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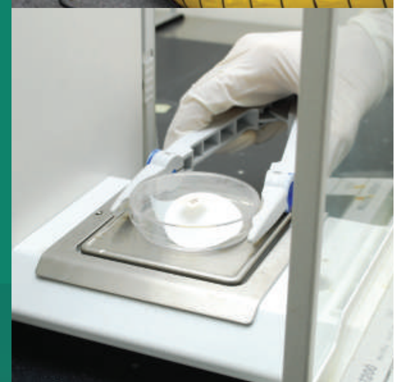

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National Institute of Occupational Safety and Health (NIOSH)
Ministry of Human Resources Malaysia

Journal of Occupational Safety and Health

The Journal

- Aims to serve as a forum for the sharing of research findings and information across broad areas in Occupational Safety and Health.
- Publishes original research reports, topical article reviews, book reviews, case reports, short communications, invited editorial a nd letters to editor.
- Welcomes articles in Occupational Safety and Health related fields.

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Introducing the Journal of Occupational Safety and Health

The National Institute of Occupational Safety and Health (NIOSH) is delighted to announce the publication of Journal of Occupational Safety and Health.(JOSH).

JOSH is devoted to enhancing the knowledge and practice of occupational safety and health by widely disseminating research articles and applied studies of highest quality.

JOSH provides a solid base to bridge the issues and concerns related to occupational safety and health. JOSH offers scholarly, peer-reviewed articles, including correspondence, regular papers, articles and short reports, announcements and etc.

It is intended that this journal should serve the OSH community, practitioners, students and public while providing vital information for the promotion of workplace health and safety.

Apart from that JOSH aims:

• To promote debate and discussion on practical and theoretical aspects of OSH

• To encourage authors to comment critically on current OSH practices and discuss new concepts and emerging theories in OSH

• To inform OSH practitioners and students of current issues

JOSH is poised to become an essential resource in our efforts to promote and protect the safety and health of workers.

From the Editor in Chief

Workplace safety is a priority. Much needs to be done to encourage employees, employers and industries to put occupational safety and health at the top of their agenda. The most important thing is our commitment in taking action; our commitment to make the necessary changes to ensure that safety is at the forefront of everyone's thinking.

The Journal of Occupational Safety and Health, (JOSH) the first to be published in Malaysia, aims to boost awareness on safety and health in the workplace.

It is no longer sufficient to simply identifying the hazards and assessing the risks. We aim to increase understanding on the OSH management system. We aim to strengthen commitment to workplace safety and better working conditions. We believe these aims can be achieved through participations and involvement from every industry.

We hope the contents of the journal will be read and reviewed by a wider audience hence it will have a broader academic base, and there should be an increased cumulative experience to draw on for debate and comment within the journal.

It is our hope that the journal will benefit all readers, as our purpose is to serve the interest of everybody from all industries. Prime Focus will be on issues that are of direct relevance to our day-to-day practices.

I would personally like to take this opportunity to welcome all our readers and contributors to the first issue of the journal. I look forward to receive contributions from the OSH community in Malaysia and elsewhere for our next issues.

Ir. Hj. Rosli Bin Husin
Editor-in-chief

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Conceptualization of Safety Leadership in Malaysia's Manufacturing Companies.

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Abstract

In the new global economy, workplace safety has become a central issue among companies all over the world. It is becoming difficult to ignore that this trend has also been happening in Malaysia especially the manufacturing sector. The worrying trend can be seen from the increasing number of workplace accidents reported by Department of Occupational Safety and Health (DOSH), Malaysia in manufacturing companies. In recent years, researchers have shown an interest in studying the role of safety leadership to reduce workplace accidents. It is found that safety leadership plays a significant role in ensuring a safe and sound workplace. Due to this concern, this paper attempts to provide a conceptualization of safety leadership from the perspective of Malaysia's manufacturing sector. It is proposed that positive safety leadership lead to a reduction of workplace accidents. In response to this matter, it is hypothesized that the higher level of safety leadership will positively affect the lower level of workplace accidents. A questionnaire from Wu *et al.* (2008) will be adopted to explain the conceptualization of safety leadership, where it is expected that the concept of safety leadership practised in Malaysia's manufacturing sector has a similar meaning from the perspective of western researchers.

Keywords: Safety leadership; Workplace accidents, Malaysia's Manufacturing Sector

Introduction

In this era of globalization, almost all of the world's countries are in pursuit of development (Tharaldsen *et al.*, 2010). The advancement of technologies all over the world has led to the raising awareness of peoples towards safety issues (Li *et al.*, 2009), and as a result, has made workplace safety issues headline news all over the world (Wameedh *et al.*, 2011). For example, accident statistics have reported as many as 591000 cases of non-fatal injuries in the years 2011/2012 in the United Kingdom (Health and Safety Executive, 2012a). In addition, the United States recorded 760000 workplace accidents during 2011 (U.S. Bureau of Labor Statistics, 2012). Based on Health and Safety Executive (2012b), there is a decreasing trend in workplace accidents in United Kingdom. However, the total number of reported cases of workplace accidents is not reassuring. In light of these numbers, issues concerning safety have become a central issue for many safety researchers (Choudhry *et al.*, 2009; Wameed *et al.*, 2011; Shang and Lu, 2009).

Overview of Safety

Accidents have been defined as the events which are unwanted, unplanned and unforeseen, resulting in the loss of cost, and even life (Alicia, 2009). Efforts to overcome workplace accidents taken to inhibit accidents from happening and improve workplace safety (Wu *et al.*, 2007). A number of studies have been conducted on safety, beginning from 1990s (Kennedy and Kirwan, 1998; Hofmann and Morgeson, 1999) until 2000s (Wu *et al.*, 2007; Wu *et al.*,, 2008; Fernandez-Muniz *et al.* 2007;Cooper and Phillip, 2004 ; Tam *et al.*, 2004), and finally, 2010s (Kapp, 2012; Lu and Yang, 2010). In this paper, safety leadership shall be discussed as it was proposed by Griffin and Hu (2013) that there is a lack of studies on specific actions required of leadership for their contribution in workplace safety.

Workplace Accidents in Malaysia

Years by years, Malaysia has developed and climbed to its robust position in the new global economy despite the challenges regarding safety issues (Ministry of Human Resources Malaysia, 2009). In reference to Figure 1, the accident rate was actually experiencing a downward trend from year 2000 to year 2011 (2000= 98281 cases; 2003= 81003 cases; 2006= 68008 cases; 2008= 56095 cases; 2011= 24290 cases) (Department of Safety and Health, 2012; Social Security Organization, 2011). Nevertheless, total accidents from year 2011 to year 2012 experienced an upturn trend, boosted from 24290 cases to 61552 cases (Department of Safety and Health, 2013).

While the total accident cases in Malaysia illustrated a downturn trend, there is a controversy when the focus swift to the sector of manufacturing. Based on the evidences, manufacturing sector reported an increased number of accidents from 2002 until 2012 (2000= 43.67%; 2003= 41.85%; 2006= 39.80%; 2008= 33.94% ; 2011=67.89%; 2012= 27.1%). Referring to Figure 1, it can be clearly seen that among all of the sectors, manufacturing sector recorded the highest numbers of accidents compared to the other sectors in Malaysia (Department of Safety and Health, 2013). Therefore, there is a need to identify the problems of safety issues within manufacturing sector in Malaysia (Social Security Organization, 2011).

Safety Leadership and Its Relations to Workplace Accidents

Safety leadership can be defined as the process through which the leaders exert their influence on employees' daily routine work via communication to achieve a low accident rate and a positive safety performance (Lu and Yang, 2010; Wu *et al.*, 2007). Previous studies (Barling *et al.*, 2002; Zohar, 2002; Hofmann *et al.*, 2003) showed that leadership practice is a vital factor influencing the accident rates. It has become the centre of attention for studies in numerous industries especially in energy and manufacturing sectors (Flin and Yule, 2004; Rowley, 2009). Cooper (2010) concluded that safety leadership is a necessity for top performing companies in shaping commitment towards safety issues as safety leadership plays a vital role in maintaining the behavioural safety process. According to Mullen et al. (2011), safety leadership is far more effective in shaping positive safety behaviour and attitudes through inspiring and promoting. Thus, it is hypothesized that the higher is the safety leadership in the organization, the lower is the accident rate in the organization.

Previous studies have investigated the relationship between safety leadership and safety performance and have reported that there is significant influence of safety leadership on safety performance (Lingard et al., 2012; Yang et al., 2010; Zohar, 2002; Rowley, 2009). Wu (2005) proposed that, leaders with efforts to coach and trained their employees regarding safety issues formed a great safety performance. Thus, it was recommended that safety caring and safety controlling be included in safety leadership. Wiegand (2007) explained that safety coaching refers to the efforts of leaders in managing the safety performance and that these efforts involve interpersonal interactions and communication. Safety caring refers to the level of concern and attention amongst leaders towards safety issues and involves efforts to ensure the quality of safety in the workplace (Wu et al., 2010; Cooper, 1998). Both Wu et al. (2008) and Cooper (1998) proposed that safety controlling is the use of power in outlining the safety rules and regulations to be complied with by the employees in order to achieve safe performance.

Throughout the years, it can be seen that safety leadership has always been based on transformational and transactional leadership model in engaging the dimensions. For example, Cooper (1998), in initiating the dimensions of safety leadership, chose to build the dimensions from the foundation of transformational and transactional leadership. Ultimately, primary dimensions of safety leadership, safety caring (transformational) and safety controlling (transactional) had been proposed. Extending from Cooper's (1998) dimensions, Wu (2005) introduced an additional dimension under transformational leadership, safety coaching, without abandoning the original dimensions initiated by Cooper (1998). Nonetheless, while Wu (2005) named her safety dimensions as safety caring, safety coaching,

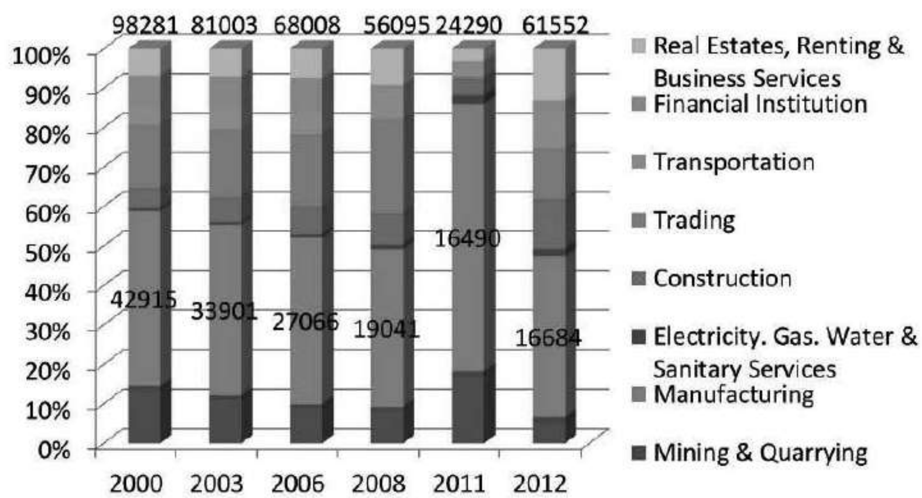

Figure 1: Workplace Accidents in Malaysia, 2000 to 2012 (Department of Safety and Health, Malaysia, 2013

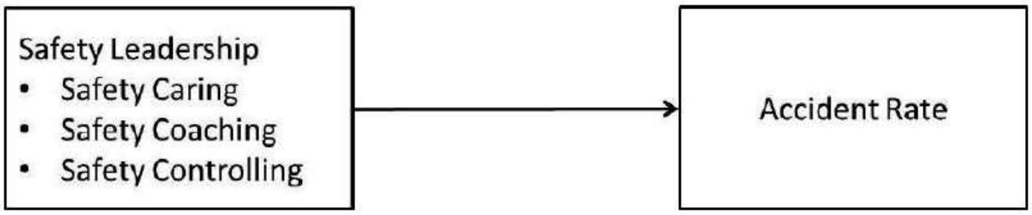

Figure 2: Framework

H1: the higher level of safety leadership will affect the lower level of workplace accidents.

and safety controlling, there had been some situations when other scholars would have revised the names of such dimensions to other labels while retaining the meanings of each dimension at the same time. There situations occurred when Lu and Yang (2010) and Du and Sun (2012) renamed Wu's (2005) safety caring as safety motivation and active management respectively, and Wu's safety coaching as safety policy and safety monitoring respectively.

Subsequently to the review of dimensions, Wu's (2005) versions of safety caring, safety coaching, and safety controlling were chosen in this study as it could be generalized to most of the industries (Shah Rollah Abdul Wahab, 2011). Thus, the conceptual framework of this study was developed.

Research Methodology

This research shall be a quantitative type. According to Creswell (2002), a quantitative research refers to research that measures causal relationships, hypothesis testing, and theoretical testing using survey as data collection instrument. Creswell (2002) further proposed that quantitative research should be used in research which contains a large amount of statistical data. Furthermore, the design of this research is descriptive and correlational in nature. Elifson (1998) proposed that descriptive study describes the characteristics of the desired trends or situations. Descriptive study helps the researcher understand the phenomena and inter-correlation between the variables (Sekaran and Bougie, 2009). Correlational study has been defined as a technique that is able to describe and measure the links and relationships between two variables statistically (Gravetter and Wallnau, 2002).

Respondents of this study will be employees from the iron and steel based manufacturing companies chosen from the Federation of Malaysian Manufacturers (FMM) directory. The main reason for selecting these industries is that the number of accidents which occur in these industries is the highest among all the other manufacturing industries, with an accident occurring every two working hours in Malaysia in 2011 (Social Security Organization, 2011).

In this research, it is apparent that the questionnaire is an adaptation of questionnaires by Wu *et al.* (2008). In order to measure safety leadership, the Safety Leadership Scale developed by Wu *et al.* (2008) shall be adopted. Meanwhile, adoption of Wu *et al*.'s (2008) Safety Performance Scale shall be adopted to explore the findings. The adoption of Wu et al.'s questionnaires in the measurements of independent variables, dependent variable, and also mediation is due to the proven high reliability of the questionnaires (Alpha Cronbach: 0.84 to 0.97) (Shah Rollah, 2011; Wu *et al*., 2008).

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Oxidative stress levels among workers in two shift work systems at stainless steel plants

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Abstract

We investigated oxidative stress levels among plant workers according to two different shift systems to examine the health effects of shift work. The subjects worked at stainless steel plants of a major steel company in China. Fifty-five crane operators in the refining department worked in a three-shift (3-shift) system, and 40 inspectors of a water-treatment facility in the water management department worked in a two-shift (2-shift) system. Spot urine samples were collected at the beginning and the end of the second day of each shift. The urinary 8-hydroxy-2'-deoxyguanosine level (U8-OHdG) as an oxidative stress marker was measured by HPLC using two step separations. U8-OHdG was further adjusted by urinary creatinine content (Ucre8-OHdG) to correct for the urinary flow variation. Longitudinal data of the Ucre8-OHdG was analyzed, using a linear mixed model of circadian base level effects and shift effects as the fixed effects, and age, BMI, and smoking habit as confounding variables. There was no significant difference between the two shift groups in the Ucre8-OHdG at the beginning of the day shift and at the end of the night shift. A significant circadian base level effect and a day shift effect were observed in the 3-shift group, while no significant effects were found in the 2-shift group. The present data suggest that there was a circadian variation of the U8-OHdG among the plant workers in the three-shift system, but not in the two-shift system.

Keywords: Shift work; Circadian rhythm disturbance; Stainless steel refining; Oxidative stress; 8-OHdG; Linear mixed model

Introduction

Shift work is common for plant workers in the steel industry. In Japan, 64% of companies in the steel industry use some sort of shift work (Japanese Ministry of Health, Labour and Welfare 2005). Sleepiness, insomnia, fatigue, cognitive impairment and digestive troubles have been discussed as major health effects caused by shift work due to disrupted circadian rhythms (Costa, 2003). Recent studies have focused on cancer as a possible consequence of shift work, as well as cardiovascular and metabolic disorders (Takahashi, 2014). Although the mechanisms remain undetermined, it has been proposed that the disturbance and suppression of anticancer and antioxidant melatonin production are linked to the increased risk of female breast cancer (Costa, Haus, & Stevens, 2010). Melatonin directly or indirectly protects cells from DNA damage by carcinogenic agents through its ability to act as a free radical scavenger (Reiter, 2004), and it exerts an anti-estrogenic effect via interaction with the estrogen receptor ER α (Collins et al., 2003). Immune suppression has also been shown to be related in part to melatonin depression (Carrillo-Vico, Guerrero, Lardone, & Reiter, 2005).

Oxidative stress is known as a risk factor for age-related chronic diseases, such as atherosclerosis and cardiovascular diseases (Madamanchi, Vendrov, & Runge, 2005), neurodegenerative diseases, including Parkinson's disease and Alzheimer's disease (Uttara, Singh, Zamboni, & Mahajan, 2009), and for carcinogenicity induced by DNA damage (Halliwell, 2007). Oxidative stress also intervenes in the process of immune suppression induced by exposure to stress or stress agents (Ercal et al., 2000; Uzma, Kumar, & Hazari, 2010). Because of its broad spectrum of adverse effects, measurements related to oxidative stress levels are widely used for surrogate health indexes (Dalle-Donne, Rossi, Colombo, Giustarini, & Milzani, 2006).

It is recognized that health problems among shift workers are in some way related to increased oxidative stress levels (Faraut, Bayon, & Léger, 2013), although only limited data is available in relation to variations within a shift and over a shift cycle. Also, few studies have examined the differences in oxidative stress levels between different shift systems, i.e., three-shift (day, evening, and night) and two-shift (day and night) systems. We thus investigated oxidative stress levels according to shift work among three-shift and two-shift workers at stainless steel plants.

Methods

Subjects

The subjects were male workers at stainless steel plants of a major steel company in China. There were two kinds of shift system: three-shift (3-shift) and two-shift (2-shift) systems. The 3-shift group worked in the crane operating sections in the refining department, and the 2-shift group worked in the inspection sections in the water management department. 55 crane operators and 40 water-treatment facility inspectors were enrolled in the study after obtaining their informed consent. This study was approved by the Ethic Committee of the National Institute of Occupational Safety and Health, Japan, and Shanxi Medical University.

Shift schedules

The 3-shift system started with two consecutive day shifts from 8:00 to 16:00 followed by two evening shifts from 16:00 to 0:00, a day off, and then two night shifts from 0:00 to 8:00, ending with another day off. The 2-shift system started with one day shift from 8:00 to 20:00 followed by one night shift from 20:00 to 8:00, and ended with a day off.

Work tasks

The crane operators worked in a movable operating house 25m above the floor level, seated in a cockpit while engaged in crane operation. The operation included transferring a ladle filled with melted steel from the furnace to the refining facilities and installing it there, and transferring the ladle after the refining and pouring the contents into a tundish in front of the inlet ports of continuous cast facilities. The operation required a high level of technical skill to maintain safety. The operators usually stayed in the operating house above the production line, but they occasionally came down to check the situation of the production line for a short period of time during the working hours or walked by the line when moving. They wore a protective respiratory mask whenever they went out of the operating house.

Inspectors at the water management department visited the pump sections and water treatment sections on a routine basis and inspected the water treatment and acid treatment facilities. Those facilities were in different buildings from the refining facilities.

Procedure

We evaluated the time course of the oxidative stress levels among the workers at the shift changes in the 3-shift and 2-shift systems. Spot urine samples were collected at the beginning and the end of the second day of each shift in the 3-shift system, and at the beginning and the end of the first day of each shift in the 2-shift system. Aliquots containing the urine were transferred to 1.5 ml tubes protected from UV light and were stored at -80ºC until measurement. Basic information such as age, work history, smoking habit, height, and weight was collected by a self-administered questionnaire.

The concentrations of 8-hydroxy-2'-deoxyguanosine (8-OHdG) in urine (U8-OHdG) as a marker of oxidative stress were measured by high-performance liquid chromatography (HPLC) using two step separations, as described elsewhere (Kasai, 2003). In short, each urinary sample was defrosted and diluted with a solution containing the ribonucleoside marker 8-hydroxyguanosine (8-OHG). The mixed solutions were stored in a refrigerator at 4ºC for 2 hours, then centrifuged at 13,000 rpm for 5 min. Each supernatant was used for the analysis. The 8-OHdG fraction from the first stage separation was collected based on the 8-OHG peak. The fraction was further separated by second stage separation, and the 8-OHdG was detected by a Coulochem II electrochemical detector (ESA) with a guard cell (5020) and an analytical cell (5011). The samples were usually analyzed in triplicate and the mean values were used for further analysis.

Urinary creatinine concentration (UCre) was analyzed by the following method: creatinine is enzymatically metabolized to produce hydrogen peroxide, which produces quinone that can be measured by a spectrophotometer (PUREAUTO S CRE-L; Daiichi Pure Chemicals Co.). U8-OHdG was further adjusted by urinary creatinine content (Ucre8-OHdG) to correct for the urinary flow variation.

Statistical analysis

T-test or chi-squared test was used for group mean comparisons. Correlation coefficient was tested by a normal distribution test after z-transformation. For the time series data, the measurements of serial urine samples from each subject were considered as repeated measures and analyzed using a linear mixed model with unstructured covariance structure. In this study, circadian base level effects (Ls) and shift effects (Es) were treated as fixed effects (Table 1a and 1b). Subject was entered as a random effect. Other variables of age, body mass index (BMI), and smoking habit were included as confounders. Statistical analyses were performed with SPSS 17.0 J for Windows.

Table 1a. : The linear mixed model for analyzing the 3-shift group

		Circadian base effects			Shift effects		
		Day	Evening	Night	Day	Evening	Night
Shifts		L1	L2	L3	E1	E2	E3
Day	Beginning (8:00)	0	0	0	0	0	0
	End (16:00)	0	0	0	1	0	0
Evening	Beginning (16:00)	0	1	0	0	0	0
	End (0:00)	0	1	0	0	1	0
Night	Beginning (0:00)	0	0	1	0	0	0
	End (8:00)	0	0	1	0	0	1

Table 1b. : The linear mixed model for analyzing the 2-shift group

		Circadian base effects		Shift effects	
		Day	Night	Day	Night
Shifts		L4	L5	E4	E5
Day	Beginning (8:00)	0	0	0	0
	End (20:00)	0	0	1	0
Night	Beginning (20:00)	0	1	0	0
	End (8:00)	0	1	0	1

Table 2. : Characteristics of the 3-shift and 2-shift groups

		3-shift (n=42)		2-shift (n=37)	
		Mean	SD	Mean	SD
Age (years old)		38.12	5.95	38.73	5.70
Work duration (years)		18.62	7.44	12.43	6.36
BMI (kg/m^2)		26.27	6.58	23.94	3.67
Smoker (n)		33		29	
Ucre8-OHdG (µg/g creatinine)	Beginning of day shift (8:00)	4.28	1.31	4.07	1.29
	End of night shift (8:00)	4.62	1.19	3.87	1.14

Table 3. : Correlation coefficients between UCre, U8-OHdG, and Ucre8-OHdG

	U8-OHdG	Ucre8-OHdG
UCre	0.829**	-0.348**
U8-OHdG		0.119*

** p<0.01, *p<0.05

Table 4. : The results by the linear mixed model on the 3-shift group

	Mean	SD	df	F	p
Intercept	11.562	2.501	1/38.8	25.48	<0.001
L2	0.721	0.342	1/41	4.45	0.041
L3	0.464	0.387	1/41	1.43	0.238
E1	0.641	0.291	1/41	4.83	0.034
E2	-0.198	0.285	1/41	0.48	0.491
E3	-0.400	0.244	1/41	2.68	0.109
Age	-0.087	0.051	1/38	2.83	0.100
BMI	-0.092	0.047	1/38	3.73	0.061
Smoking habit	-0.206	0.754	1/38	0.07	0.786

Results

The characteristics of the 3-shift and 2-shift groups are shown in Table 2. Ucre8-OHdG did not differ significantly between the two groups of shift workers at the beginning of the day shift (8:00) or at the end of the night shift (8:00). There were no differences between the two groups in age, working duration, BMI, or smoking habit.

The correlation coefficients between UCre, U8-OHdG, and Ucre8-OHdG are shown in Table 3. The correlations between U8-OHdG and UCre and also between Ucre8-OHdG and UCre were statistically significant, but the level of the association was less in the latter. These data indicated the validity of using the creatinine-corrected values.

Longitudinal data analyses using the linear mixed model showed that the circadian base level effect in the evening shift (L2) and the day shift effect (E1) were significant in the 3-shift group (Table 4). Neither circadian base level effect nor shift effect was significant in the 2-shift group.

Discussion

In this study, the base level of Ucre8-OHdG was elevated in the evening shift, and the level increased from the beginning to the end of the day shift in the 3-shift group. By contrast, no significant effects were found in the 2-shift group.

An interview with the safety and health manager revealed that the studied plants were running continuously during 24 hours and the work pattern and work load were similar across the different shifts. Therefore, the circadian rhythms and some factors unrelated to the work load appeared to be important factors relevant to the present findings. In light of the normal physiological rhythms and U8-OHdG rhythm, the time 16:00 at the end of the day shift and at the beginning of the evening shift in the 3-shift group might nearly coincide with the circadian peak time (18:00). However, the time 8:00 at the beginning of the day shift and at the end of the night shift in the 3-shift group corresponded to the time period just after the nadir of the circadian rhythms (Åkerstedt, 2003; Kanabrocki et al., 2002). It is thus assumed that normal circadian effects remained for workers in the 3-shift system.

It is not possible here to give a reasonable explanation about the results in the 2-shift group, but it is likely that the amplitude of the circadian rhythm in this group was lower than that in the 3-shift group, which might reflect some circadian disruption. This view may be supported by the difference in night shift exposure between the two shift systems. Specifically, the monthly exposure to night shifts was higher in the 2-shift system (120 hours) than in the 3-shift system (56 hours). In addition, the night shift interval in a shift cycle (i.e., time off between the last night shift and the next night shift) was shorter in the 2-shift system (2 days) than in the 3-shift system (6 days). These features are unfavorable for healthy shift schedules (Stevens et al., 2011).

There is no consensus that there is a difference in health effects between 3-shift and 2-shift systems (Ferguson & Dawson, 2012). Even more, most previous studies on oxidative stress level compared day workers with shift workers and did not analyze the inter-shift relationship (Gromadzinska et al., 2013; Kasai et al., 2001). An investigation of hospital nurses compared oxidative stress levels between shifts, i.e., day shift (8:00-16:00) vs. night shift (16:00-8:00), and found that the oxidative stress level increased at the end of a day shift or a night shift, and its level was higher for the night shift group (Ulas et al., 2012). It should be noted, however, that the shift pattern was different from the patterns in this study. Given such sparse evidence, we consider it quite difficult to explain by 3-shift schedule alone the increase in Ucre8-OHdG at the end of the day shift and its base level in the evening shift.

We need to discuss the characteristics of the work tasks that the 3-shift and 2-shift workers performed. In terms of the amount of physical activity required by their tasks, the 3-shift crane operators spend a longer time sitting, and their energy consumption would be less than that of the 2-shift water facility maintenance workers. These differences might account for the lower levels of oxidative stress in the crane operators (Kasai et al., 2001; Loft, Astrup, Buemann, & Poulsen, 1994). An increase in mental stress is reported to elevate oxidative stress (Irie, Asami, Nagata, Miyata, & Kasai, 2001), and the 3-shift crane operators have to pay more sustained attention than the 2-shift counterparts, because near misses and errors due to poor attention can cause delays in processing time and may also cause serious accidents. The two above-mentioned factors – less energy consumption but more mental stress – will produce opposite influences on the oxidative stress level. The present results of higher levels of oxidative stress in the 3-shift crane operators, however, would favor the possibility of the relative importance of mental stress.

Another difference in work-related factors between the 3-shift and 2-shift groups may be associated with the potential exposure to metals, which mainly include nickel and chromium as the major contaminants in stainless steel, but we are not able to show an association between metal exposure and U8cre-OHdG in this study. Although a few studies have reported an association between metal exposure and oxidative stress in residents (Merzenich et al., 2001) and child workers (Sughis, Nawrot, Haufroid, & Nemery, 2012), we have not found any attempts to reveal a relationship between the timing of metal exposure and oxidative stress. A more precise study that considers the exposure time course is needed for further understanding of this issue.

In conclusion, the results of this study suggest that there was a circadian variation of the U8-OHdG in plant workers in the 3-shift system, but not in the 2-shift system. More study should be performed by using carefully selected shift workers that the work load and job title are equal, and only shift schedule (cycle) is different.

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Work-related Carpal Tunnel Syndrome among computer users – a review of the associated risk factors and intervention strategies

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Abstract

Work-related musculoskeletal disorders of the upper limb (WRMSDs-UL) account for one of the largest types of occupational disorders worldwide. This broad term includes several disorders, such as carpal tunnel syndrome, tendonitis, tension neck syndrome and lateral epicondylitis (tennis elbow) which are generally caused by poor postures, repetitive strain and psychosocial factors. Various workplace interventions have been investigated and employed to prevent the different WRMSDs-UL, but a common consensus to address the problem has yet to be achieved. This paper reviews and discusses the efficacies of some interventions which have been tested for the most prevalent type of WRMSDs-UL, carpal tunnel syndrome (CTS). The focus will be on computer users who developed CTS out of the prolonged and repetitive use of keyboards and pointing devices. The interventions studied include engineering design, management strategies, personal development, medical treatment and multi-dimensional approaches. Outcome of the study reveals that the most effective approach would be one that is multi-dimensional in nature, with the inclusion of at least two or more intervention strategies at the same time.

Keywords: Work-related musculoskeletal disorders; carpal tunnel syndrome; computer workers; intervention strategies

Introduction

Musculoskeletal Disorders (MSDs) refer to the stress, pain or discomfort that affects mainly the back, neck, shoulders and limbs (Putz-Andersen, 1988). MSDs can be attributed to work or non-work related factors. It can also be a result of previous injuries, fracture, accidents or existing ill-health conditions. WRMSDs-UL are significantly associated with physical, psychological and sociological factors present at the work place. They are defined as the subset of MSDs that arise out of the occupational exposures that may lead to work restriction, work-time loss or consequently cause work leave (Forde et al., 2002). Non-work related factors of WRMSDs-UL include age, gender, anthropometric characteristics, hobbies, sports or recreational activities and smoking habits (Aptel et al., 2002). In general, WRMSDs-UL are usually symptoms that are reported by the patient and diagnosed by occupational health specialists on a case-by-case basis. They are considered to be one of the biggest health problems facing contemporary workforces (Reilly, 2002). In Europe alone, a quarter of the adults are affected by long-standing WRMSDs-UL that limits everyday activities (Glover et al., 2005). In the United States, the number represents in excess one-half of all work-related diseases, or about 3.7% of the total population (Ong et al., 1995; Brininger et al., 2007).

WRMSDs-UL comprise of various conditions both clinically defined with recognized risk factors and well established medical management such as carpal tunnel syndrome, tendonitis, tension neck syndrome and lateral epicondylitis (tennis elbow), and clinically undefined ones, such as those that usually affect the nerves, tendons, muscles and support structures in general. Of the clinically defined ones, carpal tunnel syndrome (CTS) is at present, the most commonly encountered entrapment neuropathy causing disability (Lincoln et al., 2000; Mondelli et al., 2002). It a progressively painful hand and arm condition that takes place when the median nerve, which runs from the forearms to the palms, becomes compressed at the wrists (Palmer, 2011). Typical symptoms include numbness, tingling or burning pain in the wrists, nocturnal pain and paresthesia (Katz et al., 1991). Weakness and abduction of the thumb and thenar atrophy can also be found in severe CTS cases (Chen et al., 2003). It also causes clumsiness in the hands and the loss of dexterity. Many sufferers face disturbed sleep at night due to pain, and they often hang their hands at the sides of the beds to gain relief. If left untreated, CTS may cause permanent damage to the median nerves and result in the loss of hand function (Brininger et al., 2007).

The clinical diagnosis of CTS is usually carried out via provocative testing and electrodiagnostic studies such as the Nerve Conduction Velocity (NCV) and electrophysiological tests (Lai et al., 2004). Some tests are based on clinical symptoms and signs (Von Schroeder & Botte, 1996) involving Tinel's (percussion over the flexor retinaculum) and Phalen's (sustained complete flexion of the wrist for a minute or so) tests, both of which are noted to be accurate and sensitive assessments (Field et al., 2004; Palmer, 2011). Their sensitivities range from 25-67% for Tinel's sign, and 48-85% for Phalen's test, and specificities range from 59-94% and 55-89% respectively (Gellman et al., 1986; DeKrom et al., 1990). Among the tests above, the most frequently performed ones are the NCV test (85.7%), followed by Tinel's sign (58.1%) and Phalen's test (16.9%), (Lai et al., 2004). The most reliable and accurate test is however, the electrophysiological test, which is viewed as the gold standard for the diagnosis of CTS (Royal College of Physicians, 2009). Choosing the type of test and diagnosis largely depends on the physician and its applicability with a particular patient.

The risk factors that cause CTS can be classified into three broad categories which involve personal, occupational and psychosocial factors (NIOSH, 1997). Personal risk factors include age, gender, hand anthropometrics, underlying health problems such as obesity, arthritis and hypertension and previous wrist injuries or fracture. Occupational risk factors involve the interaction of the worker with the physical work environment that include awkward postures, static or repetitive movements, force or pressure applied, using vibrating tools, working in cold environments and lack of rest and recovery (NIOSH, 1997; Boz et al., 2004). Psychosocial factors include stress, interpersonal factors, deadlines, discomfort, job demands and job satisfaction. Recently, it is believed that genetics also play a role in causing CTS, as genes determine the anthropometrics of an individual (Lozano-Calderon et al., 2008).

Over the years, there has been much debate on the primary cause of CTS, as to whether it is occupationally or personally caused. Research has revealed that the former plays a major role in the development of CTS, with an average occurrence of more than 66% (Lincoln et al., 2000; Lozano-Calderon et al., 2008). Although some authors have questioned the relationship between CTS and WRMSDs-UL (Hadler, 1987; Nathan et al., 1992), there is abundant evidence today of a strong relationship between CTS and work-related factors (Martin, 1991; Beck-Foehn, 1992; Armstrong et al., 1993; Silverstein et al., 1998; NIOSH, 1997; Burt & Hales, 1999; Lincoln et al., 2000; Kumar & Fagarasanu, 2003; Wu et al., 2003; Huisstede et al., 2010a). The present research work discusses occupational risk factors caused by computer usage that lead to the development of CTS. Along with that, an analysis of the various intervention strategies that have been employed and their efficacies in addressing the problem will be discussed. The primary focus of this study will be on the multi-dimensional intervention strategy, which involves a more comprehensive approach in tackling the problem. Each element under the umbrella of the multi-dimensional approach strategy will be discussed separately, with a conclusion given in the end.

CTS due to computer usage

Typing on a computer keyboard and using pointing devices such as the mouse and trackball are activities that involve pressure, repetition, vibration and sustained posture. It is known that the position of the hands and wrists while using keyboards and pointing devices can elevate carpal tunnel pressure (CTP), causing pain and injury (Keir et al., 1998). In normal tissues, the resting pressure of the upper limbs is approximately 8 mm Hg (Watts & McEachan, 2006). With CTS, the pressure in the carpal tunnel increases to above 10 mm Hg and can rise to about 90 mm Hg for severe cases (Gelberman et al., 1981; Okutsu et al., 1989; Thomsen et al., 2008).

The main problem with the use of keyboards is their height and degree of tilt, which is often above elbow level (Sauter et al., 1991). Studies have found that the larger the wrist angle (20° and greater) when typing on the keyboard, the higher the risk of developing CTS (Chen et al., 2003). And when the arm and wrist are not horizontal (not in neutral position), it causes the CTP to rise to over 40 mm Hg, which falls in the CTS risk range. Besides that, the location of the alphabets and numbers also play a role in causing discomfort to the fingers and hands as some fingers become overworked and some too little (Kumar & Fagarasanu, 2003). Because force is applied when typing, the key-switch force and key travel distance become important CTS risk factors as well.

Pointing devices are frequently used these days for keying in data, internet browsing, performing word processing activities, using spreadsheets, drawing and creating graphics. Research studies have found that just by placing the hands on the mouse, the CTP is increased by 13 mm Hg (Kumar & Fagarasanu, 2003). Pressure is then further increased by pointing (28 mm Hg), and dragging (33 mm Hg). Besides that, double-clicking also causes significant amounts of increase in CTP (Laursen & Jensen, 2000). Women and the elderly (60 to 70 years of age) are more susceptible to CTS caused by prolonged use of the mouse due to higher ulnar deviation, wrist velocities, range of motion and percentage of maximum force applied (Wahlstrom et al., 2000). Similar observations were made with the use of the trackball (Burgess-Limerick et al., 1999). An interesting finding is that most people develop CTS on their arms and hands that operate the mouse or trackball, indicating that pointing devices are a greater contributory factor towards CTS when compared to the keyboard. The reason is because in most applications, pointing devices are used at the rate of 60-70%, in terms of the number of users and daily time spent in using it (Jensen et al., 1998). Besides that, the posture when using pointing devices is greatly deviated from the neutral position and maintained for a longer period of time, hence causing strain to the hands, arms and shoulders (Keir et al., 1999).

Generally, in computer related tasks that involve repetitive use of the hands and wrists, the positions that are deemed to be unacceptable are: ulnar deviation > 24°, radial deviation > 15°, pronation > 40°, supination > 57°, abduction > 67°, extension > 50° and flexion > 45° (Bergamasco et al., 1998). Other factors that increase CTP while typing and pointing include changes in the cross-sectional area due to wrist position, the folding of the skin at the distal palm and movement of lumbrical muscles into the carpal tunnel (Kumar & Fagarasanu, 2003). Exceeding these limits, due to trying to fit the hands and fingers to the keyboard and mouse, for a prolonged period of time, lead to a deviated wrist and elevated CTP that can lead to CTS.

Intervention strategies

Intervention strategies include attempts to either prevent CTS in the first place or to treat and recover patients who have already developed CTS. The type of intervention used depends on the stage and severity of the CTS case. Interventions to prevent the occurrence of CTS in the first place include engineering (ergonomic keyboard and mouse) and management interventions. Interventions to treat an existing CTS problem include personal development and medical treatment (surgical and non-surgical). One that takes a more holistic approach and covers both prevention and treatment involves a multi-dimensional approach.

Engineering interventions

Engineering interventions are defined as any engineered manipulations of sources for occupational hazards or routes of exposure to them (Lincoln et al., 2000). They include alternative keyboard/mouse designs and keyboard/mouse support systems. Changes in keyboard and mouse designs or having support systems may improve typing and navigation in a positive manner, where repetitiveness can be reduced and comfort increased. Most of the research and design involve reshaping the standard keyboard, while keeping the basic 'QWERTY' key arrangement. This makes it easier for people to adjust to the new keyboard without having to learn a new typing skill. The various alternative keyboard designs that have been tested include the split keyboard, negative slope keyboard, adjustable split angle lateral slope keyboard and the curved/concaved key rows keyboard (Kumar & Fagarasanu, 2003).

When it comes to typing on a keyboard, the best position for the arms and hands is horizontal or parallel with the floor. When the arms and hands are at such neutral position, there is minimal risk for increment in CTP. If it was a standard keyboard, this can be achieved by placing the keyboards about 1 inch above the thighs. Otherwise an alternative keyboard may be used, such as a negative slope keyboard (keyboard sloped away from the user) or a split keyboard (keys split to two or three groups at different positions and angles) that helps keep the wrist within the neutral zone more than 60% of the time (Kumar & Fagarasanu, 2003). They also help reduce ulnar deviation, pronation and tendon travel in the hands, thus reducing the force applied on carpal bones, tendon sheaths and ligaments (Marklin et al., 1999). The curved and concave key rows keyboard design helps to reduce stress on the fingers caused by excessive finger stretching and finger flexion respectively.

A study carried out by Rempel et al., (1999) found that an ergonomic keyboard is more effective than a standard keyboard in reducing CTS symptoms. In their study, 12 subjects were allocated ergonomically modified keyboards, and 12 others a regular controlled keyboard. Results obtained showed that there was significant decrease in hand pain within 6 to 12 weeks of study within the group that used the ergonomic keyboard. Another group of researchers, Huisstede et al., (2010a), experimented with three types of alternative keyboards, which were the Comfort keyboard, the Apple adjustable keyboard and the Microsoft natural keyboard. Among the three, the last two were found to have more ergonomic design as they improved comfort and relaxation for the arms and wrists in the long-term. Several other alternative keyboard studies also gave the same desired outcome (Tittiranoda et al., 1999; Ripat et al., 2006).

To choose the right keyboard, several keyboard designs have to be tested. This is because for each individual, there is much variation in the hand anthropometrics, posture, arm or wrist load, keystroke pressure and angles when typing. Because the area is very complex and difficult to control, current intervention practices include training the individual to adjust his or her position based on the keyboard placing and design. For instance, an ergonomic keyboard is chosen and the person using it alters their arm and hand position so that it is at neutral position most of the time, and uses keystrokes of lower pressure and speed when typing. After some time, the individual will get used to the process and adapt to the new keyboard.

As for the mouse, it can be redesigned to be much broader and flatter, so that it will be in a more neutral position for the hands and there is greater distance between the two click buttons for the fingers. While working, it is best to be seated at a position where the mouse is at elbow height, so that it does not require shoulder flexion to use. In addition, forearm supports may be used to reduce wrist extension angles. Keir et al., (1999) studied three different designs of mice, which were the Contour mouse, Apple II ADB mouse and Microsoft Serial mouse for 'drag-and-drop' and 'point-and-click' activities. Participants were advised to sit at ergonomic positions while using the mice. From their study, the researchers found that for all three mice, there was no significant change in the CTP when the hands were static at neutral position. But CTP increased to about 30 mm Hg with the active use of mice, indicating that prolonged usage may lead to the risk of developing CTS. Very little difference was observed for the three designs of mice, indicating that mouse shape and design may be a less important factor when it comes to reducing CTP. Hence, at present, the best solution for any pointing device usage would be to adjust one's posture so that they are at neutral position and limit the duration of continuous usage. Besides that, it is advisable to use a suitable mouse mat, keep the mouse as close as possible, apply the right pressure, release the mouse when not in use and identify keyboard shortcuts that could minimize mouse pointing and clicking (McKeown & Twiss, 2004).

Management interventions

Management interventions are defined as any management initiative which modifies the work process or exposure to reduce CTS-related stress. They include managing work-place ergonomics, providing training, job modification, practicing occupational health and safety leadership and proper management of disability. When it comes to work-place ergonomics, management can plan out work-station layouts that would suit each computer user and their task demands (McKeown & Twiss, 2004). Adjustable desks and seats with armrests and back support would be ideal for comfort. Besides that, there must be sufficient space on the desk so that the computer screen and keyboard are directly in front of the user. It should also allow space for the hands and arms to rest when the keyboard and mouse are not in use.

On top of providing an ergonomic workspace, it is the responsibility of the management to train workers to adapt to the new work-station furniture, computer, keyboard and mice. Without proper training, there is a tendency for workers to misuse the equipment, which can lead to unnecessary upper limb discomfort or injury. It is important that workers are educated about methods on how to reduce physical and mental stress at work, especially when there are repetitive and long duration of work involved. Other factors that the management should control for overall comfort when using the computer would be the lighting, noise levels, indoor temperature and ventilation (McKeown & Twiss, 2004).

Job modifications can be done to mitigate work-related illness of the arms and wrists. For example, management can limit the work time on the keyboard and computer or provide job rotations or shifts to those involved. Job demands and deadlines can be made more flexible to reduce unwanted stress. Some organizations introduce rest and break time or even exercise programmes into daily work routines as a measure of combating the effects of monotony, boredom and sitting too long in the same posture (McKeown & Twiss, 2004). The employer can also hire more people for a particular job, so that the effect of repetitive tasks for too long can be eliminated. Higher management should have a health and safety policy in place and practice leadership that encourages and motivates workers to perform at an optimal level without any injury.

Apart from the above-mentioned interventions, the management should also be responsible towards any form of work-related disorder or disability that occurs and provide the right treatment or compensation for the worker affected. Insurance coverage for each worker exposed to the risk of developing CTS is crucial. Introducing a rehabilitation programme to help workers get back to work after treatment or surgery would be highly beneficial as it creates a more supportive environment for workers (Palmer, 2011). It is to be noted that any changes introduced into the organization have to be evaluated from time to time and modifications made if needed. This ensures a balanced work system with zero injuries.

Personal interventions

Personal interventions include more physical and psychological efforts such as counseling, worker behaviour modification, activity modification, education and exercise programmes (Lincoln et al., 2000). Sometimes psychological stress may lead to the development of physical illnesses such as CTS. It has been proven scientifically that stress at workplace can increase the biomechanical loads on muscles and tendons, causing edema that can contribute towards the occurrence of entrapment syndromes such as CTS (Aptel et al., 2002). Thus, it is crucial that workers who are under stress go for counseling and behaviour modification programmes to ease the situation. Activities carried out may also be modified so that it becomes less intense and stressful. Education and exercise programmes such as yoga may also be very helpful in bringing about relaxation and comfort at the work-place. Basically, personal interventions are those at an individual level. It is up to the individual worker to decide what best suits them to avoid injuries or illnesses and work in harmony with their environment.

Medical interventions

Medical interventions include surgical and non-surgical treatments for patients who have already developed CTS due to work. Surgery is only recommended for patients with severe symptoms (Di Geronimo et al., 2009). The basic principle behind CTS surgery is to increase temporarily the carpal tunnel volume by dividing transverse the carpal tunnel ligament to release the pressure on the median nerve (Aroori & Spence, 2008). Two common types of surgeries include the open and endoscopic surgeries (Huisstede et al., 2010b). Along with surgery, there are also pre- and post-operative interventions that help reduce recovery time. However, there is no evidence that these two intermediate interventions help to treat CTS in the short and mid-term (Cook et al., 1995; Bury et al,. 1995; Provinciali et al., 2000; Hochberg, 2001; Stevinson et al., 2003).

Non-surgical treatments vary from ultrasound, laser, chiropractic treatment, acupuncture, nocturnal neutral wrist splinting, hand therapy (median nerve gliding exercise), carpal bone mobilization, taking vitamins and oral medication (Huisstede et al., 2010a). These conservative treatments have been found to be beneficial in most cases of mild to moderate cases of CTS, often providing immediate and temporary relief for patients (O'Connor et al., 2003). The most common and effective non-surgical treatment would be splinting (56.3%) and the administration of oral steroids (50.8%), (Miller et al., 1994). From research carried out comparing surgical and non-surgical treatment, it was found that surgical treatment was more effective in the mid- and long-terms for severe CTS cases. The improvement is durable, reliable and relatively risk-free when performed by experienced surgeons. It allows faster recovery and return-to-work. In general, for workers diagnosed with CTS, surgery is advised for patients with severe symptoms while non-surgical interventions are advised for patients with mild and moderate symptoms.

Multi-dimensional approach

Although there is abundant research evidence that identifies various risk factors associated with work-related CTS, planning out an intervention strategy to prevent this disorder needs careful assessment. The potential risk factors and the actual benefit of the intervention should be investigated through well-designed studies of intervention-effectiveness (Lincoln et al., 2000). Currently, it is difficult to make any definitive conclusions from literature regarding the success of each intervention strategy due to the variations in the outcome measures. Thus, a multi-dimensional approach is proposed, as it gives a good balance of all the intervention strategies combined together. This approach focuses on preventing the occurrence of CTS in the first place through proper engineering design of the computer workstation (furniture, computer, keyboard and pointing devices) along with appropriate management strategies (ergonomic training and job redesign). If at all there is an incidence of CTS, then depending on its severity, a combination of management, personal and medical interventions may be introduced. Thus, the multi-dimensional approach tackles the problem by prevention of the initial incidence, occurrence and recurrence of CTS. For example, a worker who shows symptoms of wrist pain or inflammation may be given some ergonomic training, asked to wear a splint and modify his job routine in order to ease the problem. Or in more severe cases, a total redesign of the workstation, exercise and medical treatment can be carried out. Since every individual is different and unique, the type of intervention chosen may vary. Thus, a multi-dimensional approach would be more suitable in the long-term.

Conclusions

CTS is one of the most widely recognized nerve entrapment disorders that is affecting computer users of the present day. The main risk factors associated with computer-related CTS include varied pressure, repetition, vibration and static posture. The problem is becoming worse by the day and needs effective intervention strategies to prevent both new occurrence and address existing problems. Some of the intervention strategies that have been employed are new engineering design of the keyboard and mouse, management strategies, personal or psychological interventions, medical treatment and a multi-dimensional approach. This research study proposes a multi-dimensional approach (a combination of two or more intervention strategies) as it is can help solve the problem in a more holistic manner.

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Safety Training Evaluation: Approaches and Practices

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Abstract

The question about which is the best approach to facilitate the effective safety evaluation, training processes involved have become and on-going debate. This article reviews current approaches to evaluation of safety training. It was focusing theoretical framework suggested and used in the previous literature. Furthermore, possible summary of several methodologies of safety training evaluation presented.

Keywords: Safety training evaluation, Training Approaches, Training evaluation

Introduction

Safety campaign or program will start with the awareness campaign. The awareness is only can be delivered through safety training. To ensure that the safety campaign successful, the training conducted must reach the objectives and its purposes (F. Robson & Mavin, 2014). Previous studies have shown that occupational safety training has beneficial effects on knowledge gain and improved behaviour but there is weak evidence for improved safety outcomes (Taylor, 2015).

Training can be a source of competitive advantage where employees gain appropriate new knowledge and skills which provides a strong argument for organisations to invest in their employees so that they can reap the benefits and differentiate themselves from their competitors (Towler, 2009). As supporting continuous improvement effort, organizations spends massive amount of budget for safety training, learning and development interventions. In 2013 U.S. training expenditures—including payroll and spending on external products and services was relatively at USD55.4 billion (Report, 2013b). Hence, it is essential for organisations to determine the outcome they gain from their investment in training (Pineda, 2010), mostly in the current economic climate. The importance of evaluating learning and development interventions was shared by Mann (1996) a widely accepted view about, "with the massive investment in developing training strategies, the question is no longer 'is it a necessity to train' but rather 'are the training valuable and effective'".

Diverse approaches to evaluation of safety training demonstrating the complexity factors associated with evaluation are addressed below. Likewise, in the following section, different approaches to evaluation and associated models are discussed. Next, recent studies concerning safety evaluation practice are presented. In the final section, opportunities for further training evaluation systems are discussed. The article concludes with recommendations for appropriate research.

Safety Training Evaluation Methodologies

Previous literature as supported by a wide range of studies agrees that training in organizations is important and recognizes evaluation as key in proving its "value". Training's role as a necessary element in developing and maintaining effective hazard control activities remained firm. Nevertheless Cohen et al, (1998) study that meaningful training procedures and the acknowledgment of factors both within and beyond the training process that could greatly affect the effectiveness of the training that contribute to the safety performance.

A critical analysis of the previous findings found certain qualifications in viewing training impacts and successes with regard to current workplace standards (Huang et al, 2006). As found in previous studies, training intervention studies did not address safety training impact, however knowledge gain and safe behaviour measures were used in many evaluations as conflicting to actual performance based on injury/disease results (Taylor, 2015). Consequently, the best way to gather useful information about training evaluation is through comprehensive meta-analysis (Cohen et al., 1998; Grossman & Salas, 2011; Robson et, al. 2013). Only these and a few other applicable studies supply the useful background for previous studies in regards with training effectiveness.

(Taylor, 2015) suggested three meta-analyses pointing common questions in their evaluations that are increase safety knowledge, safer workplace behaviour and better safety outcomes. According to (Brinkerhoff, 2009), good evaluation should be able to prove that the programme:

- is aimed at important and worthwhile organizational benefits;
- operates smoothly and effectively and is enjoyed by participants;

- achieves important skills, knowledge and attitude objectives;
- uses the best available and most cost-effective designs;
- is used effectively on the job; and
- provides valuable and cost-effective organizational benefits.

This construct measures the effectiveness of formal orientation programs and subsequent follow-up training pertaining to safety practices at work (Huang et al., 2006). However Lingham, et al, (2006) suggested evaluation for training programs, as a necessary and essential to leverage the learning and ensure the efficient use of resources by emphasising the crucial of post training performance. Brinia & Efstathiou, (2012) also suggest that the effectiveness of training should be based on the learners' ability to apply the knowledge, skills and attitudes obtained in the training course. However, most evaluation methods are based on a cost-benefit analysis or simple ordinal evaluations with ambiguous scales, such as the determination of the satisfaction level among participants (Emery et al, 2006; Judith, 1993; Richard et al, 2014; Wang et al, 2015).

Safety Training Evaluation Models and Approaches

Systematic approaches to the design of training were commonly used in training evaluation method (Eseryel, 2002). Instructional System Development (ISD) methodologies is strongly influences the choice of training evaluation, which developed in the USA in the 1950s and 1960s and are represented in the works of a few prominent scientist (Goldstein (1993), Gagné et al, (2005) and Bersin, (2008)). Evaluation process is conventionally embodied as the final stage in a systematic approach with the purpose presence to improve interventions (formative evaluation) or mark a judgment about worth and effectiveness (summative evaluation) (Gustafson & Branch, 2002).

Previous literature identified six general methodologies to educational evaluation which each determined different set of approached and fundamental (William Arthur Ward, 1996; Worthen & Sanders, 1991), as follows:

- Goal-based evaluation
- Goal-free evaluation
- Responsive evaluation
- Systems evaluation
- Professional review
- Quasi-legal

Goal-based and System Based Training Evaluation Approach

Essentially, all this six general approaches was developed from two approaches that predominantly use in the evaluation of training that were goal-based and systems-based approaches (Phillips, 2003). Most of the frameworks for evaluation of training programs have been proposed under the influence of these two approaches. The prominent framework has come from Kirkpatrick (Capps, 2013; Chang, 2010; Galloway, 2005; Pulichino, 2007; Rouse, n.d.; Tan & Newman, 2013). The goal-based evaluation approach proposed by Kirkpatrick's model (1959) is based on four simple questions that translate into four levels of evaluation. These four levels are generally known as reaction, learning, behavior, and results. In other hand, Phillips, (2003) has gone beyond even Kirkpatrick's level 4 to focus on real measurement of ROI. In extend Bailey, (2005) extend the justification into the financial return based on the cost of training constructed on the return on investment and organizational impact. Training in this sense has thus moved from satisfying trainees to improving organizational performance (Emery et al., 2006; Judith, 1993; Olaniyan & Ojo, 2008; Phillips, 2003; Worthen & Sanders, 1991; Zinovieff, 2008).

In contrast, the three most influential models deployed by the systems approach include: Context, Input, Process, Product (CIPP) Model (Worthen & Sanders, 1991); Training Validation System (TVS) Approach (Ftiz-Enz, 1994); and Input, Process, Output, Outcome (IPO) Model (Bushnell, 1990). System-based models (e.g. CIPP, IPO and TVS) seem to be more useful in terms of thinking about the overall context and situation but they may not provide sufficient granularity (Zinovieff, 2008). Systems-based models may not represent the dynamic interactions between the design and the evaluation of training. Few of these models provide detailed descriptions of the processes involved in each steps. None provide tools for evaluation. Furthermore, these models do not address the collaborative process of evaluation, that is, the different roles and responsibilities that people may play during an evaluation process. Review on these models summarized in Table 1.

Systematic Training Evaluation Approaches

There are two type of major training evaluation what is known as the formative and the summative types of evaluation. In other hand, recently the concepts of confirmative and meta evaluation has arisen much attention. Formative evaluations strengthen the evaluated object. The purpose is to help form it by examining the delivery of the program, the quality of its employment, and the assessment of the organizational context, personnel, procedures and inputs. Nevertheless summative evaluations, examine the outcomes of the evaluated object. It represent it by describing what happens succeeding to delivery of the program or technology; assessing whether the object can be said to have caused the outcome; determining the overall impact of the causal factor beyond only the immediate target outcomes; and, estimating the relative costs associated with the object.

Formative evaluations were form by five type of evaluation that were, assessment of need and evaluability, structured conceptualization, implementation and process evaluation (Dahiya & Jha, 2011). In the other hand summative evaluation can also be subdivided four level of evaluation and analysis which form of outcome evaluations, impact evaluation, cost-effectiveness and cost-benefit analysis and last meta-analysis and secondary analysis (Zinovieff, 2008).

Nevertheless previous literature suggested that these two fundamental types of evaluation do not suffice to constitute what is referred to as "full-scope evaluation" (Brinia & Efstathiou, 2012; Brinkerhoff, 2009; Cohen et al., 1998; Council, 1998; Eseryel, 2002). Full-scope evaluation systematically judges the merit and worth of a long-term training programme before, during, and after implementation. Full-scope evaluation is appropriate only for training programmes that are designed to run for one year or more; it is not appropriate for a one-time training event, such as a single-session workshop to introduce a new product to sales representatives (Dahiya & Jha, 2011).

Full-scope evaluation integrates all four types of programme evaluation – formative, summative, confirmative and meta – into the training programme evaluation plan. Working together, the four types of evaluation help to determine the value of a long-term training programme and develop the business case. Full-scope evaluation introduces the concepts of the confirmative and the meta type of evaluation. These concepts may not be of priority interest to other than evaluation practitioners but deserve at least the brief mention below.

Goal Based Training Evaluation		**System Based Training Evaluation**		
Kirkpatrick Model – 4 Level	Return On Investment (ROI)	CIPP - (Context, Input, Process, Product)	IPO - (Input, Process, Output)	TVS - (Training Valuation System)
Reaction: to gather data on participants reactions at the end of a training program	Level 1: Reactions	Context evaluation – which helps in planning and developing objectives	Input – such as the instructor experience, trainee qualifications, resources	Step 1: Situation analysis – this is similar to an in-depth training analysis.
Learning: to assess whether the learning objectives for the program are met	Level 2: Learning	Input evaluation – which helps to determine the design by examining capability, resources and different strategies	Process – the plan, design, development and delivery of the training	Step 2: Intervention – this involves diagnosing the problem and designing the training;
Behavior: to assess whether job performance changes as a result of training	Level 3: Job behavior	Process evaluation – which helps to control the operations by providing on-going feedback	Outputs – the trainees reactions, knowledge and skills gained and improved job performance	Step 3: Impact – this examines the variables that impact on performance
Results: to assess costs vs. benefits of training programs, i.e., organizational impact in terms of reduced costs, improved quality of work, increased quantity of work, etc.	Level 4: Organization – the effects on the organization, from participant's job to performance changes	Product evaluation – which helps to judge and react to the programme attainments in terms of outputs and outcomes.	Outcomes – profits, customer satisfaction and productivity.	Step 4: Value – this step places a monetary worth on the changed performance.
	Level 5: Ultimate value – the financial effects, both on the organization and the economy.			

Table 1: Goal-based and systems-based approaches to evaluation

Level	Formative	Summative	Confirmative	Meta
1	• *Needs assessment* determines who needs the programme, how great the need is, and what might work to meet the need;	• *Outcome evaluations* investigate whether the programme or technology caused demonstrable effects on specifically defined target outcomes;	Level one: evaluate programmes while they are still in draft form, focusing on the needs of the learners and the developers;	Formative: examining the delivery of the program, the quality of its implementation, and the assessment of the organizational
2	• *Evaluability assessment* determines whether an evaluation is feasible and how stakeholders can help shape its usefulness;	• *Impact evaluation* is broader and assesses the overall or net effects – intended or unintended – of the programme or technology as a whole;	Level two: continue to monitor programmes after they are fully implemented, focusing on the needs of the learners and the programme objectives:	Summative: examine the effects or outcomes of some object
3	• *Structured conceptualization* helps stakeholders define the programme or technology, the target population, and the possible outcomes;	• *Cost-effectiveness and cost-benefit analysis* address questions of efficiency by standardizing outcomes in terms of their dollar costs and values;	Level three: assess the transfer of learning to the real world.	Confirmative: the evaluation and training practitioner collects, analyzes, and interprets data related to behavior, accomplishment, and results
4	• *Implementation evaluation* monitors the fidelity of the programme or technology delivery;	• *Secondary analysis* re-examines existing data to address new questions or use methods not previously employed;		
5	• *Process evaluation* investigates the process of delivering the programme or technology, including alternative delivery procedures.	• *Meta-analysis* integrates the outcome estimates from multiple studies to arrive at an overall or summary judgments on an evaluation question.		

Table 2: Systematic type of training evaluation

Current Practices in Evaluation of Safety Training

In general practice, systematic and planned safety evaluation was not found in practice nor was the difference between formative and summative evaluation. Formative evaluation does not seem to take place explicitly while summative evaluation is not fully carried out (C. Bailey, 1993; Brinia & Efstathiou, 2012; Pineda-Herrero, Belvis, Moreno, Duran-Bellonch, & Úcar, 2011; D. Robson et al., 2013; F. Robson & Mavin, 2014; Shoji & Ge, 2015; Soares, García-Díez, Esteves, Oliveira, & Saraiva, 2013). The most common activities of safety evaluation seem to be the evaluation of student performance (assessment form) (Harvey, Bolam, Gregory, & Erdos, 2001; Mavin, Lee, & Robson, 2010; L. S. Robson et al., 2011; Rozar, Ibrahim, & Razik, 2011; Thiele, Hasson, & Tafvelin, 2015; Zierold, Welsh, & McGeeney, 2012) and there is not enough evidence that evaluation results of any type are used to revise the training design (Eseryel, 2002). It is important to note here that the majority of the literature used post survey result as their data collection analysis to support their finding.

However, literature reports indicate that not all training programs are consistently evaluated (Pineda, 2010). The American Society for Training and Development (ASTD) found that 45 percent of surveyed organizations only gauged trainees" reactions to courses (Report, 2013a). Overall, 93% of training courses are evaluated at Level One, 52% of the courses are evaluated at Level Two, 31% of the courses are evaluated at Level Three and 28% of the courses are evaluated at Level Four. These data clearly represent a bias in the area of evaluation for simple and superficial analysis. Analysis of the literature also found that formative and summative evaluations were not widely used. On the other hand, immediate and context (needs analysis) evaluations are more widely used. In the majority of the cases, the responsibility for evaluation was that of managers and the most frequently used methods were informal feedback and questionnaires.

Only a few evidence shows that the evaluation of the training mainly focuses on the working performance after learning, and a characteristic of the trainee's is relation with efficiency of training (Nikandrou et al, 2009). (Colquitt et al, 2000) conducted a meta-analysis to examine the relationship between training motivation and training outcomes. Similarly, (Blume et al, 2010) conducted meta-analytic review with 89 empirical studies that examine the predictors of training transfer. In addition, (Nikandrou et al., 2009) conducted in-depth interview method with 44 trainees from different organizations who participated in a training program. All the result using meta –analysis showed that trainee characteristics are critical factor in the training transfer process. This is only a few literatures that found applying meta-analytic review in their safety training evaluation.

Conclusion

Selecting the best approaches for safety training evaluation is very crucial to ensure that the safety training serve the purpose and goal. What is important, it will give positive impact to the knowledge, skills and attitudes to perform safety at the right level. It may involve hard work and vigorous activities that may require detail examination, re-evaluation and comprehensive review. This guidance may utilize by other researchers or organization to ease the selection of their training evaluation activities and methodology.

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Overview of Statutory Inspection Enforcement For Certificated Machinery By Licensed Person

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Abstract

Licensed person is a third party who was awarded a license to perform statutory inspection for certificated machinery under the provision of section 40 (1A), Factories and Machinery Act (Amendment) (FMA) 2006. The objectives of the study is to identify issues related to statutory inspection in Malaysia and to make comparisons with respect to the statutory inspection by Licensed Person adopted by other countries. The enforcement of Licensed Person in Malaysia is still in not yet implemented although Section 40 (1A) in FMA (Revision) 2006 regulating on Licensed Person had been introduced on 2006 and compared with other countries especially our neighboring country Singapore. Based on the DOSH inspection data analysis, the main issues relating to statutory inspection in Malaysia is the increment in backlog cases due to lack of number officers compare to the number of registered certificated machineries in Malaysia. As a conclusion, the implementation of Licensed Person is crucial in Malaysia to reduce the work and financial burden of Department of Occupational Safety and Health (DOSH) officer in enforcing FMA 1967 and also to improve the quality of statutory inspection for the safety in workplace.

Keywords: Licensed person, Statutory Inspection, Certificated Machinery, FMA 1967

Introduction

Licensed Person was a third party who was given license under Section 40 (1A), Factories and Machinery Act (Revision) 2006. This act states all machinery in respect of which a certificate of fitness is prescribed shall be inspected by an inspector or a licensed person at such periods and in such manner as may be prescribed. According to Section 7D, Factories and Machinery Act (Revision) 2006, the Minister has the power to appoint third party to conduct the statutory inspection. Statutory inspection was the re-examination of all registered certificated machinery 15 months from the last inspection date and was performed to ensure that all certificated machinery was always in good condition and safe to be used. Certificated machinery included unfired pressure vessels, hoisting machines, passenger lifts, escalators and steam boilers [3].

Statutory inspection was the re-examination of all registered certificated machinery 15 months from the last inspection date and was performed to ensure that all certificated machinery was always in good condition and safe to be used. Certificated machinery included unfired pressure vessels, hoisting machines, passenger lifts, escalators and steam boilers [3].

Historically, the machinery inspection was first performed in Malaysia on 1878, in which Mr. William Givan was appointed as the Machinery Inspector. In the 1890s, the Perak state government had implemented the machinery inspection by individual person, in which an individual person who had the qualifications in steam boilers was appointed as the boiler surveyor. However the boiler surveyor system was terminated in 1900 with the appointment of Mr. C. Finchman as Inspector of boilers. This shows that Malaysia had already implemented the law of Licensed Person for machinery inspection [19].

Statutory inspection was conducted by the Statutory Section in Department of Occupational Safety and Health (DOSH) of every state, to ensure that all the registered machinery was inspected and the Certificate of Fitness (CF) will be renewed every 15 month depending on the results of the inspection. All of the inspection was conducted by the DOSH officer depending on the qualification stated by DOSH. However, the issue was that the provision of Section 40 (1A) and Section 7D were not yet practiced in Malaysia.

Issues Related With Statutory Inspection In Malaysia

The existing statutory inspection requirements for statutory inspection were stated in Section 40 Periodical Inspections starting from (1) to (8) of the FMA (Amendment) 2006. In this amendment, Section 40 (1A) and (2A) were added specifically related to

Licensed Person. However, until 2013 the requirements of section 40 (1A) and (2A) had not yet being practiced.

Similarly as the requirements of Section 7D to 7F, the requirement for appointment, powers, duties of a Licensed Person, the cancellation of the license and approval of new license after revocation had not been practiced. Statutory inspections were carried out by the Factories and Machinery Inspector (FMI). There were several issues identified regarding the existing statutory inspection related problems. The following were among the issues that were discussed:

i. Cannot meet the entire demand of the industry to comply with the requirements of Section 40 of the Periodic Inspection.

ii. Become a liability for DOSH.

iii. Towards the implementation of self-regulation

i. Inability to Meet the Entire Demand of the Industry to Comply with the Requirements of Section 40 of the Periodic Inspection, Factories and Machinery Act 1967.

Statutory inspection was carried out by the DOSH State Office under Statutory Inspection Section. Other than statutory inspection, there were many other tasks undertaken by DOSH besides performing statutory inspections. As there were high numbers of certificated machinery in Malaysia, the statutory inspection allocated more than 70% of their routine activities carried out each year compared to the enforcement activities of the FMA 1967 and the Occupational Safety and Health Act 1994 (OSHA 1994). Table 1 showed the number of Statutory Inspection under FMA 1967 compared to the total enforcement of FMA 1967 and OSHA 1994 for the years 2004 to 2011.

Although more than 70% was allocated to the statutory inspection every year, there was still backlog cases recorded every year, this showed the trend of increasing in backlog and it contributed to 40% of backlog cases. This can be seen by comparing the number of certificated machinery and the number of inspected certificated machinery where only contributed to 149, 835 machinery (60%) for the year 2011 as compared to the entire machinery should be inspected during that year totaling 251, 708 (100%). Similarly in 2010 and 2009, the number of inspected machinery were total up to only 150, 835 (62%) and 128, 868 (64%) [6][7][8][9][10].

Table 2 showed the number of machines (should be checked) and the number of machine inspected for years 2009 to 2012. This issue caused the enforcement activities of OSHA 1994 to a level still below 30% from the total activities provided. OSHA, which was introduced on 1994, should be given more attention in enforcement activities in order to raise awareness in the concept of self-regulation. The study of the effectiveness of OSHA 1994 after ten years had proposed a Short Term Action Plan to administer and enforce OSHA 1994. It was developed to strengthen the enforcement of OSHA based on governance, culture, human resources and databases. The data obtained showed that the requirements of Section 40 (1A) and 7D should be practiced in order to meet the demands of the industry and at the same time DOSH can expand OSHA's enforcement activities and other tasks [6][7][8][9][10].

ii. Liability to DOSH

Referring to the requirements of Section 7D (6) stated that the authorization of a licensed person under subsection (3) shall not render the Federal Government liable to any person in respect of any injury, damage or loss occasioned by the failure of the Licensed Person to carry out his obligations under this Act in respect of which charges, fees and levy are demanded, collected and retained. This requirement reduces the liability to the inspector if it is practiced. However, from the data obtained up to now, all statutory inspections are carried out fully by the Examiner.

iii. Towards the Implementation of Self-regulation

As the country were directing towards total self-regulation, designation of the Licensed Person can also compliment the philosophy and principles of self-regulation contained in the OSHA 1994[15]. The industry will no longer depend solely on the government to ensure the safety and health at work. Instead, the industry itself can determine the safety and health at work.

Comparing Implementation Of Licensed Person Of Different Countries

i. Act and Regulations

Apart from Malaysia, the implementation of the Licensed Person had also been implemented in other countries such as Singapore, Australia, Japan and Thailand. Referring to Table 3, the implementation of Licensed Person has been practiced in the following countries:

i. Malaysia was covered under Section 40 (1A) and 7D, Factories and Machinery Act (FMA) amendments of 2006 [3].

ii. Singapore was known as an authorized examiner and subject to the Workplace Safety and Health Act of 2006 (Chapter 354 A) [18].

iii. Australia was covered under Boiler and Pressure vessel Regulations 1954 [1].

iv. Thailand was covered under The Safety, Health and Environment Act 2011[16].

v. Japan was covered under Industrial Safety & Health Law 1972 [4].

ii. Current Practice

The main responsibility of the Licensed Person was to carry out statutory inspections of registered certificated machinery within the time stipulated by the legislation of each country. Referring to Table 4, the current practice Malaysian statutory inspections was carried out every 15 months and performed by inspectors from the Department of Occupational Safety and Health (DOSH). In Australia, Japan and Thailand, the machinery inspection was conducted once a year while in Singapore, machinery inspection was conducted every 24 months for air receiver/ steam, every 12 months for a steam

iii. Type of Machineries

Statutory inspection should be conducted to make sure that all the machinery were in good conditions and can operate accordingly. The types of certificated machinery inspected were depending on the legal requirements for every country. Table 5 showed the types of certificated machinery in other countries.

iv. Inspection fees

The inspection fee was charged for every inspection conducted on every registered certificated machinery. Referring to Table 6, Singapore, Australia and United Kingdom are charging a fee for each inspection conducted.

Table 1: Number of Statutory Inspection under FMA 1967 comparing to the Enforcement of FMA 1967 and OSHA 1994

OPERATION	2004	2005	2006	2007	2008	2009	2010	2011
Statutory Inspection	**125,543 (71%)**	**135,257 (77%)**	**133,212 (78%)**	**138,283 (78%)**	**147,855 (79%)**	**136,951 (78%)**	**160,083 (77%)**	**158,344 (77%)**
FMA Enforcement	2,943 (2%)	3,221 (2%)	3,476 (2%)	3,777 (2%)	4,023 (2%)	4,940 (3%)	4,687 (2%)	4007 (2%)
OSHA Enforcement	47,634 (27%)	37,785 (21%)	34,948 (20%)	34,899 (20%)	34,876 (19%)	33,161 (19%)	42,396 (21%)	44,413 (21%)
Total	176,120 (100%)	175,263 (100%)	171,636 (100%)	176,959 (100%)	186,754 (100%)	175,052 (100%)	207,166 (100%)	206,674 (100%)

(Source: DOSH 2011)

Table 2: Number of Certificated Machinery Needed to be Inspected Compared to Number of Certificated Machinery Inspected

Year	Machinery (Active)	Certificated Machinery that should be Inspected (12/15 x operation)	Certificated Machinery that was Inspected	Backlog
2009	252,373	201,898 (100%)	128,868 (64%)	73,030 (36%)
2010	305,104	244,083 (100%)	150,835 (62%)	93,248 (38%)
2011	314,635	251,708 (100%)	149,835 (60%)	101,873 (40%)

(Source: DOSH 2011)

Table 3: Act and Regulations related to Licensed Person in Other Countries.

Countries	Legislation
Malaysia	**Factories and Machinery Act 1967 (Act 139)** **Part 1, Section (7D)** Not win standing any other provision of this Act, the Minister shall have the power to grant a license on such conditions as he may think fit to any other person to perform any of the functions specified in this Act as the functions of a Licensed Person as it appears to him to be necessary. **Part 5, Section (40)(1A) (Amendment) 2006**

Countries	Legislation
Singapore	**Workplace Safety and Health Act 2006** **Part 2, Section (4)** "Authorised Examiner" means any person approved by the Commissioner under section 33 for the purpose of carrying out any prescribed examination or test of any machinery. a. accompanied by such information, statements and documents as the Commissioner may require; and b. accompanied by the prescribed fee. 1) Upon receiving an application under subsection (1), the Commissioner may :- a. grant the approval applied for either unconditionally or subject to such conditions as the Commissioner thinks fit; or refuse the application. 2) The Commissioner shall not approve any person as an authorised person unless the Commissioner is satisfied that the applicant:- a. Possesses the prescribed qualifications and prescribed practical experience; and is sufficiently competent and is, in all other respects, a fit and proper person, to be entrusted to carry out the work of the relevant authorised person. 3) The Commissioner may at any time vary or revoke any of the existing conditions imposed under subsection (2) or impose new conditions. 4) Upon the approval of a person as an authorised person, the Commissioner shall issue the applicant with a certificate of approval to act as a relevant authorised person for such period and subject to such terms and conditions as the Commissioner may specify therein.
Australia	**Machinery Act 1949** **(Boiler & Pressure Vessel Regulations 1954)** **Part 3, Section (29)** Power of entry: 1) Subject for an internal inspection to Section 30, an inspector may, at any time, enter into or on premises for the purpose of inspecting or examining a boiler or pressure vessel on the premises. 2) The entry may be made between sunset and sunrise only when the boiler or pressure vessel is in operation.
Japan	**Industrial Safety and Health Law 1972** **(Amendments 31/05/2006, No. of Law-25)** **Part 5, Section (1), Article 39** 1)Regional Director, Bureau of Labor or registered manufacturing inspection and other agencies shall be as provided by Ordinance of the Ministry of Health, Labour and Welfare, issued a certificate of inspection for portable machine as described and others who have passed the examination referred to in paragraph (1) or (2) of the preceding article (hereinafter referred to as "manufacturing inspections and other") particular machine and others, who have passed the examination in connection with the installation of the machine and set the rest of the set out in paragraph (3) the previous article. 3)The Head Office of Labor Standards shall be as provided by Ordinance of the Ministry of Health, Labour and Welfare, endorse the certificate of inspection specified machine and others, who have passed the examination of the alteration of partial or re-use the specified machine, and the other in inspections specified in paragraph (3) of the preceding article.

Countries	Legislation
Thailand	**Safety, Health and Environment Act 2011** **Part 4, Section (33)** 1) Any person who can act as an expert on safety, health and environment should have a license from the Director-General in accordance with this act.

(Source from FMA 1967, Workplace Safety and Health Act (WSHA) 2006, Machinery Act 1949, Industrial Safety and Health Law 1972, Safety, Health and Environment Act 2011)

Table 4: Current Practice regarding the Statutory Inspection in other Countries

Countries	Current Practice
Malaysia	**Factories and Machinery Act, 1967 (Act 139)** **Factories and Machinery (Notification, Certificate of Fitness, and Inspection), Regulations, 1970** **Part 3, Section 14.** Initial Inspection:- 1) After initial inspection every factory and every machinery shall be inspected at regular intervals by an Inspector so long as such factory remains in operation or such machinery remains in use. 2) The regular interval shall ordinarily be fifteen months subject to such extension not exceeding thirty-six months in any particular case as may be authorized by the Chief Inspector in his discretion, and the regular inspection shall ordinarily be carried out during the fifteen months following the month in which the last inspection was made or where the interval has been extended by the Chief Inspector during the month following the expiry of the extended interval.

Countries	Legislation
	Factories and Machinery (Steam Boiler and Unfired Pressure Vessel) Regulations, 1970 **Part 4, Section 72 (4)** Every steam boiler shall be tested hydrostatically at intervals not exceeding seven years Types of machinery:- ▪ Steam Boiler ▪ Unfired Pressure Vessel ▪ Lifting Equipment ▪ Passenger and Goods Lift ▪ Factories and installation
Singapore	**Workplace Safety and Health (General Provisions) Regulations 2006** **(**Chapter 354A, Section 65**)** **Part 3** Hoists and lifts **Section 19 (3)** Subject to paragraph (10) (c), every hoist or lift used in a workplace shall be thoroughly examined by an authorised examiner at least once every 6 months or at such other intervals as the Commissioner may determine. **Section 20 (3)** Every lifting gear used in a workplace shall be thoroughly examined by an authorised examiner at least once every year or at such other intervals as the Commissioner may determine. **Section 21 (3)** Every lifting appliance and lifting machine shall be thoroughly examined by an authorised examiner at least once every year or at such other intervals as the Commissioner may determine.

Countries	Legislation
	Air receivers **Section 31 (5)** Subject to paragraph (6) and regulation 31A, every air receiver shall be thoroughly cleaned; and examined by an authorized examiner at least once every 2 years. Steam boiler **Section 28 (6)** a. steam boiler referred to in paragraph (5),including all its fittings and attachments, shall be thoroughly examined by an authorised examiner at least once every 2 years and also after any extensive repair; and b. surface of the external shell of a steam boiler referred to in paragraph (5) shall be examined by an authorised examiner at least once every 6 years, and for the purpose of such examination, the insulation on the shell shall be removed completely **Section 28 (9B)** Have a safety valve attached to the boiler which shall be examined and tested by a competent person at least once a month, and the report on every such test shall be recorded and shall be made available for inspection at any time by an inspector. Gas plants **Section 35 (3)** Every water-sealed gasholder which has a storage capacity of not less than 25 cubic meters shall be examined externally by a competent person at least once every 2 years. **Section 35 (7)** a. the cylinder has been examined or tested by a competent person i. where the cylinder is for corrosive gases, at least once every 2 years; or ii. where the cylinder is for other gases, at least once every 5 years; and b. the result of such examination or test is entered in a register and kept for inspection by an inspector. Machines Categories:- *Hoist & Lift, Lifting gear, Air receiver, Steam boiler, Gas plants*
Australia	**Machinery Act 1949** **(Boiler & Pressure Vessel Regulations 1954)** **Part 3, Section (25), (26)** Duration of certificate:- 1) Subject to this section and Section 26, a certificate of inspection of a boiler or pressure vessel remains in force for 12 months from the date of the inspection to which it relates. Types of machine:- ▪ Pressure Vessel ▪ Steam Boiler ▪ High temperature hot water boiler

Countries	Legislation
Japan	**Industrial Safety and Health Law 1972** **(Amendments 31/05/2006, No of Law-57)** **Ordinance on Authorized Inspection Agency** **Part 8, Article 72** Certification:- 1) The license referred to in paragraph (1) of Article 12, Article 14 or Paragraph (1) of Article 61 (hereinafter referred to as the "license") shall be effectuated by giving licenses to those who have passed the license examination provided for in Paragraph (1) Article 75 or those who possess the qualifications prescribed by the Ordinance of the Ministry of Health, Labor and Welfare. 2) Any person who comes under any of the following matters disqualified license: i. A person whose license has been revoked under the Provisions of paragraph (2) of Article 74 (excluding item (iii)) and for one year from the date of revocation. ii. In addition to the above, the person designated by the Ordinance of the Ministry of Health, Labor and Welfare according to the type of license. 3) Regarding the license specified in paragraph (1) of Article 61, provided by the Ordinance of the Ministry of Health, Labor and Welfare, as those who cannot work on a license to operate properly due to mental and physical disorders, may lose eligibility for a license in the paragraph. 4) When the Regional Director of the Bureau of Labor license disqualification prescribed in paragraph (1) of Article 61 under the foregoing provisions, he shall inform the applicants about the facts and with their request, the officer designated by the Regional Director of the Bureau of Labor shall hear their opinion. Types of machinery:- ▪ Pressure Vessel ▪ Steam Boiler
Thailand	Factory Act 1969 (Amendments 1972, 1975, 1979 and 1992) Part 2, Section (33) 1) If the factory ceased their operations for more than a year, a person who engages in the business or receiving a permit as the case may be shall inform the authority within seven days from the day following the date of the last 1 year. If the person is under the one that you want to continue involvement in the milling business, he shall notify in writing prior to starting a business and in the case of the three factories, the person must obtain written permission from the authorities before engaging in a factory business. Section 15 paragraph two and Section 16 shall apply mutatis mutandis to the permission to continue involvement in the business for 3 factories. Types of machinery:- ▪ Pressure Vessel ▪ Steam Boiler

(Source from FMA 1967, Workplace Safety and Health Act (WSHA) 2006, Machinery Act 1949, Industrial Safety and Health Law 1972, Safety, Health and Environment Act 2011)

Table 5 Types of Machinery in Other Countries

Countries	Type of Machinery
Malaysia	a. Lifting Equipment (Passenger Lift, Moving Crane, Crane Tower, overhead travelling crane) b. Unfired Pressure Vessel (Air tank , sterilizer, heat exchanger) c. Steam Boiler & Autoclave
Singapore	a. hoist & lift b. lifting gear c. lifting appliances or lifting machine d. Steam boiler e. steam receiver f. Refrigerating plant pressure receive g. Pressure vessel
Australia	a. Pressure vessel b. Steam boiler c. High temperature hot water boiler
Japan	a. Pressure Vessel b. Steam Boiler c. Moving crane
Thailand	a. Pressure Vessel b. Steam Boiler

(Source from FMA 1967, Workplace Safety and Health Act (WSHA) 2006, Machinery Act 1949, Industrial Safety and Health Law 1972, Safety, Health and Environment Act 2011)

Table 6 Inspection Fee for Statutory Inspection in other Countries

Countries	Inspection Fee
Malaysia	**Factories and Machinery Act 1967 (Act 139)** Notice to occupied factories, registration and use of machinery **Part 5, Section 40** Periodical inspection:- All factories and machinery in respect of which a certificate of fitness is not prescribed shall be inspected by an inspector at such periods and such manner as may be prescribed. **Factories and Machinery Act 1967 (Act 139)** **Factories and Machinery (Fencing of Machinery and Safety) Regulation** **Part 5, Section 41-44, First-Seventh Schedule** Measurement of safety and machine guarding
Singapore	**Workplace Safety and Health ACT 2006** Part 2 of Schedule 5 Shall apply only to machinery, equipment and hazardous materials.
Australia	***Machinery Act 1949*** ***(Boiler & Pressure Vessel Regulations 1954)*** **Part 2, Section (7) (2)** Height does not exceed 9m^2 boiler heating surface.

Countries	Inspection Fee
	Part 2, Section (17B) If the working pressure is less than 689kPa, then only 1/10 if the pressure is taken into account but equal pressure 689kPa, then the existing pressure must be increased by 68kPa. **Part 3, Section (29)** Power of entry 1) Subject to Section 30 of the internal inspection, an inspector may, at any time, enter into or on the premises for the purpose of inspecting or examining the boiler or pressure vessel on the premises. 2) The entry shall be made between sunset and sunrise only when the boiler or pressure vessel operates.
Japan	N/A
Thailand	**Factories Act 1969** **(Amendment 1972, 1975, 1979 and 1992)** **Part 2, Section (35)** For the enforcement of this act: 1) To introduce a factor or a building, place or vehicle, suspected to be involved in the business of the factory, in the period from sunrise to sunset or during working hours for the place is to check the condition of the plant, building, place or vehicle, or any act of the state machine who violate the provisions of this Act. 2) To take specimens suspected their quality products in reasonable quantities for their quality inspection together with the relevant documents. 3) To examine, search, detain, seize or attach the product, container, books of account, documents or any other items that may be in cases where there are reasonable grounds to suspect that the involvement in the business of land plants to suspect involvement in a business that the plant can cause harm to people or property in the factory or the surrounding area or an offense under this Act has been committed. 4) To summon in writing any person to give evidence or to produce any document or object to be considered.

(Source from FMA 1967, Workplace Safety and Health Act (WSHA) 2006, Machinery Act 1949, Industrial Safety and Health Law 1972, Safety, Health and Environment Act 2011)

Discussion

Licensed Person implementation in Malaysia was compared with the implementation of similar legislation in other countries such as Singapore, Japan, Australia and Thailand. Comparison were made on 4 factors including Acts and Regulations, current practice, type of machinery, and inspection fees.

In Malaysia, Licensed Person referred to a third party who was awarded a license to perform statutory inspection for certificated machinery under the provision of section 40 (1A), Factories and Machinery Act (Amendment) (FMA) 2006. In other countries, this third party were also implemented by using other terms such as authorised examiner for Singapore which was enforced under the provision of Part 2, Section 4 of Workplace Safety and Health Act 2006 (WSHA 2006).

Licensed Person was implemented to fulfill the requirement of periodic inspection of certificated machinery PMT, PMA and PMD for their renewal of Certificate of Fitness (CoF) which valid for 15 months according to FMA 1967. In Singapore, the validity of the certificate of inspection varied according to the types of machinery with the minimum validity of 6 months to maximum of 5 years [11][12] . Other than that, in Australia, a certificate of inspection for a boiler or pressure vessel valid for 12 months from the date of the inspection.

Statutory inspection was only performed on certain types of machinery. For most of the countries, the type of machinery that required statutory inspection include steam boiler and pressure vessel. But some of them included lifting equipement such as passenger lift, moving crane, hoist and lift and crane tower.

Last but not least was the inspection fees charged for the statutory inspection services. Every country charged a certain fees for the statutory inspection but the value varied according to the type and size of machinery. For Malaysia, the current fees was charged by DOSH and wil be paid by the owner of the certificated machinery. These fees however, did not inlcude the service charge of the License Person.

Conclusion

There were several issues identified regarding the existing statutory inspection related problems. The following were among the issues that were discussed:

i. Cannot meet the entire demand of the industry to comply with the requirements of Section 40 of the Periodic Inspection.

ii. Become a liability for DOSH.

iii. Towards the implementation of self-regulation

As compared to other countries, Malaysia is still far from reaching its effort in implementing Licensed Person for Statutory Inspection for Certificated Machinery. Clearer guidelines and system need to be develop so that stakeholders will be able to understand and implemented Licensed Person for their company in order to fulfill the requirement of FMA 1967.

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Indoor Plants as a Filtration of Indoor Air Pollution: A Review

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Abstract

Indoor pollution increasingly becomes a public concern. These concerns are related to energy efficiency in a building. There are various ways in which it can ensure energy conservation can be achieved, including superinsulation and reduced fresh air exchange. As a result, indoor air becomes stagnant and odours, thereafter contaminants of air will accumulate and will certainly disrupt human health. It is quite difficult to make people comfortable in a building with consumption of energy-saving and human health guaranteed. Indoor plants are one of the alternative solutions that have been studied since the last three decades. This paper intends to review the abilities of indoor plants to purify air, and the ways used by previous researchers to prove that indoor plants can treat the air. In general, it can be stated that indoor plants are able to absorb various types of volatile organic compounds (VOCs). An advantage of indoor plants to cure air from carcinogen gas is greatly needed for human health. Therefore, studies on indoor plants to neutralize the air are gaining attention. Enclosed space or chamber is often used by researchers to test the ability of indoor plants absorb gaseous toxins in their study; because it is easy to handle and can quickly determine the absorption rate. In the other hand, environmental factors such as temperature, humidity, and light are important to be taken into consideration during the study. As a conclusion, it can be stated that the existence of indoor plants in a building is very reasonable, because it can give positive impacts on human health and the total energy consumption.

Keywords: Indoor pollution, Indoor plants, Energy efficiency, Human Health

Introduction

In the early 1970s, the energy crisis has swept around the world, where the price of fuel (oil and coal) has increased. Consequently, many initiatives have been carried out to conserve energy, especially in the buildings, by making the interior space more tighter (Roubini & Setser, 2004; Aydogan & Montoya, 2011). There are two ways of change the building design that can improve energy efficiency, which is superinsulation and reduced fresh air exchange (B.C. Wolverton, 1989). There is no doubt that making an airtight building will make more energy efficient compared non-airtight building (Kraus, 2014).

Indoor air pollution will occur if too isolating the interior space with the outdoor environment, or in other words, is limiting the circulation of fresh air inside the building. Air pollution has a relationship with adverse health effects, and it included respiratory infection, heart disease, and lung cancer (WHO, 2012). Moreover, according to Codey (2004), buildings that are too tight will cause health problems known as Sick Building Syndrome (SBS) or Building Related Illnesses (BRI).

Hence, indoor air quality (IAQ) needs to be maintained, it is because 90% of human time is spent at indoors (home, school or office) (Codey, 2004; Haryati Shafii, 2012; Llewellyn & Dixon, 2011;Khoa et. al., 2013). Nevertheless, it is quite to know that indoor air pollution is higher than outdoor air pollution, which is about 5-10 times (Nelson & Wolverton, 2011; Burchett, 2004; Kim et al., 2014). The content of gaseous from outdoor air such as nitrogen, sulfur, carbon dioxide, carbon monoxide, and organic will absorb into indoor air; and coupled by indoor air pollution itself mainly of volatile organic compounds (VOCs), and from other causes such as furniture, detergents, paints, and printers (Tarran, Torpy, & Burchett, 2007).

Apparently, it is difficult to achieve two desires simultaneously (the better health of occupants and energy-saving) (Perspectives, 2011). Since last three decade, National Aeronautics and Space Administration (NASA) try to solve this puzzle problem, finally they know that human cannot be separated with nature's life, which mean human life must be supported by plants even they life at indoor space (B.C. Wolverton, 1989). Indoor plants have the potential to be used as an alternative solution to this problem.

There are many benefits that can be derived from indoor plants when put together into the buildings. Through the process of photosynthesis by indoor plants, it has led to reduce carbon dioxide and increase oxygen for human needs (Torpy et. al., 2014; Hew et. al., 1969; Raza et. al., 1995). In addition, plants are able to reduce the room temperature, and also give a good contribution to human psychology through increased work productivity (Asmat Ismail, 2010; Energy, 1994; Bakker & Voordt, 2010; Lohr et. al., 1996). However, in this paper, researcher wants to study the ability of indoor plants that is able to serve as an air filter of toxins that can affect human health, and review the ways used by previous researchers to prove that indoor plants can treat the air. Indeed there are many indoor plants that can be used as a tool to absorb the gaseous which can lead to human cancer (Wolverton, 1996).

Ability of Indoor Plants to Deteriorate Gas Pollutants

First attempt to reduce gases that are harmful to human health has done by Bill Wolverton which has been reported in 1989, and the research was supported by National Aeronautics and Space Administration (NASA). His research has been conducted under controlled conditions, which only applies in a small enclosed chamber, and anyhow carcinogen gases has been involve in his study like formaldehyde, benzene, and trichloroethylene (B.C. Wolverton, 1989). In that study has found positive thing where indoor plants capable to remove amounts of VOCs gaseous in sealed chamber with reduction ranging from ten percent to ninety percent in 24 hours (Llewellyn & Dixon, 2011).

Table 1: Researchers and their finding of indoor plants to absorb gases contaminant

Researchers	Finding
J. Zhou *et. al.*, (2013)	Families' plants from *Marantaceae* and *Pteridophytes* can reduce concentration of formaldehyde during seven days assessments. This reduction it seems clear during the first three days. However, there is some impact damage to plants such as yellowing of the leaf blade.
(K. J. Kim et al., 2008)	Using *Ficus Japonica* and *Ficus Benjamina* as an indoor plants, both of plants can absorb half concentration of formaldehyde in one cubic meter of chamber in 96 and 123 minutes. In both species, aerial plants will absorb formaldehyde gas at day time and little gas at night, but, at root zone, formaldehyde is absorbed during the day and night.
(Aydogan & Montoya, 2011)	Four interior plants species, English Ivy, Pot Mum, Dumb Cane, and Golden *Pothos* can reduce at rate of 2/3 formaldehyde gas (in a small chamber) in 23, 30, 34, and 56 minutes. All four species also found that remove at root zone is more rapid than remove at aerial plants.
(Khoa et al., 2013)	Ten of native species plants use for reduce formaldehyde gas, where all plants selected can be planted in pots and placed in a room as ornamental plants. After 24 hours tested in closed chamber, all plants species was reduced concentration of gas with ranging 0.27 $\mu g/m^3$ till 16.4 $\mu g/m^3$.
(Liu, Mu, Zhu, Ding, & Crystal Arens, 2007)	*Crassula portulacea*, Hydrangea *macrophylla*, Cymbidium Golden, *Ficus microcarpa, Dendranthema morifolium*, and Citrus *medica* (as indoor plants) can reduce benzene gas in glass chamber with removal rate varied between 22.1 and 561.3 μgm^{-2} min^{-1}. Initially all plants are exposes with 150ppb of benzene gas, where it will effect to human health.
(M. D. Burchett, 2004)	Janet Craig, *Epipremnum aureum*, Dracaena *marginata*, and *Howea forsteriana* got reduce concentration of benzene with ranging 12-27ppm in chamber. Root zone for every species of plants is a major part of benzene reduction.
(Irga, Torpy, & Burchett, 2013)	*Syngonium* as an indoor plant is used to reduce 25ppm of benzene gas with two conditions (potting mix and hydro-culture). Even potting mix can reduce more fast compare hydro-culture, but benzene exposure did not alter the hydro-culture communities (microbiology).
(Mosaddegh, Jafarian, Ghasemi, & Mosaddegh, 2014)	D. *deremensis* and O. *microdasys* significantly reduced concentration of benzene. O. *microdasys* plant can remove 2 ppm concentration benzene in 48 hours in glass chamber, but for D. *deremensis,* it took 105 hours to complete remove. The removal ability of the D. *dermensis* and O. *microdasys* plants were expressed based on leaf area.
(Oh, Jung, Seo, & Im, 2011)	Peace Lily and Areca Palm used as indoor plants experiment. That is two conditions first testing in chamber just have indoor plants, and second animal also include in chamber. For all plants species, reduction of CO2 is higher at second condition.
(Raza et al., 1995)	*Apicra deltoidea*, Sedum *pachyphyllum, Bryophyllum pinnata*, and B. *calycinum* were employed as the succulent plants to remove the CO2 that accumulated in the experimental chamber and the rooms. *Apicra deltoidea* seems to be a very useful succulent plant in removing almost 80% of the accumulated CO2.

Indoor plants are seen as alternative solution to deal with this problem, and their ability is gaining attention. There are many researchers attempt to prove the truth of indoor plants to be able freshen the air, as well as to act as air filtration (Mahathir et. al, 2014). According to Cruz et. al (2014), indoor plants can act as an alternative way to reduce the level of VOCs in indoor air. There are certain indoor plants that have the ability to cure indoor air from pollutant (Downer, 2009). Table 1 shows the others researchers that involved with indoor plants to overcome the problem of pollution in the air. However, there are certain limitations to their research studies, such as the study was only conducted in the chamber, and only one parameter of the gas used in a time of experiments conducted.

Table 2: Dimension sizes of chamber which was once used by researchers before

No.	Researchr	Size chamber/ volume
1.	(Aydogan & Montoya, 2011)	(0.61 X 0.31X 0.41)m = 0.078 m^3
2.	(Irga et al., 2013)	(0.26 X 0.20 X 0.31)m = 0.1612 m^3
3.	(Torpy et al., 2014)	216 litter
4.	(Wang, Pei, & Zhang, 2014)	(1.83 X 1.68 X 1.68) m = 5.2 m^3
5.	(Wang & Zhang, 2011)	(4.84 X 3.63 X 3.05) m =54.4 m^3
6.	(Tarran & Torpy, 2007)	(0.6 X 0.6 X 0.6) m = 0.216 m^3
7.	(Xu, Qin, Wang, & Tong, 2010)	Cylindrical plexiglass = 0.076 m^3
8.	(Sriprapat & Thiravetyan, 2013)	15.6 litter
9.	(M. D. Burchett, 2004)	(0.6 X 0.6 X 0.6) m = 0.216 m^3
10.	(B.C. Wolverton, 1993)	310 litter
11.	(Song, Kim, Yoo, & Kays, 2010)	1 m^3
12.	(Zhou et al., 2013)	(1 X 1 X 0.8) m = 0.8 m^3

Laboratory Studies of Potted Plants to Treat Air Contaminated

Laboratory experiments are important thing to evaluate performance of indoor plants to acts as air filtration. It is scientific way to determine part of parameter that affecting indoor plants to perform like lighting, temperature, humidity, climate and ambient. Method of laboratory study many carried out by the researchers before (Cruz et al., 2014). Normally the test was conducted in small size chamber because easy to control with small fan, gases meter, gases contaminant, and indoor plants itself (Sriprapat & Thiravetyan, 2013, Khoa et al., 2013). Table 2 shows the dimension sizes of chamber which was once used by researchers before.

However, there are some arguments that found at laboratory studies. According to Cruz et al., (2014) stated that, when put indoor plants or ornaments plants in closed chamber with no air exchange or fresh air, relative humidity will increase and CO2 concentration will decrease due to transpiration and photosynthesis proses. Nevertheless, in real situation, the ambient is very different with chamber condition, where air exchange and carbon dioxide often varies, and relative humidity below than 60% (Missia, Demetriou, Michael, Tolis, & Bartzis, 2010). All these changes should be considered, because it can affect readings.

Factors That Effect Indoor Plants to Perform

Indoor plants originally come from forest, and plants need similar environments as his native to survive (Mahathir et al., 2015). However certain indoor plants species have abilities to down-regulation in photosynthesis at indoor spaces, where the process is important to plants live based on environment itself (M. Burchett, 2011). Light and temperature are two major factors can effect to the indoor plants whether to perform as bio-filtration and requirement to life (Allewalt et. al. 2006; Murchie et al. 2005).

Lighting on Indoor Plants

The thing that really needs to be considered for placing the plant in a building which is light, because light energy is very important to the plants during their photosynthesis process, where it is part of produce food plant itself for growth (Sterck et al., 2013). Most plants grow best in full sunlight and all plants need some light to survive. The amount of shade a plant is growing under will directly affect the density of the foliage, as well as the flowering and fruiting characteristics. In choosing plants, the level of light the plant will receive should be taken into consideration (Nuss, 2004).

When light intensity is too high and too low, inhibits photosynthetic performed, which leads to reductions in net photosynthetic rate (Forti, 2008; M. Burchett, 2011), and this phenomenon can be describe as a Figure 1. Accordingly, suitable of light level are needed to make sure that plants can survive at any places. In addition, in a study that put the plant in a building, light compensation point (LCP) should be identified as a Figure 1. LCP is a minimum light for plants can perform photosynthesis process, and below that level, inhibits photosynthetic will occur (Craine, 2005).

However, it difficult to predict since makes the plant as an agent of air filtration, because every plants

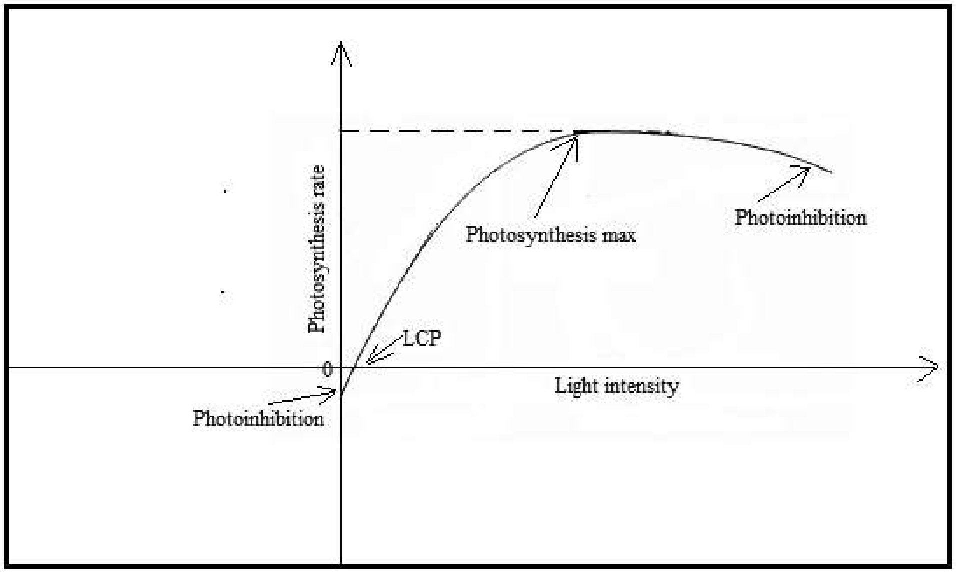

Figure 1: Graph photosynthesis rate versus light intensity for leaf
Source: Forti, (2008)

will perform with various results. Based on previous research, Aydogan & Montoya (2011), found some of plants in their research can perform very well to absorb gas contaminant in range intensity of 2000 to 5000 lux, below or above than that, abilities of plants will decrease. Even so, Irga et al., (2013) stated that based on his research, some of plants will perform to absorb gas contaminant at light intensity of 700 to 1450 lux. By doing so, selection of light level must be investigated in proper way to ensure the findings are accurate.

Temperature on Indoor Plants

Temperature is one of factors that can affect to the plants life. Most of the plants will live on temperatures between 150C to 300C (Pastenes & Horton 1996; Hew et al., 1969). The ability of plants to survive will diminish when the temperature reaches 350C (Pastenes & Horton 1996). Figure 2 shows the illustrations of plants life represented by photosynthesis process versus level of temperature. Based on Allewalt et. al. (2006), at low temperature the enzymes do not have enough energy to meet many substrate molecules, so the reaction is slowed, as results, rate of photosynthesis is low. Meanwhile, at optimum temperature, the enzyme is most efficient, and this condition also make rate of photosynthesis at high reading. Lastly, at higher temperature, the structure of the enzyme is broken down, and the enzyme cannot be used again, so, rete of photosynthesis will decrease.

Plants can be tolerated with ambient temperature around them. Based on previous research, temperature that used by researchers is varies from 200C till 300C as indicated in the Table 3.

Conclusion

Indoor plants have a potential to serve as alternative solution to acts as air filtrations and their ability is gaining attention. Using this micro-biology, it seems

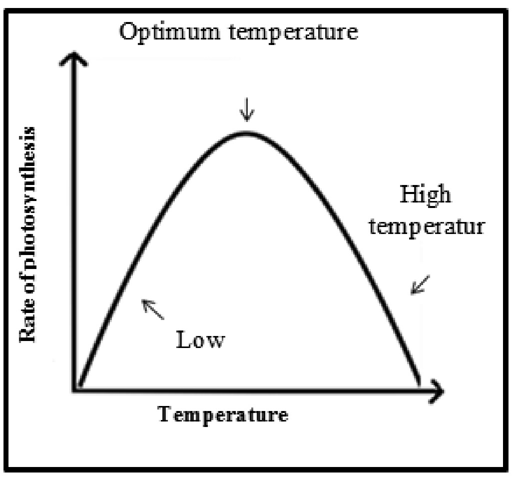

Figure 2: Figure 2 shows the illustrations of plants life represented by photosynthesis process versus level of temperature
Source: Allewalt *et. al.* (2006)

Table 3: The temperature used by other researchers

Name of researcher	Temperature
In this research	**≈25^{0}C**
(Zhou, Yue, Chen, & Xu, 2013)	20^{0}C±1^{0}C
(Torpy et al., 2014)	23.7±3.6 ◦C
(Wang & Zhang, 2011)	22◦C
(Wood et al., 2006)	23±0.2◦C
(Tarran & Torpy, 2007)	23±0.2◦C
Irga et. al. (2013)	23.0^{0}C ± 1^{0}C
Aydogan & Montoya, (2011)	21^{0}C ± 1^{0}C
Wang et al., (2014)	23±0.6◦C

also can improve energy conservation if advanced investigation conducted to the real situation. If the views from researchers who conduct their research earlier in laboratories, there was a positive development of the results of their study using plants to absorb toxic gas. However, there are several factors to be taken into account such as temperature and lighting to ensure all indoor plants that are studied can perform as bio-filtration and live with long periods when placed at indoor spaces.

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