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Country Report

Systematic Strategies for the Third Industrial Accident Prevention Plan in Korea

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Abstract: To minimize industrial accidents, it's critical to evaluate a firm's priorities for prevention factors and strategies since such evaluation provides decisive information for preventing industrial accidents and maintaining safety management. Therefore, this paper proposes the evaluation of priorities through statistical testing of prevention factors with a cause analysis in a cause and effect model. A priority matrix criterion is proposed to apply the ranking and for the objectivity of questionnaire results. This paper used regression method (RA), exponential smoothing method (ESM), double exponential smoothing method (DESM), autoregressive integrated moving average (ARIMA) model and proposed analytical function method (PAFM) to analyze trends of accident data that will lead to an accurate prediction. This paper standardized the questionnaire results of workers and managers in manufacturing and construction companies with less than 300 employees, located in the central Korean metropolitan areas where fatal accidents have occurred. Finally, a strategy was provided to construct safety management for the third industrial accident prevention plan and a forecasting method for occupational accident rates and fatality rates for occupational accidents per 10,000 people.

Keywords: Prevention Factors and Strategies, Cause and Effect Model, Priority Matrix Criterion, Fatal Accidents, Industrial Accident Prevention, Forecasting Method

Introduction

Recently, the occupational accident rate has been reported to be 0.71, which is a decrease of 1.4% compared to the previous yr with 95,806 employment injuries in Korea in 2008[1)]. The fatality rate of occupational accidents per 10,000 people was 1.80% which is a decrease of 6.3% compared to the previous yr with 2,422 deaths[1)]. In addition, 1,448 people died due to occupational diseases, and the fatality rate related to occupational causes was reported as 1.07% per 10,000 people, which is a decrease of 2.7% compared with the previous yr[1)]. However, taking inflation into consideration, the total cost, direct cost and indirect cost, increased by 12.3% compared to the previous yr and cost 18.2 trillion won[1)]. The formula for the occupational accident rate and occupational fatality rate are presented below.

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$$\text{Occupational accident rate} = \frac{\text{Total number of occupational accident workers (deaths and injuries + illnesses) requiring medical care at least 4 or more days in one yr}}{\text{Total number of workers in one yr}} \times 100 \quad (1)$$

$$\text{Occupational fatality rate} = \frac{\text{Total number of occupational accident workers (death) in one yr}}{\text{Total number of workers in one yr}} \times 10{,}000 \quad (2)$$

In terms of number of industrial accidents recorded in 2008, manufacturing companies are the highest with 37.4% or 35,819 people, and construction companies are second with 21.4% or 20,473 people[1]. Manufacturing companies and construction companies account for 58.8% of the industrial accidents in total. Therefore, fundamental methods for industrial accident prevention in these two groups are urgently needed. In particular, 92% of occurrences and 83.7% of total deaths were in businesses with less than 300 employees. Looking at the type of occupational accidents, there were 18,527 people involved in slips, 15,250 people involved with stricture, 14,027 people involved in falls, 8,670 people involved in falling from a height, and 7,279 people involved in collisions accounting for 74.1% of all occurrences in 2008[1]. Falls, slips and strictures account for 55.5% of all occurrences.

Therefore, industrial accident prevention in Korea should perform fundamental cause analysis of unsafe acts and unsafe conditions of the occupational accidents that induce traditional accidents such as falls, slips and strictures. Examining occupational diseases for 6 yrs from 2000 to 2005, work-related musculoskeletal disorders (WMSDs) accounted for 50% of total diseases. Thus, the administration and laws for preventing WMSDs were strengthened, and job analysis evaluation should be done systematically for work places with less than 50 employees.

Looking at the trend of industrial accident rates in Korea for 11 yrs from a general point of view, the occupational accident rate is static at 0.7%[1]. Moreover, according to the trend of the fatality rate of occupational accidents per 10,000 people, the fatality rate of occupational accidents per 10,000 people is static for 9 yrs, from 2000 to 2008. Korean firms should implement systematic strategies for industrial accident prevention to solve the cause of industrial accidents. Therefore, this paper is intended to propose methods for minimizing industrial accidents by analysis and prioritization through statistical testing using questionnaires after developing prevention factors and strategies through cause analysis of industrial accidents for manufacturing and construction companies.

Subjects and Methods

Background

There were several reports on the analysis of the causes of industrial accidents in Korea. According to the analysis of accident causes by type of occurrence and original object involved, fatal accidents in construction companies could be cut by more than half if there are protective equipment, safety inspections and safety supervision[2]. In a paper classifying accidents in small businesses with less than 30 employees, more accidents were identified as occurring to workers in their 20's, to unskilled workers with less than 1 yr experience, and on Saturdays. Unsafe acts that include unsafe posture and motion were identified as the leading direct cause. Unsafe condition was followed by workplace and environmental defects[3]. The lack of safety management was the highest indirect cause[3]. The study asserted that safety education for young staff, improvement in posture, and development of systematic safety management programs were required[3].

An analysis of industrial accidents with fuzzy inference showed a lack of safety consciousness, insufficient safety management and passivity in countermeasures for potential hazards as leading causes. That report concluded that the accident rate was low where the company and its staff had high safety awareness[4]. Industrial accidents aboard fishing vessels were caused by the lack of qualifications and knowledge of workers, insufficient safety management system and faults in the vessel itself[5]. The solution proposed in the report was for ship owners to recognize the need for safety awareness by the workers and to provide periodic education. Case studies on safety management should be developed with the contents made part of the test for the seaman engineer's license[5]. The report also proposed that the safety management system and the emergency rescue system be developed as well as strengthening the vessel test procedures to remove accident causing factors[5]. A behavioral science approach analyzed the intensity of stress factors through normal testing of several Korean life change unit (LCU) models developed from life stress factors adapted to actual life in Korea[6]. A comparison of minor and major industrial accidents using a measure of 5 points - work load, inadequate training, operating procedure, lack of knowledge and

ignorance of danger - was made using statistical analysis. The results showed that the conditions giving rise to major - and minor-injury accidents are similar[7], so there should be no differentiation in analyzing the two groups.

In the analysis of cause and effect in the Bopal gas water leak, alarm absence, chemical potential hazard, insufficient system functionality, insufficient equipment, misinformation, and inadequate maintenance are identified as causes of industrial accidents[8]. The method for removing injury and risk is through a logical framework approach (LFA) related to education, alarm, development of adequate maintenance systems, and emergency action plans[8].

In Korea, the prevention of fatal accidents in small and medium sized companies has been developed by using a Korean LCU model with life stress factors adapted to actual Korean life and proposing systematic management method for this[9, 10]. In Korea, among the research for prevention of industrial accidents by basic cause analysis, there was little research proposing synthesis of solutions for all companies. The methods for grasping the cause of industrial accident and preventing industrial accidents were mainly for specialized companies or characteristic facilities. Thus, the development of models from the fundamental cause analysis for all companies by type of occupational accident and disease has to be done.

Promoting Method for Priority of Prevention Factors and Strategies

For minimizing industrial accidents, it was important to evaluate the priority of prevention factors and strategies that systematically provide decisive information for establishing the method of accident prevention and safety management. Also, forecasting of the occupational accident rate provided practical information for the strategy of prevention of industrial accidents over the long term. Therefore, promoting a system for preventing industrial accidents using prevention factors and strategies is shown in Fig. 1.

Prevention Strategy by Cause Analysis of Industrial Accident

Recently, the government established a strategy to minimize deaths from traditional accidents, such as falls, slips and stricture, by 50%. At the end of the third five-yr plan for prevention of industrial accidents (2010-2014), a foundation for becoming an advanced country in occupational safety and health would be achieved with an occupational accident rate of 0.5 and occupational fatality rate of 0.74 per 10,000 people[11]. Therefore, for preventing industrial accidents, this paper intends to draw prevention factors and strategies from existing cause and effect models with cause analysis and dramatically reduce industrial accidents by using priorities. The result of analyzing existing domestic/international cause and effect models and strategies, the number of prevention factors and strategies were set at 32.

Scope and Methodology

In Korea, 74% of the fatal accidents occurred in the metropolitan and central areas, so workers and managers in these areas were the subjects of the investigation. Before the questionnaire, we gave the subject a brief introduction of the questionnaire and explained that had obtained data for personal information don't use other purposes. And, we carried out the questionnaire to prevent industrial accident under the support from Office of Culture & Public Relations of KOSHA.

The personnel, including male workers and managers in the sample to evaluate the priority of prevention factors, are from manufacturing, construction companies and service industrial companies with less than 300 employees. These areas include Seoul, Inchon, Gyeonggi Province, Chungcheong Province and others. In total, 1,545 persons collected to the questionnaires. The investigation by questionnaire is a simple random sampling method for the objective response of priority and shown in Table 1.

To develop the methods for prevention of industrial accidents systematically and promote priority evaluation of prevention factors and strategies, the following procedure was carried out:

First, occupational accident rate and occupational fatality rate per 10,000 people were forecasted based on obtained data from statistics of the occupational accident from 1973 to 2008[12]. This rate was used as input data for the industrial accident rate forecasting program which was developed to estimate the accident rate, zero accident time and achievement probability of an efficient industrial environment[12] and predicted the accident rate from 2009 to 2018.

Second, prevention factors and strategies of industrial accidents were extracted from the cause analysis.

Third, a questionnaire randomly arranging the participating enterprise, prevention factors, and strategies was constructed.

Fourth, the questionnaire was applied to enterprises in the metropolitan and central areas of Korea for manufacturing and construction companies with less than 300 people. The subjects for the questionnaire were field work-

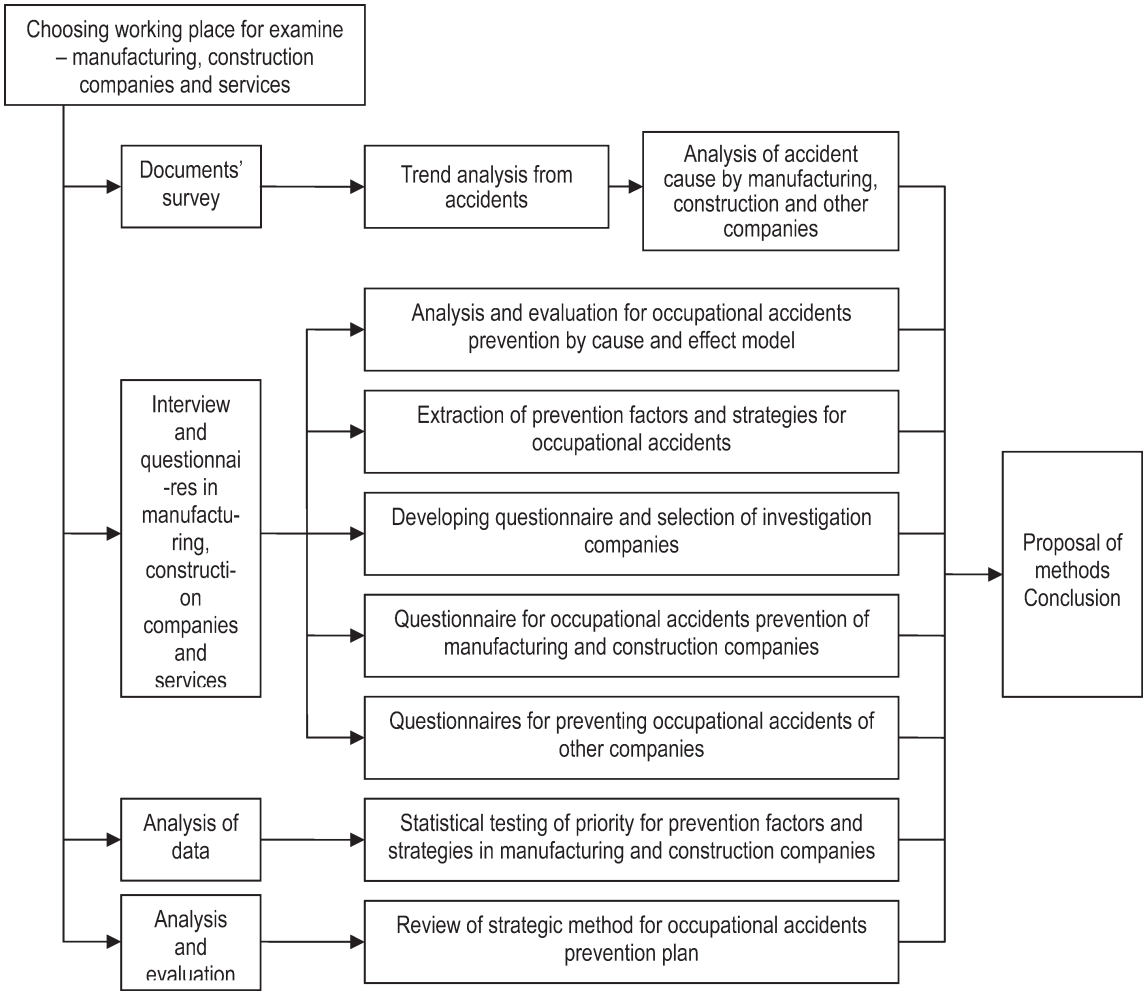

Fig. 1. Occupational accident prevention method system based on prevention factors and strategies

ers and managers of safety and health.

Fifth, under the subject of worker and manager of safety and health in the middle region, questionnaire subjects were selected based on a simple random sampling method.

Sixth, for securing objectivity of priorities from the questionnaire, a priority matrix criterion was applied. Therefore, the sample response rate of prevention factors and strategies was measured from the principal diagonal on the priority matrix. Then, the priority of each item was established.

Seventh, an intensity analysis was performed to identify how much each prevention factor and strategy differs in the priority of prevention factors and strategies. For analyzing difference of intensity, normal testing was performed with a significance level of 0.05 (α=0.05) by sample response rate. Finally, based on the result of normal testing, the strategies for minimizing industrial accidents were systematically established.

Results

In this paper, we used Microsoft Foundation Class (MFC) software for efficient forecasting of occupational accident rate and occupational fatality rate per 10,000 people. Using with the occupational accident rate for 36 yrs, the forecasting for occupational accident rate for 10 yrs is shown in Fig. 2. The Sum of Squared Errors (SSE) value of the ARIMA Model in Fig. 2 is 2.79. It has been suggested that the ARIMA model is the most desirable in case of forecasting the occupational accident rate in Korea[13]. Also, in the case of maintaining the existing prevention strategy of industrial accidents; the trend of the occupational accident rate very slowly decreases in Korea.

With the existing data of occupational fatality rate per 10,000 people for 18 years, the result of forecasting for 10 years in the future is shown in Fig. 3. In case of forecasting occupational fatality rate per 10,000 people, the SSE

Table 1. Data for Participating Enterprises

No.	List of Selection Items	Frequency (No. of data)	Percentage (%)
	Residence area		
1	City of Seoul	85	6.5
2	Gyeonggi Province	774	50.1
3	City of Incheon	176	11.4
4	Chungcheong Province	244	15.8
5	Other	266	17.2
	No. of workers		
6	Above 300	617	39.9
7	100~300	373	24.1
8	50~100	340	22.0
9	Under 50	215	13.9
	Age		
10	Over 50 age	81	5.2
11	40 age	496	32.1
12	30 age	734	47.5
13	20 age	215	15.1
	Industrial Classification		
14	Manufacturing company	602	40.0
15	Construction company	518	33.5
16	Other	425	27.5
	Sex		
17	Male	1,545	100.0
Total		1,545	100.0

value obtained by doubling the exponential smoothing method was the lowest at 1.19. Thus, the double exponential smoothing method is shown to be most desirable[8].

Therefore, the death trend of occupational accidents appeared to be stagnated for 10 years. Thus, epochal prevention strategies for industrial accidents have to be established and fulfilled in a sustainable direction.

Using 32 prevention factors and strategies for the questionnaire, the priorities were evaluated for workers and managers in the field. The material developed from participating enterprises is in Table 1. Table 1 is the result of distributing questionnaires to 2,110 workers and managers in companies whose staff is less than 300 people and collecting 1,545 questionnaires (collection rate : 73.2%).

Table 2 is a priority evaluation model developed to match our actual life by evaluating prevention factors and strategies based on a priority matrix for dramatically minimizing industrial accidents for workers and managers of safety and health in middle regions of the country.

Therefore, with prevention factors and strategies, the priorities adapted to our actual life were analyzed including leadership of company owner (1), prevention of stress

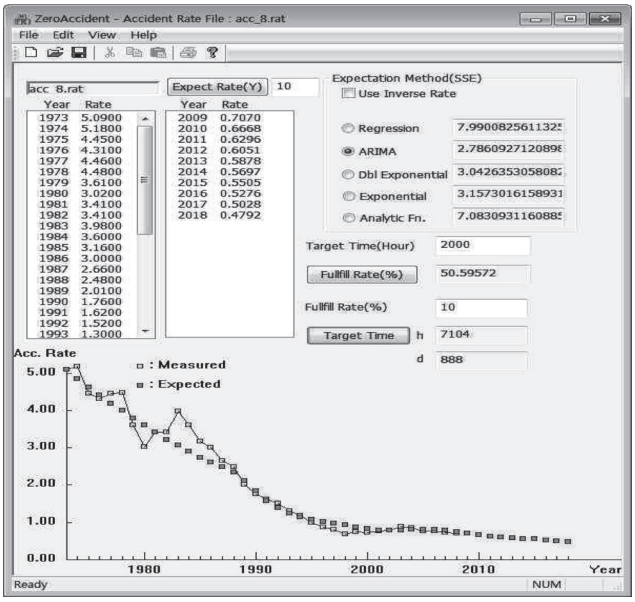

Fig. 2. The forecasting of occupational accident rate for 10 yrs

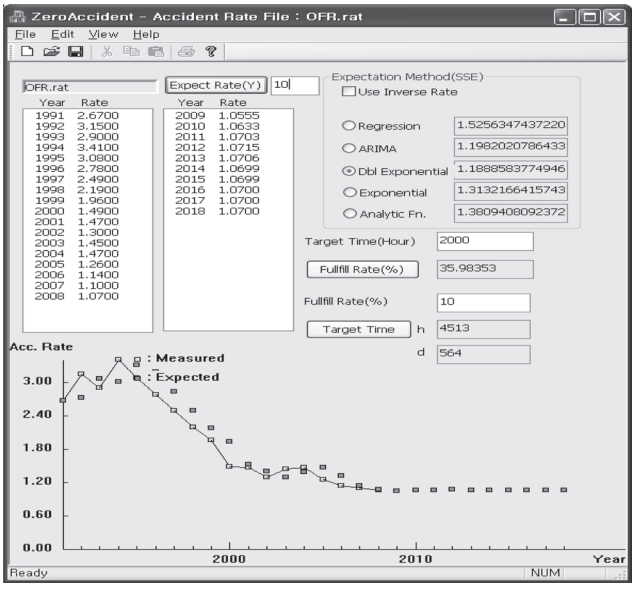

Fig. 3. The forecasting of fatality rate of occupational accidents for 10 yrs

(2), development of self-safety and health movement for conscious reform and reliable information from material safety data sheet (MSDS) (3), quantitative risk assessment (5), safety and health association (6), expansion of lockout/tagout for important tools (7), construction of occupational safety and health management system(OSHMS), enforcement of safety and health education, and hazard and risk prevention plan (8), small safety and health team (11) and promotion of sufficient experts for prevention of

Table 2. Priority model of prevention factors and strategies

Rank	Prevention factors and strategies	Frequency	Response rate
1	Leadership of company owner	307	0.199
2	Prevention of stress (job, working place, life stress, etc.)	124	0.080
3	Development of self-safety & health movement for conscious reform	86	0.056
3	Reliable information from material safety data sheet (MSDS)	86	0.056
5	Quantitative risk assessment	85	0.055
6	Safety & health association	80	0.052
7	Expansion of lockout/tagout for important tools	73	0.047
8	Construction of occupational safety & health management system (OSHMS)	66	0.043
8	Enforcement of safety & health education	66	0.043
8	Hazard and risk prevention plan	66	0.043
11	Small safety & health team	65	0.042
12	To promote sufficient experts for prevention of musculoskeletal disorders	64	0.041
13	Evaluation of safety work plan daily and weekly	63	0.041
14	Industrial safety & health committee	62	0.040
15	Zero accident campaign	61	0.039
16	Enforcement of work study in the field	60	0.039
17	High-five movement for fatal accident prevention	59	0.038
17	Process safety management (PSM) of chemical companies	59	0.030
19	Standardization of temporary structure construction	58	0.028
19	Safety management of aged workers	58	0.038
21	Enforcement of safety rules	56	0.036
22	Prevention of human error	55	0.024
23	Advanced technology using information technology (IT) for accident prevention	53	0.034
24	Expansion of clean business with less than 50 workers	42	0.027
25	Increasing fines for a default	41	0.027
26	Education for children's safety & health	34	0.022
27	Safety education for foreign workers	33	0.021
28	Accident prevention to company picnic and athletic meetings	32	0.021
28	Expansion of safety & health research & development (R&D) cost	32	0.021
30	Enforcement of fall prevention education	28	0.018
31	Prevention of musculoskeletal diseases in service industries	26	0.017
32	Work-related disease prevention for women workers	14	0.009

Table 3. The normal testing result by significance level (α=0.05)

Item of sample rate	Test statistic	Rejection region
$P_1 = P_2$	9.52	$Z \geq \|\pm 1.96\|$
$P_2 = P_3$	2.65	$Z \geq \|\pm 1.96\|$
$P_3 = P_{14}$	2.08	$Z \geq \|\pm 1.96\|$
$P_{14} = P_{24}$	2.01	$Z \geq \|\pm 1.96\|$
$P_{24} = P_{32}$	3.77	$Z \geq \|\pm 1.96\|$

Where,

P_1 = Leadership of company owner

P_2 = Prevention of stress (job, working place, life stress, etc)

P_3 = Development of self-safety & health movement for conscious reform

P_{14} = Industrial safety & health committee

P_{24} = Expansion of clean business with less than 50 workers

P_{32} = Work-related disease prevention for women workers

musculoskeletal disorders (12). Among these strategies, leadership of company owner played an important role to minimize accidents more than any prevention factor or any strategy. Especially, in Table 2 and 3, items with a significance level of 0.05 (α) were:

(1) Leadership of company owner and prevention of stress (job, working place, life stress, etc.)
(2) Prevention of stress and development of self-safety and health movement for conscious reform
(3) Development of self-safety and health movement for conscious reform and industrial safety and health committee
(4) Industrial safety and health committee and expansion of clean business with less than 50 workers
(5) Expansion of clean business with less than 50 workers and work-related disease prevention for women workers

The analysis of the difference in intensity of the sample response rate for prevention factors and strategies between these items was not significant.

Discussion

Currently large companies have established OSHMS programs and have actively created systems for real time management of industrial accidents by recognizing the importance of safety and health in the work place. Also, small sized industries with less than 50 employees have actively performed fundamental prevention of industrial accidents supported by the government. Leadership of the company owner as ranking first in the priority plays a decisive role in industrial accident prevention. Therefore, for sustainable safety management from the top-down, the number of managers studying safety and health needs to be enlarged, and resurrection of laws and education of company owners with less than 50 staff must to be increased.

The main issue of advanced safety and health countries is stress related. The results of stress are traditional accidents that include brain vein and heart disease, cancer, gastric ulcer, depression, Basedow's disease, tuberculosis, digestive trouble, and rheumatoid arthritis. Accordingly, more efficient methods for prevention of stress ranking second in priority are required in national strategies. Also, Korea has to search for fundamental solution for prevention of stress by expanding the focus to include the job, the workplace, and life stress. Therefore, a Korean stress prevention model integrating job, workplace and life stress has to be developed and systematic prevention strategies have to be established for fundamental stress prevention.

The hazardous factors in the workplace are well known by workers in high risk work areas or processes. From the long-term perspective, small safety and health team is an essential, core factor that has to be promoted for prevention of industrial accidents through development of self-safety & health movement for conscious reform in the workplace as the third priority. Korean recognition and attitude for safety and health consciousness is insufficient in comparison with countries having advanced safety and health programs. Therefore, to minimize industrial accidents by establishing a safety culture, development of self-safety and health movement for conscious reform should push education and improvement of unawareness, indifference, disregard, ignorance, and recklessness. The reliable prevention information of harm from nanoparticles and safety of new materials by complex advanced factory automation are necessary. For reliable information from MSDS as the third priority, definite proposals for existing/new MSDS as well as continuous management of a chemical material information system are required.

Advanced safety and health countries are introducing several incentives for quantitative risk assessment as the fifth priority. Therefore, Korea has to perform quantitative risk assessment not only centered on large companies, but also for workplaces with less than 50 workers. For revitalization of the safety and health association as the sixth priority, it is desirable to entrust related certification/verification though associations rather than the government. Especially, the number of safety and health associations has to be gradually increased with customized services to small and medium sized businesses for dramatically minimizing industrial accidents in the workplaces with less than 50 workers. For expansion of lockout/tagout for important tools as the seventh priority, malfunction of equipment or non-existent safety equipment must be assured in not only manufacturing companies but also in construction companies. Accordingly, installation of lockout/tagout for important tools program is immediately required for important equipment causing fatal accidents in workplaces with less than 50 workers.

Large companies have actively constructed OSHMS, but workplaces with less than 50 workers have limitations from a cost standpoint in establishing OSHMS. For construction of OSHMS as the eighth priority, workplaces with less than 50 workers must gradually construct OSHMS under government support to prevent industrial accidents. For enforcement of safety and health education as the eighth priority, it's essential to establish useful safety and health education adapted to each workplace and to introduce early safety education. In addition, in early school system, a model for safety education has to be established and operated systematically. Because advanced safety and health countries are performing safety and health education from childhood, the recognition of safety and health is deeply rooted. Therefore, those who are educated from childhood would encounter accident prevention without difficulty due to a safety and health consciousness. Yet, Korea performs very little safety and health education from childhood. Also, from the man-machine interface standpoint, 84% of all accidents are caused by human error or wrongly planned work environment[13].

While Korea takes rank with advanced countries in the competition of quality for exporting, in safety, small safety and health teams as the eleventh priority have not been activated. Therefore, for minimizing industrial accidents

by revitalization of small safety and health teams, the prize rule or contest for task division of safety has to be promoted and the government has to positively support this so that it is maintained and developed from the bottom up.

Recently, the number of specialist in the prevention of musculoskeletal disorders as the twentieth priority is insufficient and needs to be increased not only for repetition work and lifting tasks but also for systematic and fundamental management.

Conclusions

The main conclusions of this paper are:

First, it provides efficient information which can systematically establish strategies for industrial accident prevention in the medium or long term by the optimal occupational accident rate and fatality rate for occupational accidents per 10,000 people through evaluation of forecasting method.

Second, through fundamental prevention factors and strategies by the priority, it is expected to achieve occupational accident rate of 0.5 and occupational fatality rate of 0.74 per 10,000 people before the five-yr period ends for the third industrial accident prevention plan.

Third, safety management and improved direction through concrete strategies of industrial accident prevention by priority can easily be established.

Fourth, it is expected to improve productivity and dramatically reduce industrial accidents by job satisfaction in a safe work environment.

Finally, we will seek more harmony of labor and top management because it is the best way to solve distrust and dissatisfaction in the workplace.

A detailed study by correlation analysis for each prevention factor and strategy should be future research.

Acknowledgments

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References

1) Korea Occupational Safety & Health Agency (KOSHA) (2008) Statistics of the Industrial Accident (per yrs), 1973-2008, KOSHA, Incheon. (in Korean).
2) Park JK (1997) A Study on the Analysis Cause for Fatal Accident in construction Works. J Korean Soc Saf **12**, 122–33 (in Korean).
3) Kim YC (1998) The Characteristics of Occupational Injury in Small Manufacturing Factory. J Korean Soc Saf **13**, 145–50 (in Korean).
4) Bae SK, Park DH (2003) An Evaluation Model for Human Attributes of Industrial Accident. J Korean Soc Saf **18**, 155–63 (in Korean).
5) Lee HK, Chang SR (2005) Cause Analysis and Prevention of Fishing Vessels Accident. J Korean Soc Saf **20**, 153–7 (in Korean).
6) Kang YS, Yang SH (2006) The Comparative Analysis of Life Change Unit Models for Accident Prevention. J Korea Saf Manage Sci **8**, 85–96 (in Korean).
7) Kenneth RL, Kent PV (1990) Major and minor injuries at work: Are the circumstance similar or different? Int J of Ind Erg **12**, 273-9.
8) Eckerman I (2005) The Bhopal Gas Leak: Analysis of Cause and Consequences by Three Different Models. J Loss Prev Process Ind **18**, 213–7.
9) Kang Y, Hahm H, Yang S, Kim T (2008) Application of the Life Change Unit Model for the Prevention of Accident Proneness among Small to Medium Sized Industries in Korea. Ind Health **46**, 470–6.
10) Yang SH, Park B, Kang YS, Gal WM, Choi JH, Kim DS, Kim TG, Cho MS (2011) Safety Management System, First Ed, 26–33, Hyoungseol Publishing Company, Seoul. (in Korean).
11) Kang YS, Yang SH, Kim TG, Kim DS (2010) The Preventive Strategies for the Third Industrial Accident in Korea, Proceedings of 3rd International Conference on Applied Human Factors and Ergonomics (AFHE).
12) Kim TG, Kang YG, Lee HY (2011) A Study on Industrial Accident Rate Forecasting and Program Development of Estimated Zero Accident Time in Korea. Ind Health **49**, 56–62.
13) Yang SH, Park B, Kang YS, Gal WM, Choi JH, Kim DS, Kim TG, Cho MS (2011) Ergonomics, First Ed, 28, Hyoungseol Publishing Company, Seoul. (in Korean).