Research Paper: The Impact of Safety Programs on Accident Indicators in a Combined Cycle Power Plant

Fereydoon Laal[1], Rohollah Fallah Madvari[2], Gholamhossein Halvani[3*]

1. Health Promotion Research Center, Zahedan University of Medical Sciences, Zahedan, Iran.
2. Department of Occupational Health, School of Public Health & Safety, Shahid Beheshti University of Medical Sciences, Tehran, Iran.
3. Department of Occupational Health, School of Public Health, Shahid Sadoughi University of Medical Sciences, Yazd, Iran.

Use your device to scan and read the article online

Citation: Laal F, Fallah Madvari R, Halvani GH. The Impact of Safety Programs on Accident Indicators in a Combined Cycle Power Plant. Health in Emergencies and Disasters Quarterly. 2019; 5(1):45-52. http://dx.doi.org/10.32598/hdq.5.1.320.1

doi: http://dx.doi.org/10.32598/hdq.5.1.320.1

Article info:
Received: 02 Mar 2019
Accepted: 27 Jul 2019
Available Online: 01 Oct 2019

Keywords:
Management, Safety, Accident indices, Occupational accidents

ABSTRACT

Background: Nowadays, safety management plans have an effective role in reducing the incidence of accidents. Therefore, this study aimed at investigating the role of safety management systems on accidents and the status of safety performance indicators in a combined cycle power plant in 2011.

Materials and Methods: This descriptive-analytical research was carried out in two stages in all Yazd Combined Cycle Power Plant units on accident victims from 2004-2011, based on the documentation of the previous years and using census sampling. The Accident Frequency Rate (AFR), Accident Severity Rate (ASR), and Frequency Severity Rate (FSI) indices were derived from the OSHA standard using the formulas and data obtained from the completed questionnaires and interviews with the people.

Results: The total number of accidents was 287 cases through the studied period (8 years). The results showed a significant relationship between age and work experience, as well as between age and marital status. The main causes of accidents were unsafe acts. The lowest level of personal protective equipment was used in 2004 (15.2%), whereas the highest rate was used in 2011 (30%). After the implementation of the Integrated Management Systems (IMSs), accident indicators showed a decreasing trend regarding the washing time. Also, the amount of AFR, ASR and FSI indices of the accidents in terms of work shift indicated a significant decrease in 2004 than after the implementation of the safety management systems.

Conclusion: According to the results, due to the positive impact of safety programs (IMS), incident indicators had a downward trend and unsafe acts were decreased.

*** Corresponding Author:**
Gholamhossein Halvani, PhD.
Address: *Department of Occupational Health, School of Public Health, Shahid Sadoughi University of Medical Sciences, Yazd, Iran.*
E-mail: *halvani39@gmail.com*

1. Introduction

Considering the rapid growth of industries and technology, occupational safety and health have become an important issue in all jobs and industries. Due to the advances in science and technology, as well as the establishment of occupational safety and health management systems, occupational damages and disorders has considerably reduced [1, 2]. More recently, the role of occupational health and safety management as a strategic key and a tool for improving long-term health in the workplace and reducing the cost of work has been mentioned [3].

The sensitivity of occupational accidents to the economic cycle can affect the effectiveness of occupational health and safety policies [4]. However, industries are known as risky environments that impose high costs due to occupational accidents and diseases [1, 2]. According to the International Labor Organization (ILO), 120 million injuries occur annually worldwide and about one-third of work-related deaths are caused by occupational accidents [5].

Accidents cause economic losses for workers, employers and the community in different levels. Direct losses may include damages resulting from work interruption due to an accident, medical expenses, and eventually damages for temporary/permanent disability or death. Also, accidents can cause irreparable harm and damage to the family and society [6].

Nowadays, organizations are working to improve their services. In this regard, management systems and standards play a key role in various industries. One of these management systems can be achieved by the combination of quality, health, safety, and environmental factors [7]. Management systems are considered as the strategies to create more coherence and coordination between existing systems. Integrated Management Systems (IMSs) have been introduced to integrate three standards of quality, environmental, and occupational safety and health management to achieve a comprehensive management system and shortly after it has been deployed, it has been able to produce positive and significant results. In general, the benefits of IMS can are its time- and cost-effectiveness, increasing productivity, improving organizationally and reducing documentation [8, 9].

In Hamidi et al. study on the impact of IMS on safety and productivity indicators in the cement industry during 2005-2010, there was a significant relationship between various safety indicators before and after the implementation of the IMS [10]. Considering the above-mentioned issues, we decided to investigate the incident rates in an 8-year period (2004-2011). Based on the available information, the limited number of studies has been conducted on the accidents occurred in the combined cycle power plants or at least, their reports has not been announced. Therefore, in this study, we tried to use the accident indicators to monitor safety performance. Accordingly, this study aimed at investigating the role of safety management systems on accidents and the status of safety performance indicators in a combined cycle power plant before and after the IMSs implementation.

2. Material and Methods

This descriptive-analytical research was carried out in two stages in all Yazd Combined Cycle Power Plant units on accident victims in a period of 8 years (2004-2011) to examine and compare the status of safety performance and safe behaviors before (2004) and after the IMSs implementation (2005-2011). The census sampling was done and all accident victims were included in the study. At the beginning of the study, written consent was received from the participants. After the necessary coordination, the initial information was extracted through questionnaires and interviews with the accident victims.

In this study, the accidents resulted in a loss of one workday or shiftwork and more were considered as occupational accidents. According to the rules of the Social Security Administration in Iran (Article 60), occupational accidents are those that occur during the work and for the insured person. It means the time, through which an insured person is working at the workplace or affiliated institutions, or when he is working outside the workplace as ordered by his employer. Also, accidents that occur during the act of rescuing other insured persons will be considered as an occupational accident [11].

Then, the Accident Frequency Rate (AFR), Accident Severity Rate (ASR), and Frequency Severity Rate (FSI) indices were obtained based on the OSHA standard [12] using the formulas and data derived from the initial analysis (Formulas 1-3).

1. $AFR = \frac{N \times 200000}{T}$

2. $AFR = \frac{n \times 200000}{T}$

3. $FSI = \sqrt{\frac{(AFR \times ASR)}{1000}}$

N: Number of accidents in a specified time;

n: Number of lost workdays due to accidents in a specified time;

T: Total efficient working hours of the workers in that specified time;

Calculation of these indicators when the accident causes permanent disability or death is obtained using the tables of lost workdays according to the type of injury. In addition, there were some limitations and problems, such as the lack of number of affected workers at the workplace to be interviewed and failure to properly record accident reports for damaged workers that instead an interview was conducted by witnesses to solve these problems and the necessary explanations were provided to convince the interviewees.

Finally, data were analyzed using SPSS v. 19 through the descriptive statistics and Chi-square test. In this research, the significance level was considered equal to 0.05. In addition, scientific methods were developed to monitor safety performance, reduce the incidence of accidents, and make the necessary management decisions.

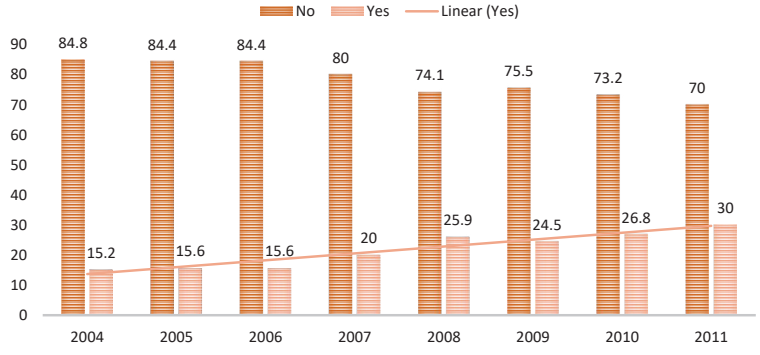
3. Results

Based on the results, 287 work-related accidents had occurred during an 8-year period (2004-2011). Most of the victims were married (68.6%) and were official or contract workers (75.6%). Also, it should be noted that the study was conducted in 2012, which was chosen based on the documentation available in previous years. All studied subjects were over 20 years of age. The highest number of accidents belonged to the workers (164 accidents, 57.2%), whereas the lowest number (55 accidents, 19.1%) was related to managers, engineers, and experts.

The results showed that a significant relationship between age and work history and also between age and marital status (P=0.000). According to the chi-square test results, there was a significant relationship between marital status, education level and work experience. However, there was no significant relationship between the different units of work, the cause of the accident, and the use of personal protective equipment. The mean and standard deviation of lost working days was 11.09±3.8 and the lowest and highest numbers of accidents had been recorded in 2011 and 2009, respectively.

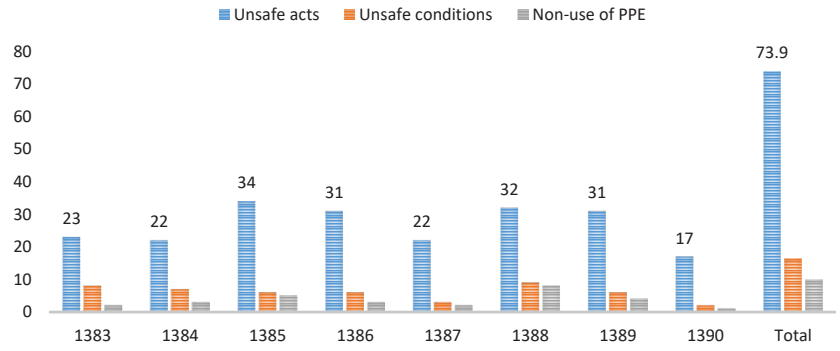
According to Figure 1, following the implementation of IMS, the use of personal protective equipment by workers has been growing. Also, it has been growing since the introduction of the integrated management systems. The lowest and highest application of these devices was in 2004 (15.2%) and 2011 (30%) among victims, respectively. Of those who used PPE, 46 subjects had used PPE for protecting the head, face, and neck, 43 subjects for hand and foot protection, 58 cases were found with protective clothing and about 10 cases with the safety belt during an accident. Meanwhile, the simultaneous use of several types of protective devices by some victims caused an increase in some of these statistics. Also, the most of the accidents affected the hands, wrists, arms, and fingers (about 125 accidents).

According to Figure 2, the main causes of accidents in this 8-year period were unsafe acts, unsafe conditions, and no use of PPE. Meanwhile, there was no significant relationship between the cause of the accident and the work experience of the victims (P>0/005). It should be noted that through the studied years, there was no work-



Health in Emergencies and Disasters Quarterly

Figure 1. Frequency of using personal protective equipment by victims before and after the implementation of Integrated Management Systems in Yazd combined cycle power plant



Health in Emergencies and Disasters Quarterly

Figure 2. The relative frequency of major causes of accidents in Yazd combined cycle power plant before and after the implementation of the Integrated Management Systems at Yazd combined cycle power plant

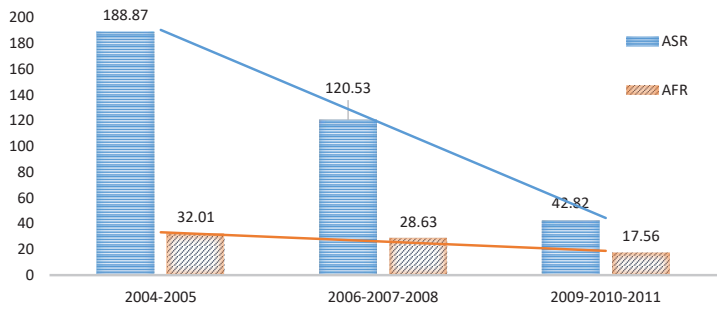
related death, permanent disability, or amputation in the Yazd combined cycle power plant and all accidents caused some injuries.

As shown in Figure 3, a downward trend was found for accident indicators after the implementation of the IMS. Also, the years following the implementation of the IMS (2006, 2007, and 2008) were considered as "Washing Time". Meanwhile, the cycle power plant comprised a two-shift operation, namely day shift (7 am to 19 pm) and night shift (19 pm to 7 am). The highest rate of accidents had occurred during the day and at the beginning of the shift (7 am to 13 pm) (187 accidents (65.2%)). Also, the highest rate of accidents had been occurred in the night shift (1 pm to 7 am). According to Table 1, it is noticeable that the frequency of the indices in 2004 (before the IMS implementation) was significantly lower than the years after its implementation.

4. Discussion

Given that today's power plants are the most important and strategic industries worldwide, and also the Yazd Combined Cycle Power Plant is an active power plant, studies on these strategic industries are of great importance. The results of this study showed a significant relationship between the age and work experience and an increase in age and work experience had reduced the rate of accidents, which is consistent with findings reported by Cloutier [13], Bylund [14] and Wadsworh [15]. In the Bylund study, only 9% of the accident victims were over 50 years old [14], which can be due to the lower work experience and educational level in the injured personnel, curiosity, hurriedness in carrying out the activities, and the lack of sufficient skills to use devices and equipment.

In fact, younger age and lower work experience, with the aggravation of each other's effect, caused a synergistic effect to occur an accident. Based on our results, the high risk occupational groups can be identified and by taking measures, they can be employed in less risky jobs. In this study, no recorded accident was found in people younger than 20 years, which indicates the importance of no employment of the youth in these critical industries. Most of the injured subjects were married, which was consistent with the results of Mohammadfam [16].



Health in Emergencies and Disasters Quarterly

Figure 3. The average of Accident Frequency Rate (AFR) and Accident Severity Rate (ASR) indices in different years

Table 1. The average of Accident Frequency Rate (AFR) and Accident Severity Rate (ASR) indices by working shift before and after the implementation of the Integrated Management Systems (IMS)

Year	Indices	Frequency of the Indices	
		Shiftwork	No Shiftwork
2004	AFR	52.63	29.11
	ASR	142.10	82.27
	FSI	2.73	1.54
2005	AFR	30.00	31.7
	ASR	100.00	93.9
	FSI	1.73	1.72
2006	AFR	16.00	32.8
	ASR	56.00	86.4
	FSI	0.94	1.68
2007	AFR	27.27	27.86
	ASR	63.63	71.33
	FSI	1.31	1.40
2008	AFR	31.57	22.82
	ASR	63.15	239.13
	FSI	1.41	2.33
2009	AFR	20.00	24.02
	ASR	30.00	70.39
	FSI	0.77	1.30
2010	AFR	33.33	17.31
	ASR	53.33	31.84
	FSI	1.33	0.74
2011	AFR	13.79	9.09
	ASR	34.48	28.40
	FSI	0.68	0.50

Health in Emergencies and Disasters Quarterly

The combination of mental and psychological stress in the workplace and family can be regarded as a factor to increase the rate of unsafe acts in the married cases, which can be reduced by improving organizational communication, individual and group counseling, improving the environment, safety, and ergonomics, and also using relaxation techniques, such as exercise stressors. This study showed that the majority of the accidents had affected the hands, arms, forearms and fingers, which is in line with the Web's results [17]. The rates of accidents in this study were almost the same as those reported by Henrich (75000 accidents) [18].

He found that 88% of the accidents were due to unsafe acts, 10% due to unsafe conditions, and 2% because of the unforeseen causes. Using effective engineering controls, as well as continuous training as the goals of the safety management systems, effective measures can be taken to eliminate unsafe situations and practices.

In the current study, the use of PPE showed a growing trend from 2004-2011, and there was no work-related death, permanent disability, or amputation through the studied period, which can be due to the role of training and management plans for health and safety. However, Goldenhar [19] have indicated that IMS will have a long-term impact (usually through 2-3 years), which was confirmed by our results (Figure 3). Another result of the present study was the high rate of safety indicators in the shiftwork group that indicates the high level of risk in this group.

Mikko Härmä et al. [20] showed that irregular shift work is a risk factor for long sleep and fatigue. Overall, the results of this study showed that the state of health in the years after the implementation of IMS (2005-2011) was improving compared with the year before its implementation (2004). The results reported by Fernández-Muñiz [21] and Hamidi [10] were also consistent with the positive role of IMS in this study. Hamidi et al. showed a significant increase in safety indicators after the IMS implementation in the cement industry [10]. Also, Jamali reported a downward trend for these factors, which is similar to our results [22]. According to the results of Seo et al., personality traits, occupational stress, and safety culture can be effective on safe behaviors that should be studied further [23].

5. Conclusion

The implementation of safety plans, especially the implementation of IMS and annual audits might have a significant impact on reducing accident indicators and the use of PPE through the studied years. Therefore, safety and health management systems are suitable tools for reducing accident rates and also accident indicators are effective to monitor safety performance, as well as monitor the safety and health of the management systems. Finally, it can be said that safety plans have a positive impact on accident reduction; however, the impact of these programs, especially on people's behavior, requires more psychological studies.

Ethical Considerations

Compliance with ethical guidelines

All ethical principles were considered in this article.

Funding

The present paper was extracted from the MSc. thesis of the first author, Health Promotion Research Center, Zahedan University of Medical Sciences, Zahedan, Iran.

Authors' contributions

All authors contributed in preparing this article.

Conflict of interest

The authors declared no conflict of interest.

References

[1] Kim Y, Park J, Park M. Creating a culture of prevention in occupational safety and health practice. Safety and Health at Work. 2016; 7(2):89-96. [DOI:10.1016/j.shaw.2016.02.002] [PMID] [PMCID]

[2] Atombo C, Wu C, Tettehfio EO, Nyamuame GY, Agbo AA. Safety and health perceptions in work-related transport activities in Ghanaian industries. Safety and Health at Work. 2017; 8(2):175-82. [DOI:10.1016/j.shaw.2016.10.002] [PMID] [PMCID]

[3] Abad J, Lafuente E, Vilajosana J. An assessment of the OHSAS 18001 certification process: Objective drivers and consequences on safety performance and labour productivity. Safety Science. 2013; 60:47-56. [DOI:10.1016/j.ssci.2013.06.011]

[4] Fernández-Muñiz B, Montes-Peón JM, Vázquez-Ordás CJ. Occupational accidents and the economic cycle in Spain 1994-2014. Safety Science. 2018; 106:273-84. [DOI:10.1016/j.ssci.2016.02.029]

[5] Joyani Y, Raadabadi M, Kavosi Z, Sadeghifar J, Momenei Kh. [Relationship between the occupational accidents and absence from work employees in Shiraz Namazi Hospital (Persian)]. Journal of Payavard Salamat. 2011; 5(3):70-9.

[6] Morsch CM, Gonçalves LF, Barros E. Health-related quality of life among haemodialysis patients - relationship with clinical indicators, morbidity and mortality. Journal of Clinical Nursing. 2006; 15(4):498-504. [DOI:10.1111/j.1365-2702.2006.01349.x] [PMID]

[7] Mariouryad P, Golbabaei F, Nasiri P, Mohammadfam I, Marioryad H. Study of the continuous improvement trend for health, safety and environmental indicators, after establishment of Integrated Management System (IMS) in a pharmaceutical industry in Iran. Journal of Clinical and Diagnostic Research. 2015; 9(10):LC18-20. [DOI:10.7860/JCDR/2015/16160.6700] [PMID] [PMCID]

[8] Labodová A. Implementing integrated management systems using a risk analysis based approach. Journal of Cleaner Production. 2004; 12(6):571-80. [DOI:10.1016/j.jclepro.2003.08.008]

[9] Shakeri A, Eyvazian M. [Integrated Management Systems (IMS) (Persian)]. Paper presented at: 2nd National Conference on Industrial Engineering, Yazd University. 30-31 May 2002; Yazd, Iran.

[10] Hamidi N, Omidvari M, Meftahi M. The effect of integrated management system on safety and productivity indices: Case study; Iranian cement industries. Safety Science. 2012; 50(5):1180-9. [DOI:10.1016/j.ssci.2012.01.004]

[11] Laal F, Pouyakian M, Madvari RF, Khoshakhlagh AH, Halvani GH. Investigating the impact of establishing integrated management systems on accidents and safety performance indices: A case study. Safety and Health at Work. 2019; 10(1):54-60. [DOI:10.1016/j.shaw.2018.04.001] [PMID] [PMCID]

[12] ReVelle JB. Safety training methods. New York: Wiley; 1980.

[13] Cloutier E. The effect of age on safety and work practices among domestic trash collectors in Québec. Safety Science. 1994; 17(4):291-308. [DOI:10.1016/0925-7535(94)90030-2]

[14] Bylund PO, Björnstig U. Occupational injuries and their long term consequences among mechanics and construction metal workers. Safety Science. 1998; 28(1):49-58. [DOI:10.1016/S0925-7535(97)00070-2]

[15] Wadsworth EJK, Simpson SA, Moss SC, Smith AP. The bristol stress and health study: Accidents, minor injuries and cognitive failures at work. Occupational Medicine. 2003; 53(6):392-7. [DOI:10.1093/occmed/kqg088] [PMID]

[16] Mohammadfam I. [Evaluation of occupational accidents and their related factors in Iranian aluminum company in 1999 (Persian)]. Scientific Journal of Kurdistan University of Medical Sciences. 2001; 5(3):18-23.

[17] Webb GR, Redman S, Sanson-Fisher R. Work injury experience at an industrial worksite. Journal of Occupational Health. 1992; 8:143-53.

[18] Brauer RL. Safety and health for engineers. 2nd ed. Hoboken, NJ: Wiley-Interscience; 2006.

[19] Goldenhar LM, Moran SK, Colligan M. Health and safety training in a sample of open-shop construction companies. Journal of Safety Research. 2001; 32(2):237-52. [DOI:10.1016/S0022-4375(01)00045-7]

[20] Härmä M, Karhula K, Puttonen S, Ropponen A, Koskinen A, Ojajärvi A, et al. Shift work with and without night work as a risk factor for fatigue and changes in sleep length: A cohort study with linkage to records on daily working hours. Journal of Sleep Research. 2019; 28(3):e12658. [DOI:10.1111/jsr.12658] [PMID]

[21] Fernández-Muñiz B, Montes-Peón JM, Vázquez-Ordás CJ. Relation between occupational safety management and firm performance. Safety Science. 2009; 47(7):980-91. [DOI:10.1016/j.ssci.2008.10.022]

[22] Jamali Givi K, Janfaza S. [Analysis of shocking events of Pars Aluminum Factory during the years 2000-2003 (Persian)]. Paper presented at: 4th National Conference on Occupational Health, Hamedan University of Medical Sciences. 4-6 October 2004; Hamedan, Iran.

[23] Seo HC, Lee YS, Kim JJ, Jee NY. Analyzing safety behaviors of temporary construction workers using structural equation modeling. Safety Science. 2015; 77:160-8. [DOI:10.1016/j.ssci.2015.03.010]

This Page Intentionally Left Blank