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ORIGINAL ARTICLE

The Effect of Integrated Management System Establishment on the Safety Performance Indices: A Case Study in a Manufacturing Industry

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ABSTRACT

Safety programs are among the effective factors that may have a key role in upgrading workforce productivity and promotion of qualitative and quantitative indicators of production. The aim of this study was to investigate the effect of integrated management systems (IMS) establishment on safety performance improvement. This study was a retrospective study conducted at the Mazrouf Glass factory in Yazd, Iran. To investigate the effect of IMS establishment on the safety performance during the studied years, indices of injury frequency rate (IFR), injury severity rate (ISR), frequency-severity index (FSI), and Safety T. Score (S.T.S) were used. The paired-samples t-test was used to compare safety indices before and after the establishment of the IMS. The results showed that the establishment of IMS had a meaningful effect on the reduction of the IFR and ISR. Also, no meaningful effect was found between IMS establishment and FSI and S.T.S. IMS establishment could reduce the IFR and ISR, which in turn may promote productivity indicators. Eventually, it could be concluded that IMS establishment can be used as an effective proceeding to improve workplace safety indices.

KEYWORDS: *Integrated Management System; Safety Performance Indices; Occupational Accident; Manufacturing Industry*

INTRODUCTION

The increasing expansion of industries and the lack of attention to the principles of industrial safety, has led to higher occupational accident rates and increased related costs in developing countries [1]. In safety management literature, accidents as the serious risk factors for capital destruction in industries are commonly acknowledged, which can cause great economic and social losses [2]. More importantly, it is indicated that the average rate of work-related deaths in Asia, the United States of America, and worldwide are 23.1, 5.89, and 14 per 100.000 workers [3-4]. Annually, about 250 million work-related injuries and 300,000 fatal work-related accidents occur worldwide [5-6]. That the financial losses from these accidents are estimated at $230 million in developing countries and $36 million in developed countries [7].

The development and use of integrated management systems (IMS) (ISO-9001, ISO-14001, and OHSAS-18001) by organizations in the twentieth century with the aim of improving organizational performance, preserving capital, and emphasizing quality, health and safety, environment, personnel, finance, and security was introduced [8]. The results of previous studies showed that IMS is interconnected and interrelated to each other so that standards establishment such as ISO-9001 facilitated the establishment of standard ISO-14001 [9]. Various definitions suggested to IMS including Bragatto et al. that interpreted this system as the most effective method to manage the affairs [10]. Moreover, different definitions have been proposed in different studies so far [11].

The benefits of IMS establishment in different industries have been brought lots of attention during the past few years. Thus, there are some important reasons for the IMS establishment, including duplication and costs reduction, risks reduction and profitability increment, conflicting objectives balance, conflicting responsibilities and relationships elimination, power system diffusion, turning the focus onto business goals, informal systems formalization, practices harmonization and optimization, consistency creation, improving communication, and training facilitation and development [8]. In one other study, it was found that the establishment of IMS as a momentous remedy for inappropriate policy, employees' unsafe actions and low attitudes minimizing toward safe behavior, and insufficient commitment of managers toward organizations [12]. The importance of integration of the HSE system with other managerial systems was also proved in order to achieve high quality and environment-friendly products [13].

The findings of the studies conducted by Laal F et al., and Hamidi N et al., in combined cycle power plants and cement industries, showed meaningful effects of IMS establishment on the safety indices improvement [8-14]. Similarly, Yoon SJ et al., in the construction industry, showed a meaningful reduction in fatal and non-fatal occupational accidents after occupational health and safety management system establishment [15]. By investigating accidents and quantifying the resulting costs, it can be concluded that accidents prevention through adaptation of the safety programs is exclusive in terms of preventing human and financial capital losses. Hence, in this study, we want to understand the value of IMS establishment on the safety improvement at the Mazrouf glass manufacturing factory in Yazd, Iran.

MATERIALS AND METHODS

Study Design:

In the present study, we calculated the injury frequency rate (IFR), injury severity rate (ISR), frequency-severity index (FSI), Safety T. Score (S.T.S), and safety performance indices, before and after IMS establishment (ISO 9000, ISO 14000& OHSAS 18000). These four safety performance indices were calculated for years that completely were documented in the health, safety, and environment department of the factory (2012 to 2019). Additionally, the effects of IMS establishment on lost days and working hours were investigated for the studied years.

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For calculating the safety performance indices, we followed the occupational safety and health administration (OSHA) guidelines for calculating safety performance indices [8-14]. We used the paired samples t-test for analyzing the possible significant impact of the IMS establishment on the safety performance indices, lost days, and working hours using IBM SPSS software version 24. The safety performance indices formulas were as follow:

Injury frequency rate (IFR):

The injury frequency rate is defined based on the 200,000 working hours. IFR was calculated based on Equation 1, where α represents the total number of injuries and accidents (number); n represents the number of employees, and total time represents the total time of work in a year (h) [8].

$$IFR=\frac{a \times 200000}{n \times total\ time} \quad (1)$$

Injury severity rate (ISR):

The injury severity rate is defined based on the number of lost days caused by accidents in 200,000 working hours. ISR was calculated using Equation 2. D represents the total lost times that are caused by accidents (day) [8].

$$ISR=\frac{D \times 200000}{n \times total\ time} \quad (2)$$

Frequency-severity index (FSI):

The frequency-severity index is an integrated index between IFR and ISR. FSR was calculated using Equation 3 [8].

$$FSI=\sqrt{\frac{IFR \times ISR}{1000}} \quad (3)$$

Safety T. Score (S.T.S):

The Safe T. Score index was used to express the improvement or non-improvement of safety conditions based on the results of accident frequency rate. S.T.S was calculated through Equation 4. Table 1. represents the S.T.S's index interpretation [8].

$$S.T.S=\frac{IFR_{new} \times IFR_{last}}{\sqrt{\frac{IFR_{last}}{total\ time/200000}}} \quad (4)$$

Table 1. The safe T-score index interpretation

Safe T-score rate	Assessment
-3 to +3	No significant different between this year and last year
Less than -3	Significant decrease in the number of accidents in this year compared with that in the last year
More than +3	Significant increase in the number of accidents of this year compared with that in the last year

RESULTS

Data interpretation showed that the highest number of accidents were recorded in 2015, the highest working days lost in 2013, the highest AFR was recorded in 2012, the highest ASR was recorded in 2013, the highest FSI was recorded in 2012, and the highest S.T.S was recorded in 2019 (see Table 2). Figures 1 to 4 show the performance safety indices in the investigated years of the study.

Table 2. Safety performance indices in terms of different years at the Mazrouf glass manufacturing factory.

Year	Before IMS			After IMS				
	2012	2013	2014	2015	2016	2017	2018	2019
Number of accident	33	35	41	59	35	33	29	29
Lost days	475	926	5020	1040	490	479	478	574
Working hours	1001639	1543402	1651482	2301886	2017144	1796771	2287713	1731227
IFR	6.59	4.53	4.96	5.12	3.47	3.67	2.53	3.35
ISR	94.84	119.99	62.97	60.36	48.58	53.31	41.78	66.31
FSI	0.79	0.74	0.56	0.68	0.41	0.44	0.32	0.47
S.T.S	-	-2.67	0.55	0.25	-2.32	0.32	-2	1.52

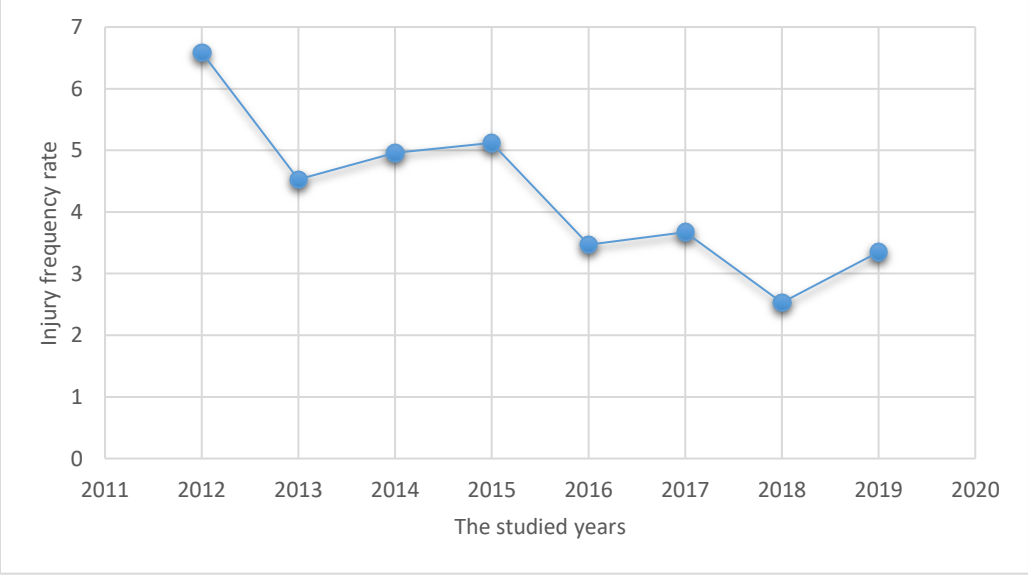

Figure 1. Injury frequency rate at the Mazrouf glass manufacturing factory during 2012-2019 years.

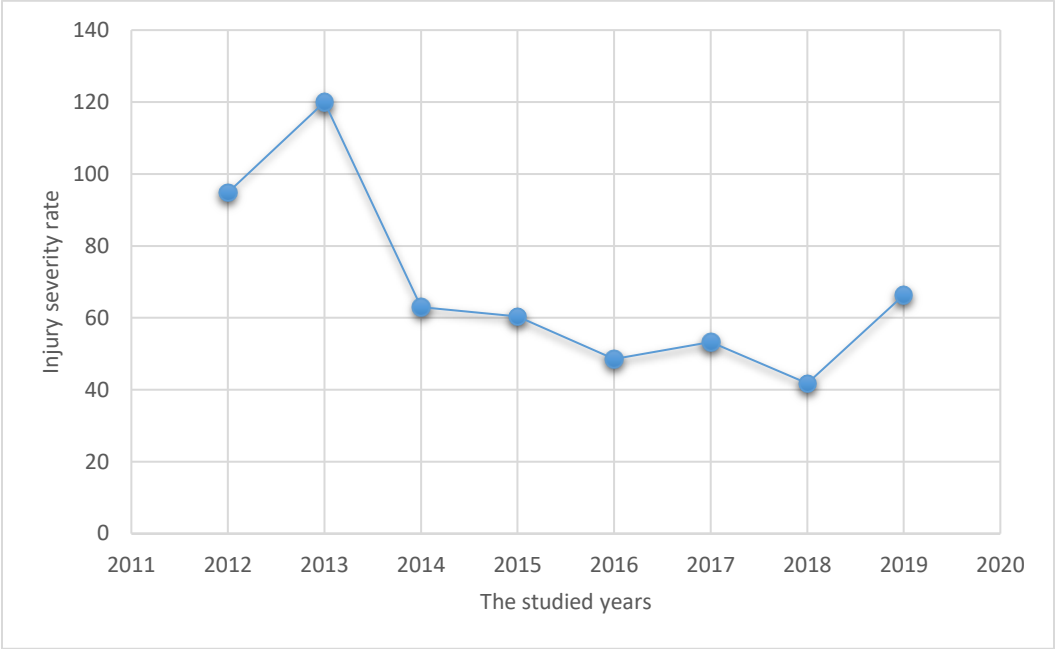

Figure 2. Injury severity rate at the Mazrouf glass manufacturing factory during 2012-2019 years.

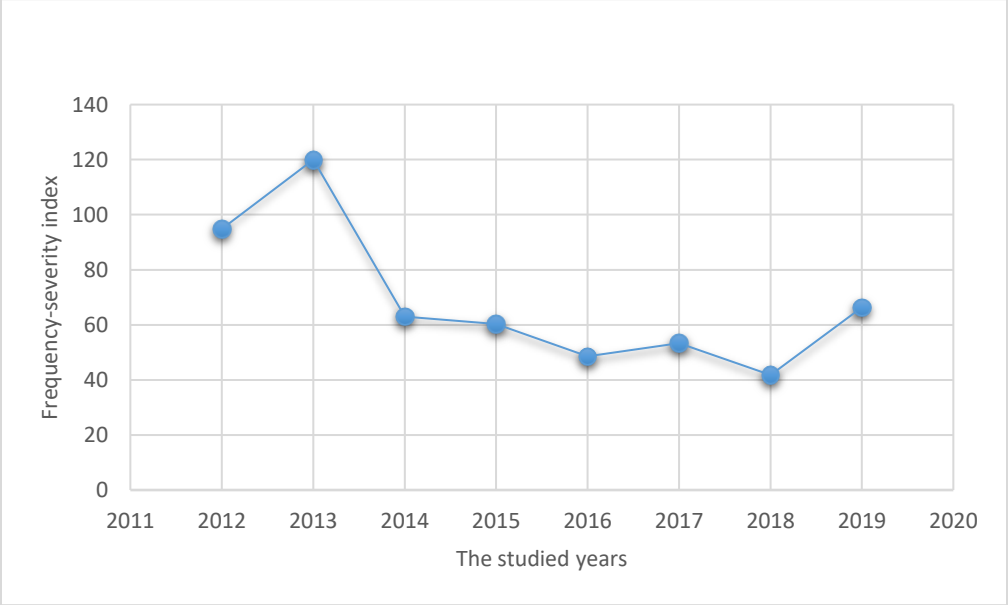

Figure 3. Frequency-severity index at the Mazrouf glass manufacturing factory during 2012-2019 years.

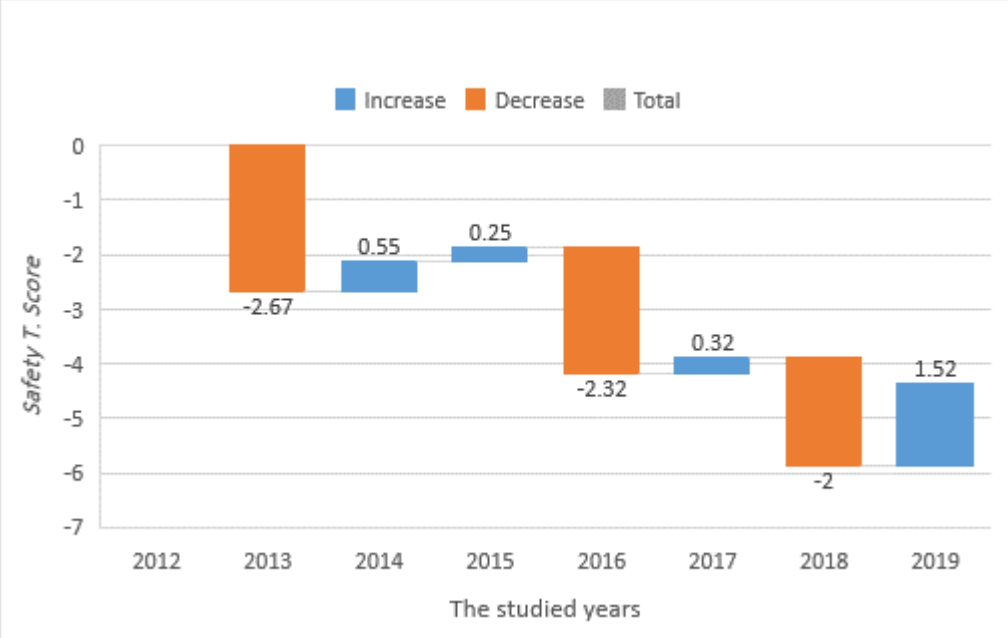

Figure 4. Safety T. Score at the Mazrouf glass manufacturing factory during 2012-2019 years.

The results of the present study showed that the IMS implementation had significant reduction impacts on the AFR and ASR indices ($P < 0.05$) (Table 2). However, there was no significant reduction impact on the FSI and STS indices ($P > 0.05$) (Table 2).

Table 3. Average of safety performance indices before and after the IMS establishment and statistical significance level (P-value).

Safety performance indices	Before IMS	After IMS	P-value
AFR	5.36	4.09	0.04
ASR	92.6	54.08	0.003
FSI	0.69	51	0.59
STS	-1.06	-1	0.87
Lost days	2140.33	669.33	0.446
Working hours	1398841	2038600.33	0.204

DISCUSSION

Nowadays, due to the expansion of urban needs and consequently the expansion of industries, it is of particular importance to examine the effect of management programs on job indicators, specifically safety indices. Therefore, conducting the relevant studies may have a significant impact on the industries' performance indicators improvement by considering indicators such as industry size, number of employees, and the importance of manufactured products. These could reduce occupational accidents and subsequent costs through the establishment and improvement of health and safety programs [8-16-17].

In the following, the results of the current study were compared with other studies. Some studies found that a comprehensive, older, and more detailed the establishment of safety programs, the greater the reduction in accident indices, which was not completely in line with our findings [14]. The results of the present study showed that the safety indices, IFR, and ISR had a meaningful effect in improving the IMS establishment in years after 2015-2019 in comparison with those before years 2012-2014. The outcomes of a study conducted by Yoon SJ et al., clarified accident rates reduction by the establishment of occupational health and safety management system (OHSMS) in the construction industry [15]. Tam et al., also proved that the safety programs establishment such as IMS can reduce the accidents rates [18].

In the present study, no meaningful relationship was found between IMS establishment and improvement in FSI and S.T.S indices in years after the establishment. Results of the study by Hamidi et al., in the cement industries, showed a meaningful effect on safety indices (IFR, ISR, FSI, and S.T.S) in years after IMS establishment that was not completely consistent with the results of the present study in terms of FSI and S.T.S [8]. Findings of other studies by Coleman, Kerkering [19], and Goldenhar et al., [20] showed significant differences between various safety indices before and after IMS establishment. The lack of meaningful differences between IMS establishment and improvement of FSI and S.T.S may be due to the difference in the places where the present and previous studies were conducted. It is worth noting that the application of regression models for the improvement and monitoring of the safety situation was encouraged through literature [14-21]. So, different indicators mentioned as crucial indicators for predicting the performance of occupational health and safety management systems indicators such as management commitment, workers' involvement in OHS activities, employee training, hazard communication, safety briefings, accident investigations, OHS inspections, incentives, and rewards system, corrective actions, safety managers' participation in OHS meetings, well-documented OHS rules and procedures, OHS promotion policies, and risk assessment [22].

The importance of monitoring lost working days as a safety assessment indicator has been encouraged through literature [19]. Despite a relative reduction in the number of lost days in years after IMS establishment, there were no statistically significant differences between the lost days and working hours before and after IMS establishment. This could be due to the expansion and increase in the studied industry production rate during the post-establishment years. Of course, this partial reduction in lost days after IMS establishment could be indicative of more and more reduction in the future. The results of one study in the cement industries showed an increment in human productivity years after IMS establishment that was not consistent with the results of the present study [8]. The significant and positive influence of safety management practices on safety performance, competitiveness performance, and economic-financial profits were found in another study [23-25].

CONCLUSION

The main goals of the present study were the effectiveness of IMS establishment assessment in improving IFR, ISR, FSI, S.T.S, lost days, and working hours. The findings showed that IMS establishment cannot ensure full development in safety indices and some safety indices might not be improved through IMS establishment. Hence, it could be said that holding safety training sessions and the involvement of all personnel were two main factors in achieving the goals of IMS implementation. Eventually, it could be concluded that the

establishment of structured health and safety management systems was useful in reducing IFR and ISR.

It would be interesting to investigate the same study in different industries to get a better view of the impact of IMS establishment on industries' performance. Due to the effects of the COVID-19 outbreak in the data collecting process and the long-term coordination process with the factory management to conduct the study, it is recommended to consider these limitations in future studies.

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CONFLICT OF INTEREST

The authors confirm that there is no conflict of interest regarding the publication of this article.

ETHICAL ISSUE

The proposal of this research was ethically approved with the ethics code of ID IR.SSU.SPH.REC.1399.161 and can also be seen on the website of the National Ethics Committee.

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