.68	

[a]Values are presented as mean ± SD.

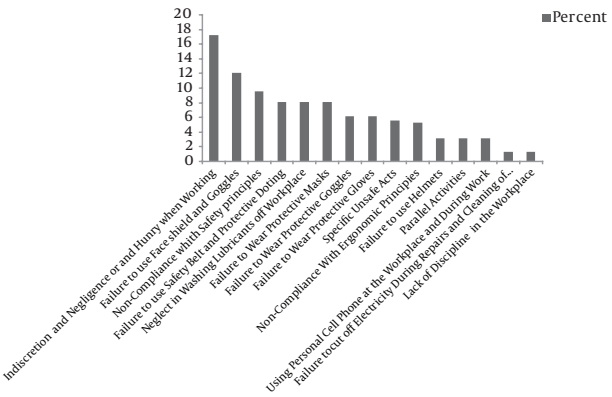

Figure 1. The Relative Frequency of Unsafe Actions of Staff in the Maintenance Unit

5. Discussion

The results of evaluating unsafe actions at the petrochemical complex suggest significant differences between unsafe actions in across the various maintenance units. Accordingly, the highest number of unsafe actions was observed in the mechanical maintenance unit (52.8%), maintenance services (47.1%), and machinery (43.8%) respectively. As such, officials need to pay further attention to the monitoring of unsafe actions to mitigate occupational accidents and their subsequent damages and costs. In a study by Mohammadfam and Fatemi, a significant relationship was found between job category and unsafe actions (11).

The findings of two studies by Lind and Hollnagel also reveal the fundamental role of unsafe measures in the occurrence of occupational accidents (12, 13). Similarly, the findings of Cheng et al. and Komaki et al. have shown that an increase in the rates of unsafe actions will significantly raise the chance of occupational accidents and injuries and their associated costs (2, 14). According to the results of the present study, there was a 42% rate of unsafe actions among the employees, which is consistent with the findings of Nouri et al.'s study on the unsafe actions of gas company employees (10).

According to the results, most unsafe actions fall into the category of indiscretion, negligence, and hastiness at work (17.2%), followed by failure to wear a face shield and goggles (12.1%) and non-compliance with safety principles (9.6%). One reason for the indiscretion and negligence of the staff under study was extreme heat in the workplace. That is, due to heat stress, they attempted to complete their work and leave the premises as soon as possible, which could explain the inaccuracy and hastiness in their work. As for the failure to wear protective equipment and non-compliance with the safety principles, it seems that more attention should be paid to promoting a positive attitude and safety culture. This could be done by using experts in the field to inform employees about the hazards of the failure to use protective devices. In addition, necessary training should be completed about the correct way of conducting work and following the safety measures with an obligation to observe safety rules and regulations, especially for novice personnel. Supervisors should encourage the correct and timely application of personal protective equipment (PPE) (15). The findings of Hashemi Nejad et al. also show that most of the unsafe actions of the employees working at the Kermanshah oil refining company fell into the category of indiscretion and a failure to use or the improper use of PPE, which is in line with the results of the current study (16).

Further, the results show that there is a significant inverse relationship between unsafe actions and the age and work experience of workers. This means older and more experienced workers were less likely to perform unsafe actions. The can be explained in terms of insufficient experience of young staff, lack of familiarity with the work environment, inadequate mastery of the work, false confidence, and lack of attention to performing tasks correctly. In this regard, Nouri et al. and Bylund and Bjornstig argue that high rate of accidents among young workers is due to factors such as carelessness, disorderly behavior, hastiness, recklessness, inaccurate diagnosis, and overestimation of their abilities (10, 17). In another study by Mohammadfam et al. a significant relationship was obtained between age and unsafe actions, which is consistent with the results of current study (11).

In the present study, a significant inverse relationship was found between education level and unsafe actions ($P = 0.001$). That is, workers with a higher education level were less likely to perform unsafe actions. There is a large body of evidence about the higher probability of accidents among people with low education levels. Yu et al. in their study on the high rate of unsafe actions among illiterate people found an unawareness of unsafe actions and their likely consequences (18). In addition, the findings of Kirschenbaum et al. are consistent with the results of current study (19).

Our study on the relationship between marital status and the unsafe actions of maintenance workers in the sample under study showed that there was a significant difference between the two groups, with the mean score of unsafe actions among single workers (24.30 ± 8.88) being greater than that of the married workers (19.38 ± 10.35).

Hashem reported that job stress in single people was greater than that of married people, positing that it was partly due to a lack of experience, the unfamiliarity of single staff in the workplace, less work skills, and a feeling of estrangement compared to their coworkers (20). The results of the present study indicated that the mean score of unsafe actions in trained and untrained workers was 19.59 ± 10.23 and 28.13 ± 6.72 respectively. Accordingly, the unsafe actions were significantly lower in the trained staff, which can be explained in respect to the effects of their training, an increased awareness of risks

in the workplace, their work-related equipment, and the use of PPE. An effective way to control unsafe actions is to encourage the participation of workers in health and safety programs to motivate the implementation of safe actions in the workplace through training (21, 22).

The studies of Nieto-Montenegro et al. and Gielen et al. on mitigating work-related accidents and injuries and their associated costs in petrochemical staff found that providing effective safety training using behavioral change patterns and designing interventions based on such patterns could significantly reduce these accidents (23, 24). Hazavehei et al. (25) have also codnfirmed the effects of safety training based on the health belief model on the behavior of workers and the improvement of their performance using PPE.

5.1. Conclusion and Recommendations

According to the results of the present study, the highest number of unsafe actions in the petrochemical company were performed by the maintenance unit, mechanical services, and the machinery unit. In addition, the most common type of unsafe actions were indiscretion, negligence, hastiness, failure to use a face shield and goggles, and non-compliance with work safety principles.

Moreover, unsafe actions were influenced by a variety of factors including job category, education level, marital status, work experience, age, and safety training. Therefore, to reduce unsafe behavior and actions, behavior-based safety training at the preliminary stages of recruitment, supervision of the health service executive officials on the implementation of safety regulations, and provision of suitable scheduling due to the weather conditions and the nature of repairs is recommended. Further, the avoidance of hastiness at work can be instigated by publishing instructional bulletins and pamphlets for staff and units and raising awareness about the causes of unsafe incidents and how to prevent their reoccurrence. In addition, the participation of employees in improving workplace safety, the provision and distribution of high-quality PPE, the mandatory use of such devices in the workplace, and evaluating contractors against this mandatory use are all suggested.

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Footnotes

Authors' Contribution: Study concept and design: Sharareh Mousavipour and Ali Safary Variani; data acquisition: Sharareh Mousavipour; data analysis and interpretation: Sharareh Mousavipour and Ramazan Mirzaei; manuscript drafting: Sharareh Mousavipour, Ali Safary Variani, and Ramazan Mirzaei; critical manuscript revision for intellectual content: Sharareh Mousavipour and Ramazan Mirzaei; statistical analysis: Sharareh Mousavipour and Ramazan Mirzaei; study supervision: Ali Safary Variani.

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