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Factors Related to the Accident at Work: Manufacturing vs. Construction Companies

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Abstract: The purposes of the study are to examine, the relationship among the demographic factors affecting accidents at work, the causes or the personal, the policy and the environmental factors affecting accidents at work, the direct and indirect costs of accidents at work and to forecasts the accidents cost. The mixed method procedure was used to investigate the qualitative study by applying the purposive sampling technique. The subjects of the study were 61 employees who had accidents at work; thereby 41 employees were derived from 2 manufacturing companies and 20 employees from 5 construction projects of a construction company, of which the operation was from September 2015 to March 2016. The majority of participants are male (60.7%) with the average age of 37.95 years old and with level of education of grade 12 and above (50.8%); most of them are Thai employees (93.4%). Besides, the average working experience for manufacturing is at 15.60 years whereas that of construction is at 2.02 years. The participants had been provided with the safety training (70.5%) and most participants get severe accident (78.7%). The results further show that females were more likely to get severe accident 1.607 times than male. The participants without safety training were more likely to get severe accident 2.750 times than who had been provided with the safety training. The participants who graduated from grade 12 and above were more likely to get severe accident 8.395 times than those who graduated from grade 9 and under. Based on content analysis, the main factors of accidents were personal factors (70.00%), environmental factors (26.25%) and policy factors (3.75%), respectively. The costs of accidents at work were classified into 2 categories including the direct costs arising from the compensation and the medical treatment (22.22%) and the indirect costs arising from the accident compensation fund, the machine maintenance costs, the transportation costs, the accident management costs and the opportunity costs (77.78%).

Key words: Accidents at work, contributing causes, immediate causes, accident costs, serious accidents, normal accidents

INTRODUCTION

In the period of 50 years, Thailand's economy has transformed from a mainly agriculture and cultivation base to various manufacturing and service sectors. The manufacturing industry is important to Thailand's economy due to the highest GDP in 2014 which now accounts for about 80% of the economic expansion of GDP. In the meantime, construction sector is one of the most important sectors that contribute to economic development in developing countries. Considering Thailand, construction industry was expected to increase in 2015 due to the contraction of the previous year. Public construction projects will be the key growth driver whereas the private projects are also expected to grow though at a slower rate.

According to a drastic competition, the companies need to apply strategies that can reduce production costs such as human resources, modern machines, equipment, technologies, advance chemical and forefront manufacturing system. In contrast, the occupational accidents frequently occur due to the absence of knowledge and expertise, carefulness, tightened control and attention from all of stakeholders which result in unsafe acts, environmental and working conditions. Workplace accidents and injuries are sources of considerable costs of society and economy (Schuster and Rhodes, 1985), especially in developing countries (Thepaksorn and Pongpanich, 2014). In addition, occupational injuries and illness in the developing countries are approximately at least between two and five times greater than such developed countries as the United States and European countries. Safety has transformed an essential role of any accomplished business. The organization has been struggling hard to improve figures of safety; thus, the demand for qualifications in this area is expanding, especially production processes and labor intensive characteristic (Yilmaz, 2014).

The study from the national profile on occupational safety and health of Thailand revealed that top ten

occupation accidents or illnesses classified by types of organization in 2011 were metal products, commercial, others, chemical and petroleum products, food and beverage manufacture, construction and machine installation, vehicle assembly, basic metal products, textile and ornament manufacture and transportation, respectively. The study further reported that the rate of occupational accident between 2002 and 2011 had reduced. In contrast, the workmen's compensation paid per case had increased. Accordingly, this can be concluded that the tendency of severe accidents at work is more than previous time.

According to the Thai Workmen Compensation Fund (WCF), the purpose of compensation costs is to substitute the employer's responsibility when employees are hurt, diseased, handicapped or dead from work. Since, 2002, this funding covers all establishments with at least one employee. The employer contribution rate varies between 0.2 and 1.0% of employee wages, based on the risk rating for the category of industrial (Ministry of Labor, 2016). Employees are entitled to assert compensation advantages, including medical services, monthly indemnities, rehabilitation, or interment grants (Thepaksorn and Pongpanich, 2014). Heinrich (1959) separated the costs of accident at work into two categories, i.e., direct and indirect cost and further proposed that indirect costs were approximately four times more than direct costs. A reliable evaluation of the costs of accident can help managers and workers to internalize the importance of safety measures from an economic-managerial perspective. However, there are few published studies that have forecasted the costs of occupational injuries and illnesses in Thailand; especially the interest in indirect costs is scarce.

Accordingly, the main purposes of this study are to examine the relationship among the individual factors related to types of accidents at work, to investigate the causes or the personal, the policy and the environmental factors that affected accidents at work, to estimate the direct and indirect costs of accidents at work and to forecast the accident cost which allow us to better understand causes and effects of accidents at work, provide effective prevention that leads to lower costs and perceive good image that results in sustainable competitiveness advantage.

Literature review: There is a congruence amongst safety engineers and there are four explicit components in the anatomy of an accident consisting of contributing causes, immediate causes, the accident and the results of the accident. Firstly, the contributing causes occur from three main reasons, i.e., supervisory safety performance such as inadequate safety instruction, safety rules not enforced, safety not planned as part of the job, infrequent employee safety contacts, hazards not corrected and safety devices not provided; mental condition of person such as lack of safety awareness, lack of coordination, improper attitude, slow mental reaction, inattention, lack of emotional stability, nervous and temperamental and physical condition of person such as extreme fatigue, deaf, poor eyesight, physically unsuitable for the job, heart condition and physically unqualified for the job. Secondly, immediate causes of accidents occur from two main reasons including unsafe acts such as protective equipment or guard provided but not used, hazardous method of handling (failure to allow for sharp or slippery objects and pinch points, wrong lifting, loose grip, etc.), improper tools or equipment used though with correct tools available, hazardous movement (running, jumping, stepping on or climbing over, throwing, etc.) and horseplay and unsafe conditions such as ineffective safety device, no safety device although one is needed, hazardous housekeeping (material on floor, poor piling, congested aisles), defective equipment, tools or machines, improper dress or apparel for the job and improper illumination or ventilation. Thirdly, the accident is mentioned as dangerous activities, e.g., fall, slip, slide, strike against, caught in or between, erupt or explode, burn which may occur from contact, entanglement, pips and traps, impact and projections, ejections, discharge and environmental, noise and vibration, electricity, chemical, temperature, radiation and explosion. Finally, results of the accident include annoyance, production delays, redued quality, spoilage, minor injuries, disabling injuries, fatality, legal costs, production costs, medical aid, insurance premiums, compensations, costs of investigation times and attorney fee (Johnson, 2004).

Reason (1990) suggested that there are two types of unsafe acts which can be categorized as errors or contraventions. Most studies on accident confirmed that the essential causes of accidents are errors. In contrast, contraventions are less common. Unsafe acts of employees may happen in two conditions. First, an employee does not know which one is safe or unsafe act whereas the other is that an employee knows safe action but does not comply with it. The first case can be easily managed by providing safety education, coaching closely and designing good work construction. However, the second case is more complicated because the reasons for acting unsafely could be due to various factors such as the worker's personality, the nature of the job being undertaken, the extent of managerial support and workgroup influence. The second case is known as "the worker's decision-to-err" in which though a worker is fully

aware that he/she is working unsafely, he/she still decides to carry on with such unsafe acts. Therefore, knowing the causes behind the decisions to act unsafely can enable construction projects to develop the appropriate strategies to improve working practices of workers (Aksorn and Hadikusumo, 2007).

According to Heinrich (1959), it is proposed that direct costs are the expenses direct to the worker who get an accident such as compensation due to absence of work and medical fees, whereas indirect costs are the other expenses. Meanwhile, Australia Safety and Compensation Council (ASCC) describes direct costs as compensation premiums paid by employers or payments to wounded or disabled employees from employees' compensation jurisdictions. On the other hand, indirect costs are explained as the providing costs of social welfare programs for wounded or disabled employees, loss of productivity, current profits, future profits and potential. The analyses of accident costs were conducted in many different aspects (Waehrer *et al*., 2007; Gavious *et al*., 2009). For example, Grimaldi and Simonds (1984) also distinguished costs into insured and uninsured costs. Insured costs might include those items covered by the corresponding insurance for damages, while uninsured costs refers to those who must be paid by the company. On the other hand, uninsured costs can be divided into various classification of accidents such as lost day cases and no-injury cases. In addition, Tang *et al*. (2004) conducted study from construction companies in Hong Kong and concluded that there were nine aspects of financial costs including costs of absence, inefficiency after resuming work, medical services and legal expenditures, time loss, damaged equipment or plant, destroyed materials or completed work, idle machinery or equipment and other expenses.

Howlett (2001) stated that every abnormal event is worth of investigation. Some require an in-depth, formal investigation whereas others can be adequately addressed with a simple, informal analysis conducted by an on-duty operator. Although, team leaders can make a decision whether a formal inquiry is warranted, without policy and appropriate training, no consistency is reporting and investigation cannot be achieved. The author further suggested that there are few elementary steps that control investigation, i.e., decide to investigate, designate investigators, gather and preserve evidence, conduct a critique, analyze the evidence, determine the causes of the event, corrects the causes of the event, document the investigation and disseminate the lessons learned from the event.

Samples and sampling technique: The study applied the purposive sampling technique to select participants. Participants of the study are 61 employees who have accidents at work. Thereby, 41 employees were collected from 2 manufacturing companies (fishnet and garment industry) and 20 employees were collected from 5 construction projects (2 luxury hotels, 2 enormous condominium, 1 modern and complex office building) of 1 company. The study was conducted from September 2015 to March 2016.

MATERIALS AND METHODS

The mixed method procedure was used for this investigation. The qualitative approach employed in-depth interview with participants as well as those involved in an accident such as manager, safety officer, colleagues and nurses to get primary data. For more complete data, the secondary data from the accident investigation record and medical services were analyzed. Then the content analysis was conducted to determine the cause of each accident and also to separate costs of each accident. Human cause refers to the event in which employees know safety conditions such as work instruction, safety act and personal protective equipment but they decide to violate them and the defective mental and physical conditions of person. Policy cause refers to the event in which a company does not provide appropriate or enough personal protective equipment as well as inappropriate work instruction which increases a chance of an accident despite worker's strict compliance. Environmental cause refers to ineffective safety device, hazardous housekeeping (material on floor, poor piling, congested aisles), defective equipment, tools or machines and improper illumination or ventilation.

On the other hand, the quantitative approach relied on Pearson Chi-square to investigate the relationship individual factor and types of accident. Based on data from Ministry of Labor, it is defined that severe accident cases are composed of dead, disability, loss of organ, leave from work >3 days whereas normal cases are only accident that make worker leave from work <3 days. Thus, the hypothesis below w developed.

- H_1: individual factors sex, nationality, working hour, educational level and safety training are associated with types of accident case

In addition, the purpose of this study is to forecast the total accident costs; therefore, the relationship between prospect antecedents and total costs were tested by Pearson correlation followed by multiple regression analysis. Hence, the hypotheses were conducted as follow.

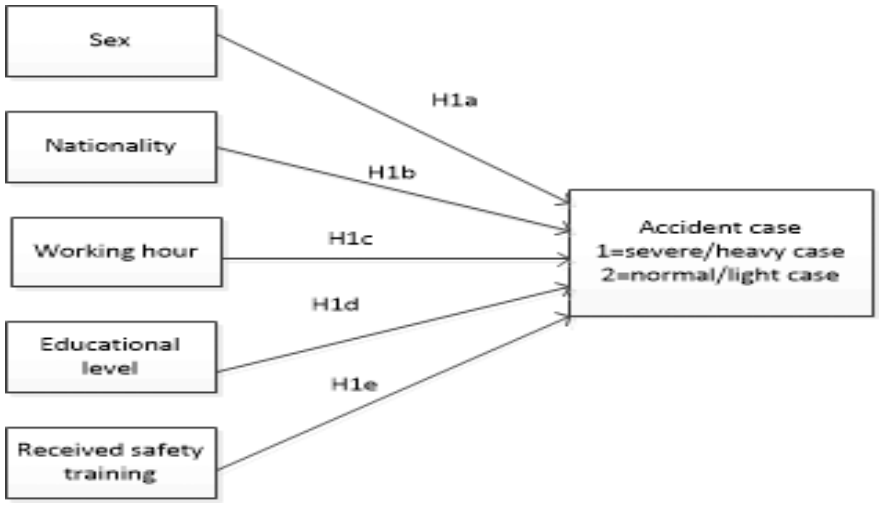

Fig. 1: Framework to test H_{1a}-H_{1e}

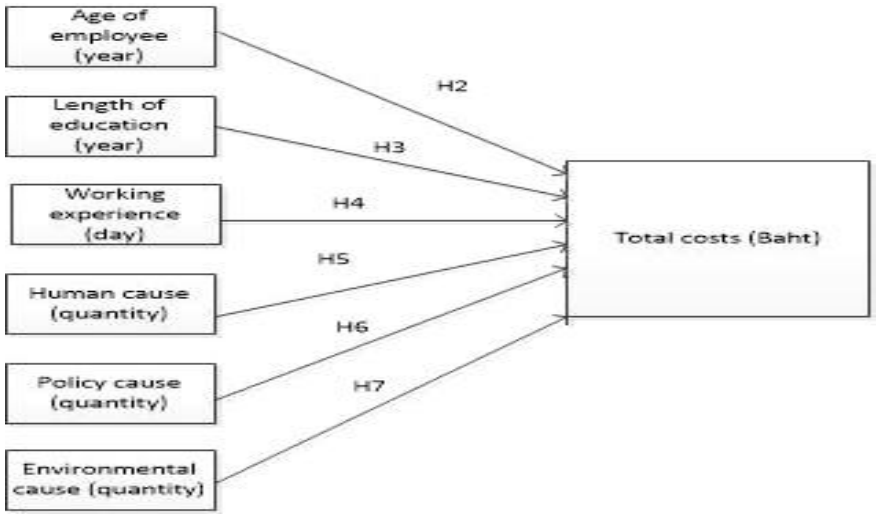

Fig. 2: Framework to test H_2-H_7

- H_2: there is a relationship between age of employee and total costs
- H_3: there is a relationship between length of education and total costs
- H_4: there is a relationship between working experience and total costs
- H_5: there is a relationship between human cause and total costs
- H_6: there is a relationship between policy cause and total costs
- H_7: there is a relationship between environmental cause and total costs

Finally, the purpose of this study is to classify type of accident; thus, equality of group member was tested by Wilks' Lambda followed by discriminant analysis. So, the hypotheses were conducted as:

- H_8: the age of employees who get severe accident is unequal to the age of employees who get normal accident
- H_9: length of education of employees who get severe accident is unequal to length of education of employee who get normal accident
- H_{10}: working experience of employees who get severe accident is unequal to working experience of employees who get normal accident
- H_{11}: the number of employees who get severe accident from human cause is unequal to the number of employees who get normal accident from human cause

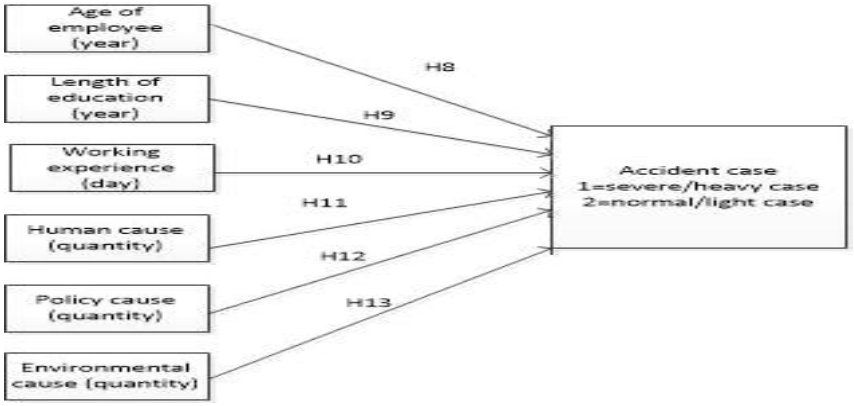

Fig. 3: Framework to test H_8-H_{13}

- H_{12}: the number of employees who get severe accident from policy cause is unequal to the number of employees who get normal accident from policy cause
- H_{13}: the number of employees who get severe accident from environmental cause is unequal to the number of employees who get normal accident from environmental cause

The theoretical framework is presented in Fig. 1-3

RESULTS AND DISCUSSION

The majority of participants are male (60.7%) with the average age of 37.95 years old and with the level of education at grade 12 and above (50.8%); most of them are Thai employees (93.4%). Besides, the average working experience for manufacturing is at 15.60 year (5694 day) whereas that of construction is at 2.02 year (737.3 day). The participants had been provided with the safety training (70.5%) and most participants get severe accident (78.7%). The results further show that females were more likely to get severe accident 1.607 times than male. The participants without safety training were more likely to get severe accident 2.750 times than who had been provided with the safety training. The participants who graduated from grade 12 and above were more likely to get severe accident 8.395 times than those who graduated from grade 9 and under. According to the results shown in Table 1 and 2, H1d was accepted.

Considering content analysis, the main factors of accidents were personal factors (70.00%), environmental factors (26.25%) and policy factors (3.75%), respectively. The costs of accidents at work were classified into 2 categories including the direct costs arising from the compensation and the medical treatment (660, 314.33 baht, 22.22%) and the indirect costs arising from the accident compensation fund, the machine maintenance costs, the transportation costs, the accident management costs and the opportunity costs (2,311,713.19 baht, 77.78%). Based on regression analysis, the results showed that there is no factor which was significantly related to the total accident costs. Based on the results, H_2-H_7 were rejected.

According to the test of equality of group member, the results show that length of education, working experience and the number of employees who have accident from policy cause are unequal in terms of severe and normal accidents. Based on the results, H_9, H_{10} and H_{12} were accepted while H_8, H_{11} and H_{13} were rejected shown in Table 3-7.

Considering the discriminant analysis, the results revealed that length of education is the most influenced factor for classifying accident case followed by work experience and quantity of worker who gets accident from policy cause, respectively. In addition, the formula for discriminant classification for severe and normal accident were as follow:

- $D_{\text{severe accident}}$ = -11.014+1.669length of education+0.000 working experience+3.670 quantity of accident occurred from policy cause
- $D_{\text{normal accident}}$ = -8.051+1.422 length of education+0.000 working experience+5.864 quantity of accident occurred from policy cause

The results show that female is more likely to get severe accident than male. This is because the majority of participants come from construction companies and fishnet companies where working hard, heavy lifting and longer working hour are common which is more suitable for male physical conditions than female. Meanwhile,

Table 1: Chi-square tests

Relationship	Values	df	Assym. Sig. (2-sided)	Exact. Sig. (2-sided)	Exact. Sig. (1-sided)
Sex accident case (H_{1a})	0.509	1	0.476	0.539	0.352
Nationality accident case (H_{1b})	2.101	1	0.147	0.196	0.196
Working hour accident case (H_{1c})	0.043	2	0.979	1.000	
Educational level accident case (H_{1d})	8.300	1	0.004	0.005	0.004
Safety trained accident case (H_{1e})	1.584	1	0.208	0.310	0.182

Table 2: Risk estimate

		95% confidence interval	
Odds ratio	Values	Upper	Lower
Odds ratio for sex (female/male)	1.607	0.434	5.957
Odds ratio for educational level (grade 12 and above/grade 9 and under)	8.395	1.672	42.160
Odds ratio for safety trained (untrained/trained)	2.750	0.543	13.920

Table 3: Test of correlations

Variables	Correlations total cost
Age of employee (H_2)	
Pearson correlation	0.104
Sig. (2-tailed)	0.424
N	61.000
Length of education (H_3)	
Pearson correlation	-0.051
Sig. (2-tailed)	0.695
N	61.000
Working experience (H_4)	
Pearson correlation	0.039
Sig. (2-tailed)	0.767
N	61.000
Human cause (H_5)	
Pearson correlation	0.074
Sig. (2-tailed)	0.572
N	61.000
Policy cause (H_6)	
Pearson correlation	-0.064
Sig. (2-tailed)	0.625
N	61.000
Environmental cause (H_7)	
Pearson correlation	0.014
Sig. (2-tailed)	0.917
N	61.000

Table 4: Tests of equality of group means

Variables	Wilks' Lambda	F-values	df1	df2	Sig.
Education	0.864	9.292	1	59	0.003
Age	0.993	0.402	1	59	0.529
Experience	0.898	6.726	1	59	0.012
Human	0.981	1.118	1	59	0.295
Policy	0.937	3.997	1	59	0.050
Environment	0.985	0.926	1	59	0.340

Table 5: Standardized canonical discriminant function coefficients

Variables	Function (1)
Education	0.595
Experience	0.444
Policy	-0.397

Table 6: Classification function coefficients

	Accident case	
Variables	Severe	Normal
Education	1.669	1.422
Experience	0.000	0.000
Policy	3.670	5.864
Constant	-11.014	-8.051

Fisher's linear discriminant functions

Table 7: Classification results

	Predicted group membership		
Accident case	Severe	Normal	Total
Original			
Count			
Severe	31.0	17.0	48.0
Normal	2.0	11.0	13.0
Percentage			
Severe	64.6	35.4	100.0
Normal	15.4	84.6	100.0
Cross-validated			
Count			
Severe	31.0	17.0	48.0
Normal	2.0	11.0	13.0
Percentage			
Severe	64.6	35.4	100.0
Normal	15.4	84.6	100.0

[a]68.9% of original grouped cases correctly classified; [b]cross validation is done only for those cases in the analysis. In cross validation, each case is classified by the functions derived from all cases other than that case, [c]68.9% of cross-validated grouped cases correctly classified

educational level at grade 12 and above is more likely to get severe accident than those with education level at grade 9 and lower. Because of humble feeling, lower graduated employees tend to pay more attention to safety than the more educated employees, who lack this feeling. In addition, higher educated employees may feel that they already know and then ignore or are less attentive in safety. The findings further show that employees who do not receive training course about safety before posited to their job are more likely to get severe accident than those who receive safety training course. Managers need to take more responsibility by providing safety education, coaching closely and designing good work construction to prevent the accident.

Moreover, the results indicate that the indirect costs are greater than three quarters of the total costs, approximately three point five times of direct costs which confirms the study by Heinrich (1959). Furthermore, the results support the previous study indicating that the main reason of accident comes from human which is known as "the worker's decision-to-err" in which though a worker is fully aware that he/she is working unsafely,

he/she still decides to carry on with such unsafe acts (Reason, 1990). Therefore, knowing the causes behind the decisions to act unsafely can enable construction projects to develop the appropriate strategies to improve working practices of workers (Aksorn and Hadikusumo, 2007).

Besides, the findings report that top organs of occupation accidents are hands and fingers which supports the results of Ministry of Labor. The second ranked organs of occupation accidents are foot and toes while Ministry of Labor indicate that the second ranked are eyes.

Most of the previous cost studies are limited to worker's compensation costs (Waehrer *et al*., 2007). Gavious *et al*. (2009) summarize the reasons for the marginalization of accident costs by managers including: managers tend to believe that most expenses are insured and therefore do not see a real reason to calculate these costs which requires data collection; the common economic approaches assume the direct and indirect accident costs as a kind of sank costs (Oi, 1974; Thaler and Rosen, 1975); measurement difficulties, overloaded managers, biased accounting methods and the low status of safety department. All of these factors place challenge for evaluating the accident costs that indirect costs which are usually also the uninsured costs, need to be evaluated carefully (Gavious *et al*., 2009) and the calculation method should include organizational, social and macro-economic parameters to overcome the narrow economic approaches adopted by many managers (Adnett and Dawson, 1998).

For most accident cost analyses, collecting data is a very difficult and complex process. Accident costs are incurred in different time periods (e.g., immediately following the accident, later, when a replacement worker takes over and on return of the injured worker after recovery); at different locations (e.g., at the site, in the field and in the office, at company head-office, in hospitals, in garages) and are handled by different organizations (e.g., the construction company, social security and private insurance companies). The components of injuries and fatality compensation are also very complex, including lump sum and weekly payments for medical, hospital and ambulance expenses, for transport and maintenance expenses, for damages and legal costs, for investigation expense, etc (Ore, 1992). Therefore, collecting data by observation on sites is not feasible because accidents are unplanned and uncontrolled events (Laufer, 1987).

The employer contribution rate of workmen compensation fund varies from 0.2-1.0% of employee wages, based on the risk rating for the type of company which is the fixed rate since the company was established until the fifth year when the funding will be changed more or less, depending on statistical record of the previous year. According to the fixed rate, the employer will not attentive to take care and reduce accident. These workplace injury costs are useful for a number of reasons. They provide a compact, comprehensive and stable measure for describing a diverse range of injuries and illnesses. They also allow us to better understand differences between incidence rates and costs of occupational morbidity and mortality and provide a baseline for future comparisons.

Although, the main reason of the accidents is described as 'dangerous behaviors of the workers', it is also well recognized that 'managerial faults' have an important effect on the accidents. In brief, ignorance, disregarding and lack of equipment which are the main reasons of dangerous behaviors, must be investigated and thus, the necessary measures must be taken in order to minimize these reasons. At this point, systematic trainings of occupational safety play a key role.

Besides, the workers must report the improper practices and obey the occupational safety rules and demand from administration to take measures. All employees have to pay attention to the use of personal protective equipment. Educational, instructional and informative occupational safety seminars which cover all topics and risks, should be conducted. Necessary interventions should be done to avoid mistakes after examining the occupational safety reports that are prepared by both company and the whole sector. Trainings should be given regularly until the workers interiorize the usage of personal protective equipment as an obligation.

Duties should not be given to a person who does not have enough expertise. Alerts and warning signs must be prepared and placed in accordance with the work type and all workers must pay attention to these signs. Necessary controls should be applied permanently in all electricity areas. Permanent measures for environment should be taken for work performed in closed areas. Personal protective equipment should be defined and classified according to the work and materials.

The findings confirm that accidents can occur from any situation. When an accident does occur, it is an indication that someone along the line has not done a good job of accident prevention and unsafe acts, so unsafe conditions have been created. The supervisor or safety officer will need to have a working knowledge of the fundamental steps that need to be taken to ensure effective control of the contributing causes of accidents.

LIMITATIONS

Several potential limitations were expected in this study. The first limitation is the effect of extraneous variables which may affect the companies' safety policy such as macroeconomics and economic crisis. Second, the data collection of the study involves two types of industries which may not be corresponding with other industries. The final limitation is the behaviors and conditions of Thai employees which may not be corresponding with foreign employees.

CONCLUSION

Based on regression model, the results showed that there is no factor that was significantly related to the total accident costs. The findings confirmed that accidents can occur from any situation. When an accident does occur, it is an indication that someone along the line has not done a good job of accident prevention and unsafe acts and unsafe conditions have been created. The supervisor or safety officer needs to have a working knowledge of the fundamental steps that need to be taken to ensure effective control of the contributing causes of accidents.

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